CANADA NEXT

BACKGROUNDER

MARCH, 2018

PUBLIC
POLICY
FORUM

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FORUM DES POLITIQUES PUBLIQUES

PPF

The Public Policy Forum works with all levels of government and the public service, the private sector, labour, post-secondary institutions, NGOs and Indigenous groups to improve policy outcomes for Canadians. As a non-partisan, member-based organization, we work from "inclusion to conclusion," by convening discussions on fundamental policy issues and by identifying new options and paths forward. For more than 30 years, the PPF has broken down barriers among sectors, contributing to meaningful change that builds a better Canada.

WITH THANKS TO OUR PARTNERS

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Disrupting Governance & Regulation

ABOUT THE PPF

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TAB 1

Government of Canada   Gouvernement du Canada

Disruptive technologies and their prospects

This deck showcases preliminary research and analysis by Department of Finance staff and is intended to inform and stimulate wider debate. Views expressed are those of the authors and do not necessarily reflect the official position or policy of the government.

March, 2018

Canada

Overview of the presentation

1. Background

2. Potential impacts

   a. *Opportunities:* economic growth, service delivery, wellbeing

   b. *Risks:* job losses, nature of work, inequality, competition, privacy and security, democratic governance

3. Policy implications

   a. *Domestic agenda:* innovation and adoption, education and skills, social and labour market, tax system, regulations and laws, infrastructure, governance

   b. *Global agenda:* global tax issues, trade and development, national security

4. Work underway across departments

5. Key takeaways

Slower growth threatens future prosperity

Innovation and technological adoption are critical to offsetting Canada's weak productivity performance, population aging, and other headwinds to economic growth

Slow productivity growth and population aging are expected to weigh on growth, increasing the importance of technological advances to Canada's economic future

A wave of economically disruptive technologies such as artificial intelligence (AI) have the potential to enhance Canada's productivity performance, leading to stronger economic growth and improved living standards

However, adoption of these technologies could be low as Canadian businesses have a poor track record on innovation and on investment in information and communication technologies (ICT)

The policy challenge then is to find how best to promote technological change to maximize growth, while managing the risks created by economically disruptive technologies and ensuring everybody gains

Average annual labour productivity growth, G7 countries

Per cent

■ 1990-2000 ■ 2000-2007 ■ 2007-2015

Average annual productivity growth rate needed in Canada just to offset the aging effect over the next 30 years
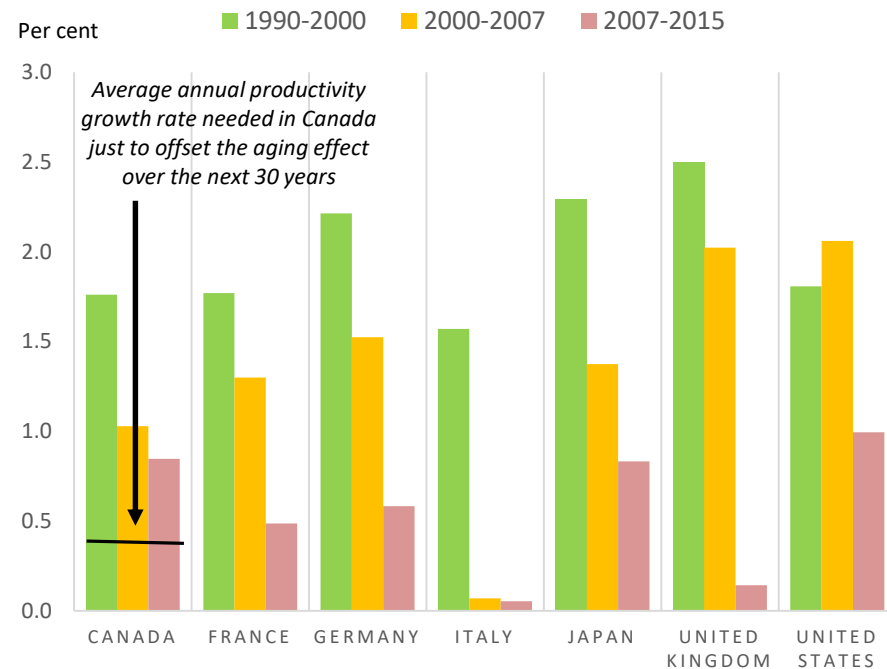
Sources: Department of Finance calculations; OECD data
Notes: Labour productivity is defined as GDP per hour worked.

New wave of economically disruptive technologies

A new wave of disruptive or transformative technologies are unlocking new capabilities and have the potential to drastically alter markets and everyday life

Economically disruptive technologies—like the semiconductor microchip, the Internet, electricity, or steam power—transform the way we live and work, enable new business models, and provide an opening for new players to upset the status quo

Disruptive technologies have several common characteristics:

- The technology is rapidly advancing or experiencing breakthroughs

- The potential scope of impact is broad – touching many firms and industries and affecting (or creating) a wide range of products

- Significant economic value or welfare could be created

- Economic impact is potentially disruptive – changing the status quo in terms of market dynamics, daily life, or the nature of work

Emerging digital technologies, such as AI, cloud technology and the Internet of Things, are at the forefront of today's technological revolution

Beyond digitalization, there has also been a wide array of advances in fields such as nanotechnology and 3D printing in what has been described as the "Fourth Industrial Revolution"

Waymo's self-driving car

Amazon's Kiva robots

Google's AlphaGo beats Ke Jie

McDonald's self-serve kiosks

What are the major disruptive technologies?

Five potentially disruptive technologies…

1) **Artificial intelligence:** Intelligent software systems based on *machine learning* built to solve specific prediction problems (translation, computer vision, legal or financial advice)

2) **Connectivity:** Broad access to high-speed Internet using computers or mobile devices (telephony, text messaging, web browsing, new digital services)

3) **Networks and Sensors:** Increasingly capable networks of sensors and devices for data collection, monitoring, decision making, and process optimization (in-store customer tracking, smart homes, precision farming)

4) **Advanced robotics:** Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans (manufacturing, fulfilling warehouse orders, maintaining nuclear reactors)

5) **Advanced manufacturing:** Additive manufacturing using an expanding range of materials (nanomaterials, biomaterials), rapid prototyping and custom product creation are transforming manufacturing (3D printers, bioprinting)

…and several other emerging technologies…

- Energy storage and clean technology
- Advanced genomics and biotechnology
- Advanced materials and nanotechnology
- Quantum computing
- Space technology

…are changing production processes

- **Automation and digitization of jobs:** Combining intelligent software, networks of sensors, and robots to automate a growing scope of tasks (medical diagnosis, in-store checkout, self-driving trucks)
- **Telecommuting and flexible work arrangements**
- **Made-to-order and customized products**

…are enabling new business models

- **Sharing economy:** Uber, Airbnb, TaskRabbit, Zipcar
- **E-commerce**: Amazon, Alibaba, Ebay, Etsy
- **Fintech:** financial services (Wealthsimple), digital money (Bitcoin), transactions (Apple Pay, Blockchain), funding (crowdfunding, initial coin offerings)

…are creating new products and markets

- **Digital services:** online banking, social networks (Facebook), media streaming (Netflix), cloud-based storage/computing services (Amazon Web Services), virtual assistants (Siri, Alexa, Cortana)
- **Digital goods:** software, audio/song files, etickets, mobile apps, augmented/virtual reality, Internet of Things (pacemakers, smart homes)
- **Connected, autonomous and electric vehicles**
- **Distributed ledgers and cryptocurrencies**
- **Earth observation**

Disruptive technologies are challenging many of the paradigms on which policies are based

Production
- Near-zero marginal cost production more common
- Increasing returns to scale production more common
- Production disassociated from physical location
- Automation of tasks requiring high skills
- Intangibles capital becoming core assets (data, IP, brands)

New technologies are changing the underlying foundations [in squares] of how the economy functions and is understood

In response, policies may need to be rethought to ensure they remain effective

General governance
- Accelerated policy adjustment and new regulatory approaches to match technology change
- Improved evidence based policy with Big data and AI

Economic measurement
- Growing share of capital stock miss measured with existing conventions (intangible capital)
- Greater under measurement of GDP with more value of free digital services ignored

Market organization
- Abundant complex markets (multi-sided trading)
- Abundant network effects and market lock-in effects
- Abundant diffused person-to-person trading
- Stronger contract enforcement with reputation effects
- Abundant in-kind transactions (personal data for services)
- Online platforms connecting more workers to gigs
- Capital sharing via online platforms (homes, cars)

Ethics
- Human machines
- Gene editing and cloning
- Pre-programed emergency response (self-driving cars)
- Discriminatory AI algorithms
- Privacy loss
- Personal information used against the individual

National security
- Cyberwarfare
- Lethal autonomous weapon systems
- Proliferation of Space Technologies

Disruptive technologies promise to boost growth

Economically disruptive technologies have improved productivity and living standards, and transformed prevailing economic and social structures

In the past, technological advances have raised productivity and wages, and fundamentally changed the way the economy is organized

- Innovative firms eroded the market share of incumbents, creating pressure to improve productivity and quality

- New markets expanded the scope of economic activity

- New tools, processes and structures allowed firms to reduce production costs and consumer prices

The potential impacts of today's economically disruptive technologies remain highly uncertain, with ongoing debate as to whether recent advances will be as transformative as those of the past (**Annex I**)

- On productivity, some early estimates point to a similar impact as previous disruptive technologies

- Full economic impacts may come after a long lag, as it takes time for the latest advances to diffuse and for individuals to learn to take advantage of them

Contribution of disruptive technologies to average annual labour productivity growth

Projections

Percentage points
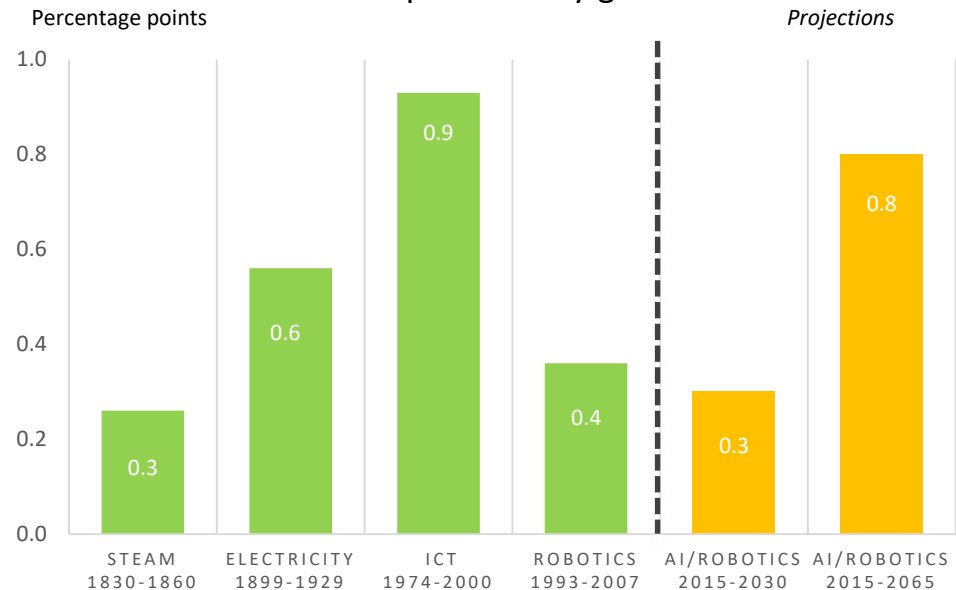
Sources: Crafts (2002), Graetz and Michaels (2015), and McKinsey Global Institute (2017)
Notes: Historical estimates for steam, electricity and ICT reflect the contribution of each technology in the country at the technological frontier of the time. Estimates reflect the percentage point contribution to the labour productivity growth. "AI/ROBOTICS" refers to all technologies that would act in parallel to improve productivity with projections based on current technology automating 50% of existing jobs by 2075.

… while within government, they create opportunities to improve service delivery

The adoption of emerging digital technologies could increase the speed of service delivery while also improving quality and reducing costs

Recent advances, particularly in digital technologies, can be used to improve service delivery and lower costs

- Digitization expands the regional reach of government services and reduces duplicative work (info collection)

- Chatbots and automated decision support systems can respond to client inquiries and approve low-risk services applications immediately and could provide 24/7 services

- AI and Blockchain technologies offer the potential to improve the effectiveness, efficiency, and security of government services

- AI may also lead to better policy design by augmenting government capacity to develop evidence-based policy

- Blockchain technologies can provide clients with secure and transparent record of how and when their information was used

- Internet of Things may improve the regulatory system by allowing real time monitoring and helping predict regulatory infractions

UN index of government online services, 2016
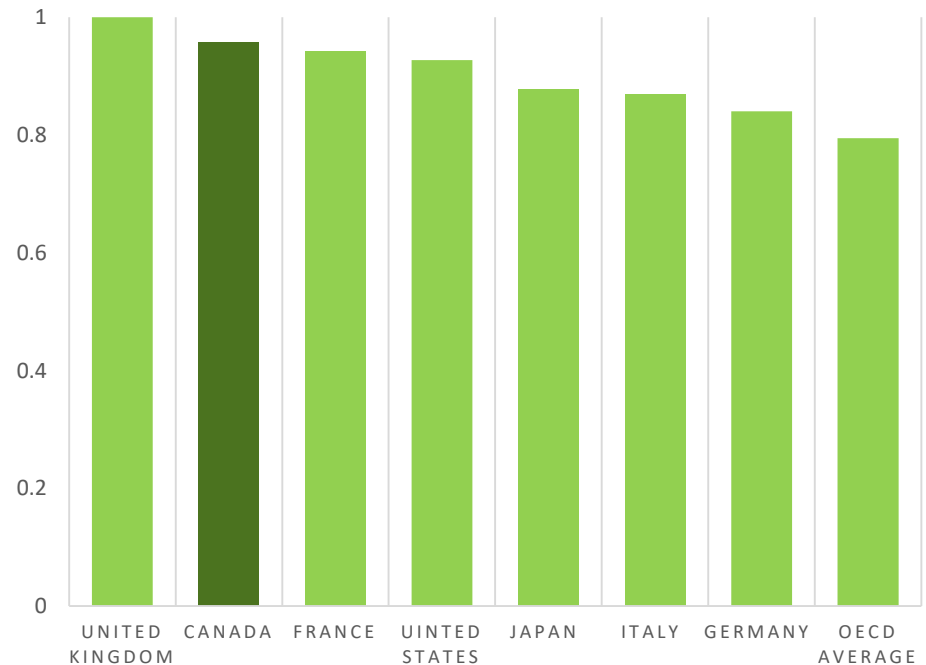
Sources: UN eGovernment Survey 2016
Notes: This index reflects the scope and quality of online services provided by governments. Index values range from 0 to 1 with higher values reflecting better results. Among all 35 OECD countries, Canada ranked 3rd behind the U.K. and Australia.

Far-reaching gains in wellbeing are also expected

Innovations create new and better-quality products that improve a wide range of health, environmental and safety outcomes, and enhance our enjoyment of daily life

New technologies promise to improve a wide range of outcomes important to peoples' quality of life

- Improved health with AI-enabled medical diagnosis, 3D bioprinting, and personalized cancer treatments

- Reduced pollution with electric cars, energy storage, and renewable energy production

- Greater safety and reduced congestion with autonomous and near-autonomous vehicles

Digital technologies are generating consumer surplus and increasing wellbeing in several ways

- Connectivity is making markets more efficient, lowering transaction/communication costs, and expanding access to information (e.g. distance learning, MOOCs, e-health)

- Smartphones make daily life more convenient by combining devices (e.g. phone, music player, camera, etc)

- Free digital services (e.g. Google search, Wikipedia, YouTube, Facebook) make significant contributions to consumer welfare that are not captured by GDP

Canada

...but in the transition, benefits will not be spread evenly

Costs and benefits of disruptive technologies will be unevenly distributed, making early policy action necessary to help those who are negatively affected

In the past, disruptive technologies have destroyed some jobs, businesses and industries while creating new ones

While evidence suggests the benefits will be broadly shared in the long run, winners and losers are created in the short- and medium-run as economies adjust*

- *"Routine"* workers with tasks that can be codified and performed by machines (e.g. accountants, cashiers) will be negatively affected regardless of their education level

- Workers skills that are complementary to machines and needed to complete *"non-routine cognitive"* tasks (e.g. managers, consultants) are expected to be winners

- *"Non-routine manual"* workers (e.g. personal support workers, janitors) are expected to be relatively unaffected as their tasks are difficult to automate

However, advances in AI and robotics are quickly expanding the scope of manual/cognitive tasks that are considered *"routine"* (e.g. driving cars, medical diagnosis)

* Using a theoretical model, economists at the IMF suggest a baseline of 20 years for the productivity effect to outweigh the substitution effect and drive up wages, corresponding with the evidence from the last 200 years of disruptive innovation.

Growth in the share of total employment, by task category, Canada, 1987-2016

Index, 1987=100

NON-ROUTINE COGNITIVE

NON-ROUTINE MANUAL

ROUTINE

Employment share changes likely reflect the impacts of not only technology and automation but also of greater global trade and production offshoring
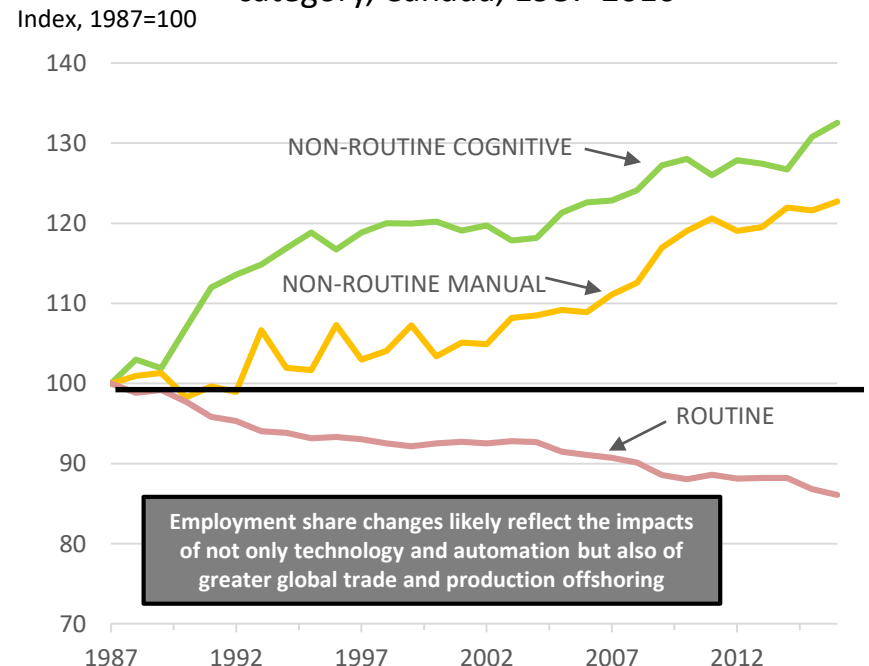
Notes: This analysis is based on an occupation classification grid developed by C.D. Howe Institute (2017).
Sources: Department of Finance calculations; C.D. Howe Institute (2017); Statistics Canada, Labour Force Survey (2016).

Potential job losses to automation are highly uncertain

Different ways of estimating the probability of automation lead to sharply contrasting estimates of future job losses in the Canadian labour market

Well-known job loss estimates, such as Frey/Osborne, may be exaggerated: they assume entire occupations rather than specific tasks will be automated

- Automation is more likely to lead to *task restructuring* within occupations rather than the complete destruction of some jobs, as some tasks – even in high-risk occupations – cannot be automated

- Job loss estimates that account for task restructuring within jobs, such as McKinsey and OECD, are significantly lower and more plausible

Moreover, these estimates reflect *gross* rather than *net* changes and, therefore, they do not tell us whether there will be an decrease in employment

- Expected job losses are of a similar magnitude to those from typical job churn, which may suggest the labour market would be able to absorb this magnitude of losses

At the same time, job loss estimates are often based on the potential of current technologies and ignore the impacts of unforeseen acceleration in technology

Estimates of the share of Canadian workers at <u>high risk</u> of being affected by automation in the next 10 to 20 years

Frey/Osborne*	42
C.D. Howe	35
Mckinsey**	18
OECD	9
Accumulated share of employment loss from typical job churn	36
Fall in labour supply due to aging	8

Occupation-based approach

Task-based approach
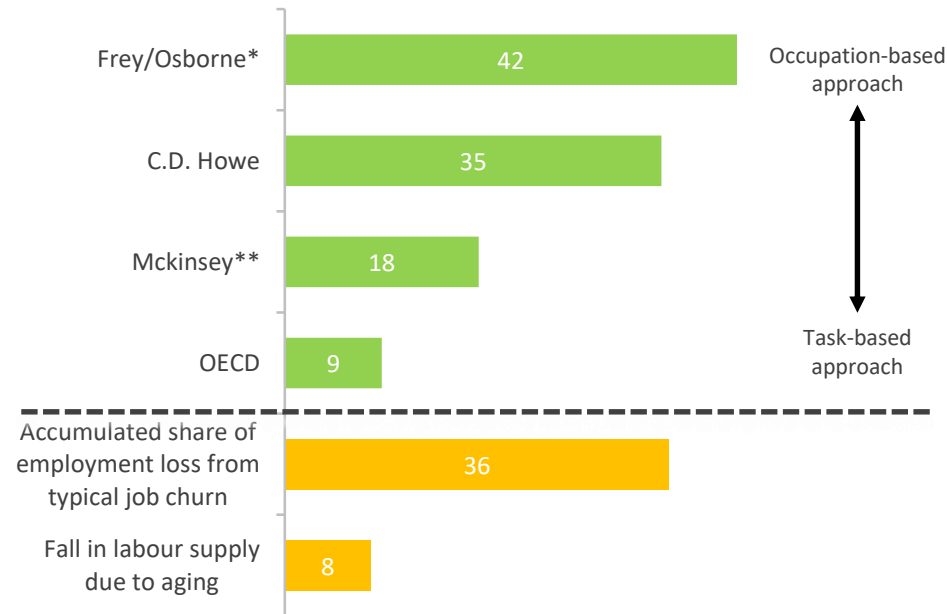
Notes: * BII+E estimate based on Frey and Osborne's (2013) methodology. ** BII+E estimate based on McKinsey's methodology. "Accumulated share of employment loss from typical job churn" is calculated by accumulating the annual layoff rate (2.9 per cent) over 15 years. "Fall in labour supply due to aging" is estimated by changing population weights to those projected for 2031, but keeping age-specific participation rates fixed. Sources: Department of Finance calculations; Brookfield Institute for Innovation + Entrepreneurship (BII+E) (2016); C.D. Howe Institute (2017); Arntz et al. (2016).

... and as a result, a debate over the magnitude of the labour-market impacts has emerged

Several barriers will slow the adoption of disruptive technologies and prevent large disruptions, while long-standing adjustment mechanisms will promote the creation of new jobs

Historically, labour markets have proven resilient to previous waves of automation, ultimately maintaining relatively high employment rates

Various factors will bolster labour demand **(Annex II)**:

* Automation could be technically feasible but not cost effective enough to replace workers

* New technologies create new markets, goods and services, fostering job creation elsewhere

* Higher productivity can raise income, lifting demand for all things including labour

* Labour force skills adjust to meet the demands unmet by automation, as younger cohorts with new skills enter the labour market and older workers retire

Indeed, similar magnitudes between predicted and typical job losses may suggest the economy can deal with today's automation with high employment rates

However, high employment impacts must still be considered as estimates do not consider future technological advances that some expect to be unprecedented and that would make impacts large

High Probability + Moderate Impact Scenario

Low Probability + High Impact Scenario

Historical experience of technological change

Macroeconomic feedback mechanisms

Job-task adjustment process

Ethical, legal and economic barriers to adoption

Potential for exponential growth in AI capabilities alongside growth in big data

Quick expansion in the scope of physical and cognitive tasks that can be automated

Rapid pace of improvements in technical capabilities of AI and robotics

Predicted labour displacement similar to peer countries

While predicted job losses are moderate, Canada may be less prepared for future disruptions with lower spending on labour-market policies and lower participation in lifelong learning

Internationally, Canada's share of workers at high risk of being displaced is slightly below the OECD average, partly reflecting our smaller manufacturing sector

However, compared to other countries, Canada's policy suite may be less prepared to help workers displaced by automation and promote lifelong learning (**Annex III**)

- Government spending on active labour market programs is about half of the OECD average
- Only 31% adults participated in job-related non-formal education, compared to 62% in Sweden

Displacement leads to persistent financial hardship, especially for lower-wage workers and their families

- Re-employment wages are often substantially and persistently below pre-displacement levels
- Displacement has also been shown to reduce the adult earnings and PSE participation of affected children

Share of workers with automatable jobs, 2012

- High risk (likely to be displaced)
- Significant risk (likely to require changes in tasks)

OECD average - share of workers with high or significant risk
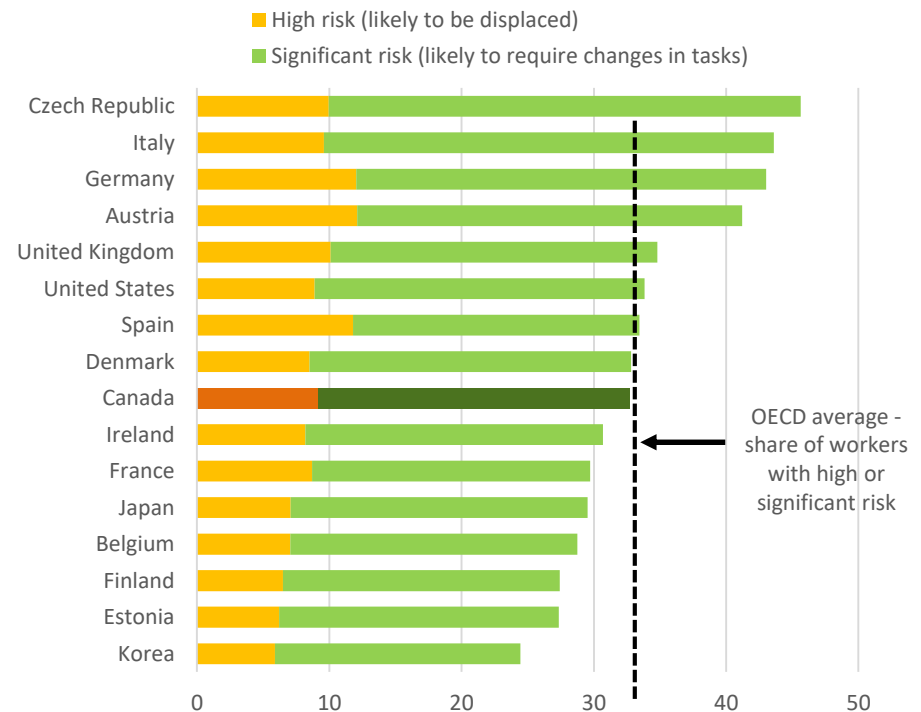
Note: Estimates are based on task-based approach. Workers with "automatable" jobs at high risk are workers who can expect at least 70 per cent of their tasks to be automated. Those at significant risk are workers who can expect 50 to 70 per cent of their tasks to be automated. Source: Arntz et al. (2016)

Recent advances may accelerate the changing nature of work

Growth in non-standard employment could be magnified by job losses due to automation and growth in "gigs" enabled by online platforms

Non-standard work arrangements, such as part-time jobs, temporary jobs and self-employment, have spread since the 1970s – partly reflecting gains in labour force participation among women and school attendance

- Non-standard jobs are often associated with lower wages, job insecurity, minimal training, lack of benefits, as well as greater difficulty to qualify for Employment Insurance

- While the overall increase stabilized in the mid-1990s, temporary employment has continued to increase

Going forward, there is concern that growth in non-standard work arrangements will be amplified by weak labour-market conditions related to automation and the emergence of platform-enabled "gigs" (e.g. Uber drivers)

- So far there is little evidence that gigs are an important part of Canada's labour market – only a small proportion of Canadians offered peer-to-peer ride services (0.3%) or private accommodation services (0.2%) in 2015/2016

- Moreover, according to U.S. data, growth in participation in the "gig economy" has slowed, and gigs are typically seen as a way to supplement wage income rather than as a replacement for more traditional employment

Share of Canadian workers in non-standard work arrangements
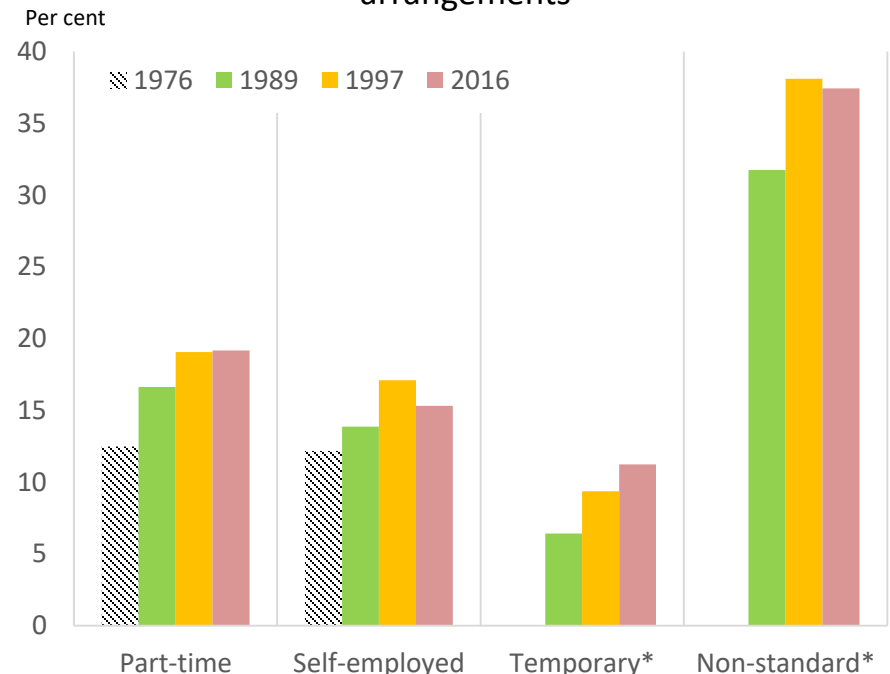
Note: Total non-standard employment excludes overlap between part-time employment, temporary employment and self-employment. * Data on the share of temporary workers in 1989 are from the 1989 General Social Survey (Cycle 4).
Source: Statistics Canada, Labour Force Survey; Department of Finance calculations.

Tomorrow's labour market will demand new skills and greater adaptability from the workforce

Equipping workers with the right skills will be essential for technological diffusion and ensuring the benefits of technology are broadly shared

Going forward, most jobs are expected to become more skills intensive, and workers will need to be adaptable to labour-market demands in order to succeed

Moreover, broad absorption of new technologies will depend on whether the workforce has the technical skills to work with new technologies, and the business acumen to value and to best exploit opportunities

Good technical and business abilities are built on fundamental skills learned through formal education and require updating through a process of lifelong learning to remain current

Fostering lifelong learning and adaptability means nurturing cognitive and social/behavioral skills necessary for gaining and improving technical skills throughout life, such as critical thinking, flexibility, communication, and perseverance

Skill that remain difficult to automate
Social perception
Originality
Assisting others
Philosophy
Initiative
Leadership
Innovation
Adaptability and flexibility
Independence

Sources: C.D. Howe Institute (2017).

Automation is likely to widen economic disparities

Irrespective of the magnitude of job losses, new technologies and automation are expected to contribute to rising inequality

New technologies are expected to raise inequality by:

- Reducing demand for lower-wage workers with skills that are easily substituted by machines

- Increasing demand for higher-wage workers with skills that are complementary to machines

- Generating rents through winner-take-all dynamics and market consolidation/concentration

Disruptive technologies may also exacerbate regional disparities in Canada

- Regional economies dependent on manufacturing or resource extraction, such as southwestern Ontario and northern Alberta, will likely experience more disruption

- Communities with a large hospital, post-secondary institution or public sector presence, such as Ottawa-Gatineau, are less susceptible to automation

Women face a slightly lower risk of losing their jobs to automation, but may benefit less from the STEM jobs directly created by new technologies

Distribution of employment by vulnerability to automation, by hourly wage group
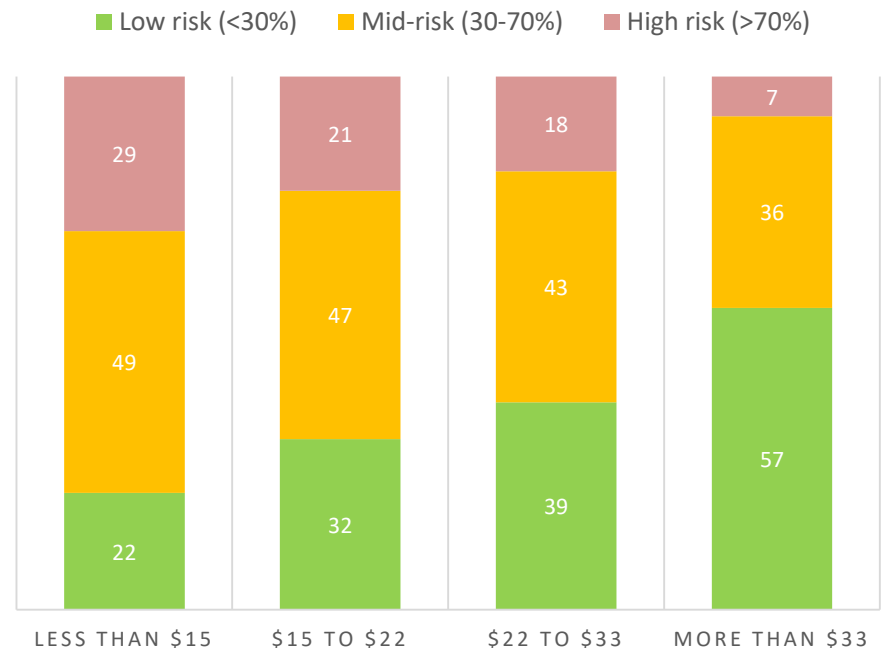
Legend: ■ Low risk (<30%)   ■ Mid-risk (30-70%)   ■ High risk (>70%)

	LESS THAN $15	$15 TO $22	$22 TO $33	MORE THAN $33
High risk (>70%)	29	21	18	7
Mid-risk (30-70%)	49	47	43	36
Low risk (<30%)	22	32	39	57

Sources: Department of Finance calculations; Brookfield Institute for Innovation + Entrepreneurship (BII+E) (2016); Statistics Canada, Labour Force Survey (2016).
Notes: This analysis is based on estimates of the share of job-tasks that can be automated using current technology, provided by BII+E (2016).

Disruptive technologies have pro- and anti-competitive impacts

Innovations cause creative destruction: destroys old markets and creates new ones, and leaves competition outcomes uncertain along with the fate of affected workers

PRO-Competitive Impacts

?
Net impact uncertain

ANTI-Competitive Impacts

- Reduce entry/search costs and broaden global reach; raise market contestability
- Create new business models that compete with existing ways of doing business

- Network effects/near-zero marginal cost of digital services create "winner-take-all" markets
- AI pricing algorithms may allow implicit collusion between firms

UBER **VS** TAXI
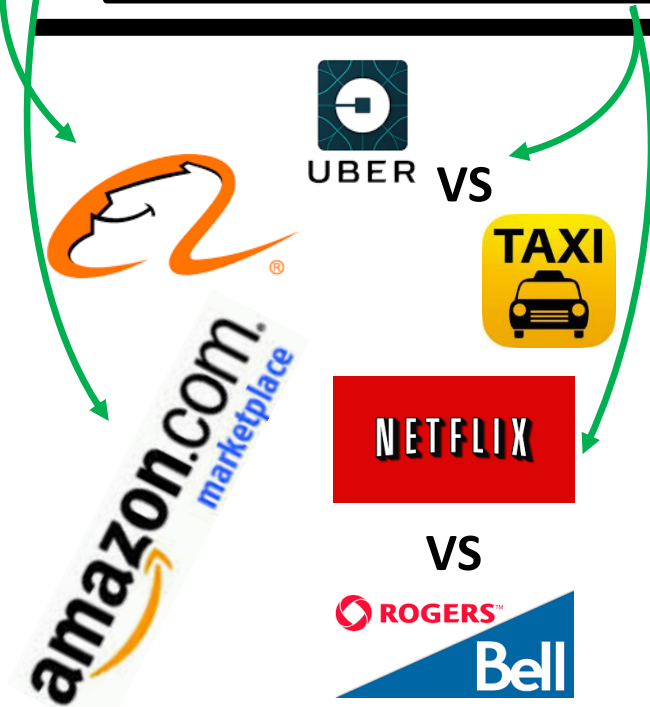
Current technologies make competition matters complex because they incorporate: platform-based business models, multi-sided markets, network effects and scale economies

NETFLIX

VS

ROGERS
Bell
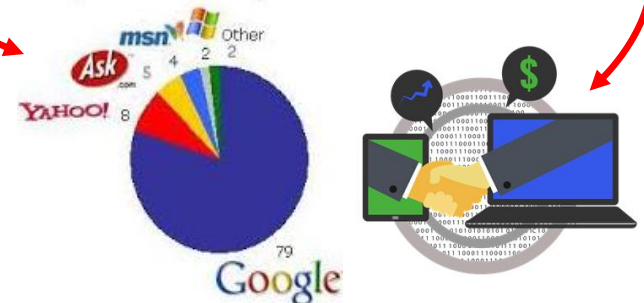
- Digital technologies enable winner-take-all dynamics but they may also make these dynamics less durable (e.g. they can reduce entry barriers)
- Access to personal data is an enormous competitive advantage and further entrenches entities already enjoying network effects
- Growing market concentration may exacerbate inequality, as dominant firms may tend to offer higher wages relative to the rest of the economy

Canada

Privacy and security policies more critical as digital technologies raise the importance of personal data for growth

Malevolent actors and benign organizations/individuals who cannot anticipate how data will be used when collected threaten privacy and security

Personal data is becoming more valuable and is increasingly considered an essential ingredient for innovation and growth

Ownership and trade issues

- What is the role of informed consent when handing over personal data?
- Limit what firms can do with their clients' personal data
- "Right to be forgotten" online
- Ownership of data following the bankruptcy of a company
- Constraints on transferring data across international borders
- Divergence of national regulations may lead to creation of "splinternet"

Security impacts

- Growing prevalence of cyberattacks targeting individuals, firms and governments (WannaCry)
- Security threats may disproportionately affect SMEs who have less capacity to manage risks
- Market concentration in digital markets also increases systemic risks (Equifax hack)
- New cybersecurity risks with spread of Internet-connected devices: pacemakers, self-driving cars, smart infrastructure
- Digital literacy critical to safeguard individuals from malicious activities
- Lack of protection of personal information leads to targeted influence operations
- Proliferation risk of WMD-related technologies increased through illicit transfers, cybercrime and 3D printing

Privacy impacts

- Businesses have access to continuously expanding amount of personal data
- Sensors and facial recognition software enhances ability to track individuals
- Personal data is key to digital innovation but may undermine privacy objectives
- Freedom of expression may be impeded with loss of privacy and anonymity
- More data and better prediction (AI) may make insurance less accessible for higher-risk individuals

Canada

New technologies are undermining trust in public institutions and hampering the political process
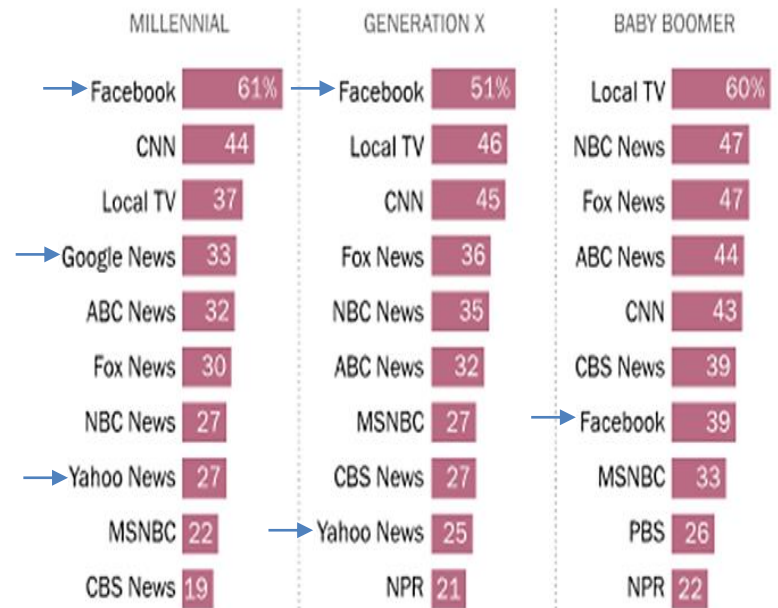
Social media has created new challenges for democratic governance, including the use of 'fake news' to influence elections and lower trust in public institutions

Democratic governance must adapt as the views of citizens, especially those of younger generations, are increasingly "filtered" and shaped by the algorithms controlling access to information on the Internet

- 'Truth neutrality' of new digital platforms is undermining trust in institutions, such as the government and media

- 'Fake news' stories shared widely on social media create the risk of "filter bubbles" or "echo chambers" that lessen exposure to new ideas, polarizing opinion and making discussion more contentious

- Foreign governments are using social media to spread 'fake news' in order to influence elections across the world

- Social media companies, such as Facebook, are starting to self-regulate to limit spread of 'fake news'

Going forward, disruptive technologies may exacerbate social unrest and dissatisfaction linked to globalization and inequality, leading to populist political movements, rising support for anti-growth policies, and weak governance

Share of people in the US getting news on politics and government from news sources, 2014

MILLENNIAL		GENERATION X		BABY BOOMER	
→ Facebook	61%	→ Facebook	51%	Local TV	60%
CNN	44	Local TV	46	NBC News	47
Local TV	37	CNN	45	Fox News	47
→ Google News	33	Fox News	36	ABC News	44
ABC News	32	NBC News	35	CNN	43
Fox News	30	ABC News	32	CBS News	39
NBC News	27	MSNBC	27	→ Facebook	39
→ Yahoo News	27	CBS News	27	MSNBC	33
MSNBC	22	→ Yahoo News	25	PBS	26
CBS News	19	NPR	21	NPR	22

Notes: Survey conducted March 19 to April 29, 2014. Based on online adults. People surveyed were asked from what sources they got news on politics and government in the prior week.
Source: American Trends Panel (wave 1), PEW Research Center.

Expected impacts call for measured policy response

Domestic agenda should focus on promoting innovation and adoption while updating our policy framework to minimize potentially harmful side effects

Opportunities
Stronger productivity
New market opportunities
Greater wellbeing
Improved public services

Risks
Displaced workers
Changing nature of work
Higher inequality
Anti-competitive effects
Privacy and security threats
Governance challenges

Potential areas for action

1 Innovation and adoption
Support rapid innovation, adoption and commercialization across sectors and regions

2 Education and skills
Ensure students: have the right skills and are adaptable to more frequent job transitions

3 Social and labour market
Minimize affected worker hardship, ensure programs parallel the changing nature of work

4 Regulations and laws
Promote innovation while minimizing risks related to privacy, security and competition

5 Tax system
Balance innovation promotion and redistribution to offset higher inequality

6 Infrastructure
Support the right infrastructure that facilitates adoption of disruptive technologies

7 Governance
Adopt technologies that will help improve government service provision

Canada

Fostering innovation and adoption will require a strong policy framework and actions to resolve market failures

Policy considerations

Broad technological diffusion is key to boosting productivity

Mixture of tax incentives and active support for research, innovation and commercialization are needed to help Canada become a leader in emerging technologies

Promoting broad diffusion of new technologies across firms will require resolving frictions in Canada that have typically inhibited the business uptake of new technologies like ICT

Regulations inhibiting technological adoption should be reviewed

How to speed-up technological adoption in public sector to improve productivity and service quality?
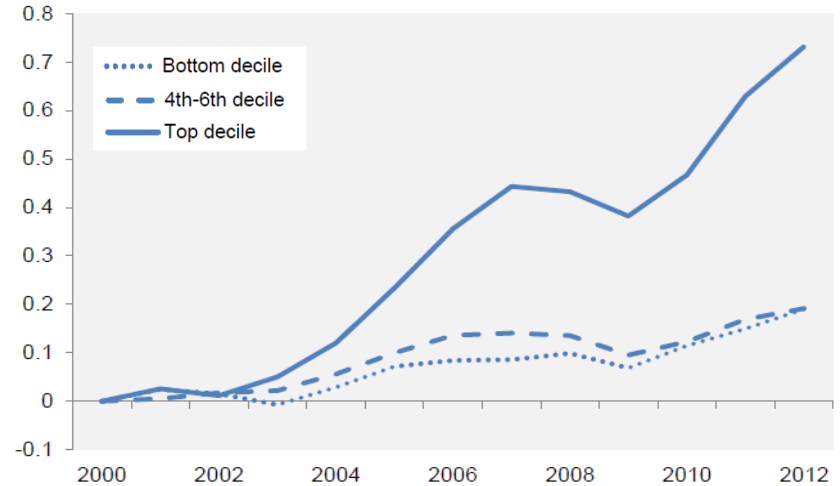
Growing divergence across Canadian firms in labour productivity performance, non-financial services

Source: OECD (2016) "The Productivity-Inclusiveness Nexus"

Actions to date

The Horizontal Innovation and Clean Technology Review is assessing how to improve Canada's suite of innovation programs with initial recommendations received in December 2017

Six industry-led Economic Strategy Tables working through mid-2018 to identify innovation barriers and opportunities, including in digital, bio/health and advanced manufacturing industries

Potential avenues

Developing strategy to promote public-sector adoption of new technologies to improve productivity and service quality

Identify regulations inhibiting the commercialization and adoption of new technologies and business models (Fintech, sharing economy, e-commerce)

Efforts to develop future skills and worker adaptability needed to ensure broadly shared economic benefits

Policy considerations

Equipping workers with the right skills is essential for broad diffusion and ensuring the benefits are broadly shared

Good technical and business abilities are built on fundamental skills learned through formal education and require updating through a process of lifelong learning to remain current

Fostering lifelong learning and adaptability means nurturing the cognitive and social/behavioral skills necessary for learning later in life and transferable to unexpectedly different jobs

Coordinated approach involving government, businesses and schools is needed to ensure the education/training is broadly accessible and quickly adapts to changing demands

Share of Canadian youth participating in post-secondary education by parental income

Legend: 2001, 2014

Categories: Bottom 20%, Second, Middle 20%, Fourth, Top 20%

Source: Frenette (2017), "Postsecondary Enrolment by Parental Income: Recent National and Provincial Trends", Statistics Canada
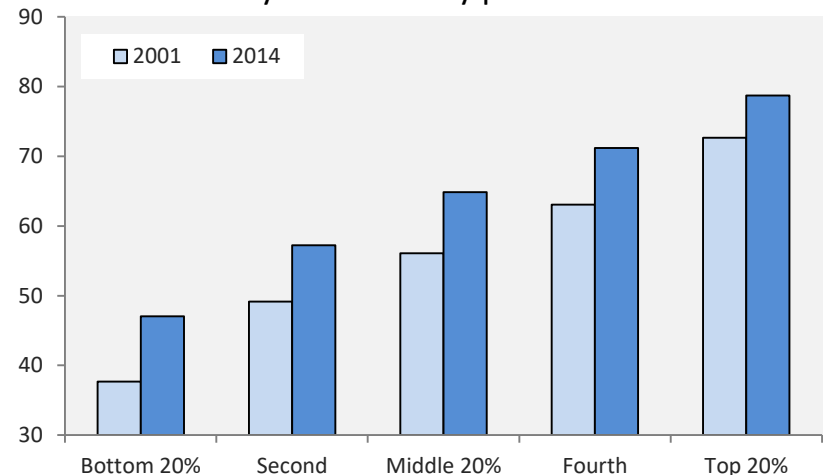
Actions to date

Providing re-training following a job loss and proactive upskilling

Establishing an adult upskilling strategy for adult learners and those with dependents

Enhancing the EI system to support and sustain re-employment and reintegration to the job market

Creating a new skills organization to identify future skills needs

Potential avenues

Promoting the early development of the cognitive, social and behavioural skills that improve adaptability/learning later in life

Boosting female participation in STEM fields

Promoting a culture of continuous/lifelong learning

Evaluating the effectiveness and adequacy of Canada's suite of training programs

Reforms to social and labour-market policies needed to help displaced workers and promote equal opportunity

Policy considerations

Policy should respond to actual disruptions rather than a reaction to worst-case predictions (e.g. mass unemployment)

Promoting an effective social and labour-market policies will require complementing new work arrangements brought about by disruptive technologies (e.g. platform-based gigs)

Minimizing the costs of displacement and improving re-employment will require more flexible and modern labour market policies that protect workers rather than jobs

Potential changes in the distribution of income and wealth may have implications for the tax and transfer system

Percentage point change in the share of total employment, by task category, Canada

Legend:
- 1987-2016
- 2016-2031

Categories: Routine, Non-routine manual, Non-routine cognitive

Sources: Department of Finance calculations; C.D. Howe Institute (2017); Statistics Canada, Labour Force Survey (2016); BII+E (2016).
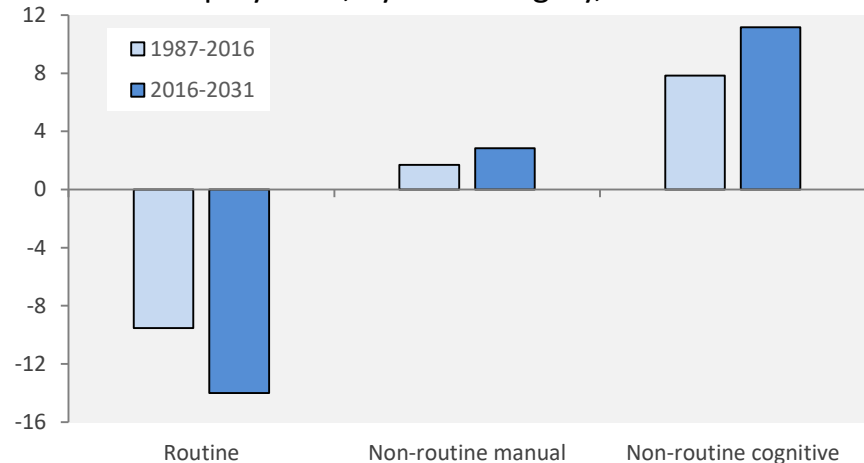
Actions to date

Modernizing employment standards to respond to changes in the nature of work

Expanding eligibility to EI regular benefits (new and re-entrants)

Promoting more equal access to post-secondary education

Boosting access to affordable housing for low-income Canadians

Potential avenues

Further adapting EI to changes in the nature of work

Ensuring benefits (e.g. pension, health, drugs, dental) are broadly accessible and portable across jobs

Promoting equity by evening the distribution of capital that is expected to capture a rising income share (e.g. public pensions)

Regulations critical to safeguarding privacy, security and competition, but may also inhibit innovation and adoption

Policy considerations

Accelerating technological change may need more adaptable and flexible regulatory system

Inherent security-privacy as well as privacy-innovation trade-offs and tensions need to be considered when designing regulations

Access to personal data is critical to AI-led growth and innovation

Regulatory burdens could inhibit innovation or new business models in industries such as health and finance

New regulations may be needed to ensure businesses have adequate cyber-defences, but could be overly burdensome

Protect sensitive and emerging technologies from illicit acquisition

The criminal justice system will need to adjust to reflect the increased social costs imposed by cybercrime

Actions to date

Canada FTA came into force in July 2017, with regulatory reform for improved interprovincial cooperation

Continuation of the Canada-US Regulatory Cooperation Council

Privacy Act review and House ETHI Committee drafting study of privacy legislation applications to commercial entities (PIPEDA)

December 2017 Growth Council recommendation on Expert Panel on Regulatory Agility under consideration

Canada's FDI regulations rank among the most restrictive in the OECD in key industries using disruptive technologies

FDI regulatory restrictiveness index

■ Canada ■ Best G7 Performer
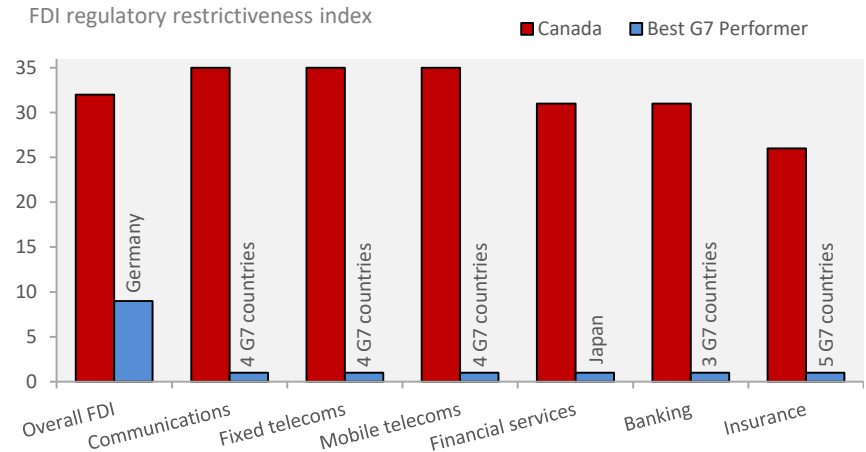
Source: OECD FDI Regulatory Restrictiveness Index. Note: Higher rank denotes more restrictive regulations. Ranking is among 35 OECD countries in 2016.

Potential avenues

Encourage government-industry personnel interchange to build government's technical capacities

Tap into end-users of goods/services to help improve regulations

Lower regulatory burden to lower business entry barriers

Accept trade-offs between competing privacy and growth goals

Foster regulatory innovation and adopt best practices for regulating high-tech/digital economy

Regulations for businesses related to cybersecurity practices

Adoption of disruptive technologies will need new infrastructure

Policy considerations

Infrastructure needs are broad: traditional physical structures, infrastructure in data space, new financial frameworks

Technological change is accelerating but it is not disrupting all infrastructure sectors in the same way or at the same rate

Differences in disruption across sectors creates uncertainty for infrastructure owners, operators and investors

New technologies may affect the stability and security of infrastructure systems

Cooperation between different levels of government will be needed to resolve obstacles limiting the adoption of new technologies to infrastructure
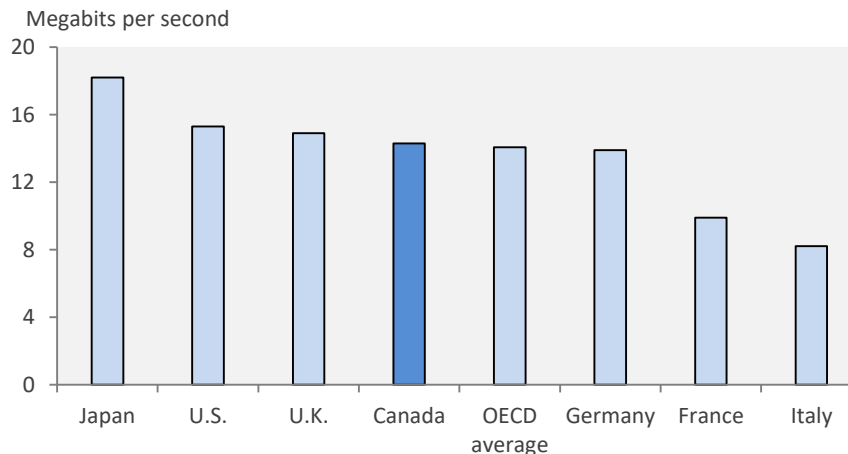
Actions to date

Canada Infrastructure Bank ready to leverage private investment to renew physical infrastructure

Smart Cities Challenge incentivising communities to develop innovative infrastructure plans

G7 and OECD average internet broadband speed, 2016

Megabits per second

Sources: Akamai (2016), "Akamai's State of the Internet Report: Q1 2016 Report."
Note: Among 35 OECD countries, Canada's average speed was 16th highest.

Potential avenues

Study the best ways to oversee new financial technologies into the financial system

Government of Canada / Gouvernement du Canada

AI and automation promise to improve governance, but adoption must be done thoughtfully and responsibly

Policy considerations

The challenges posed by new technologies are broad and require more integrated collaboration across government silos

Technical capacity within government needs upgrading to better understand and keep pace with new technologies

AI use to improve government services may introduce biased decision making to the detriment of already marginalized groups

AI based decisions need to be better understood else procedural fairness could be hindered if decisions are challenged in court

Many federal departments have not managed data appropriately while few government-wide data standards exist

Intervention in media to limit damages to governance due to fake news could see legal challenges

Government AI readiness index, 2017

Sources: Oxford Insights Notes: The Government AI Readiness Index captures the current capacity of OECD governments to absorb and exploit the potential of AI. Higher values reflects a greater degree of preparedness for AI. Among all 35 OECD countries, Canada ranked 3rd most prepared.
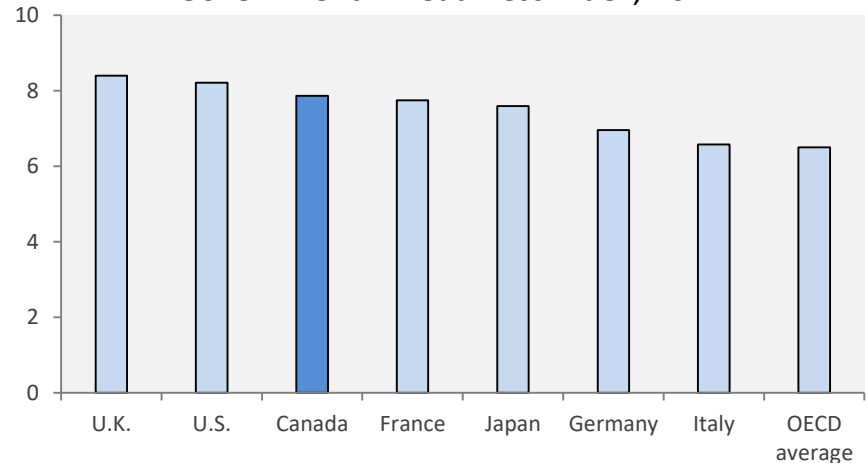
Actions to date

Various technologies in pilot or full implementation around government: Chatbots answering routine client questions, AI analytics supporting decision making

White paper commissioned to unpack policy considerations of using AI and the strategies to address these considerations

AI Task Force formed to examine legal implications of machines informing – or making – administrative decisions

Financial measures supporting better journalism (CBC funding)

Potential avenues

Drafting policy guidance to help improve data governance and help departments manage risks of using AI

Research to make AI decisions more understandable

Semantic-analysis pilots in several departments to passively gauge public reaction on social media, or to monitor consumer complaints for possible regulatory action

Funding of an independent non-profit press agency to provide news content at no charge

Canada

Tax system should support innovation and investment, while responding to potentially higher inequality and capital share

…

Policy considerations

Actions to date

Potential avenues

To be developed

Source: … Note: …
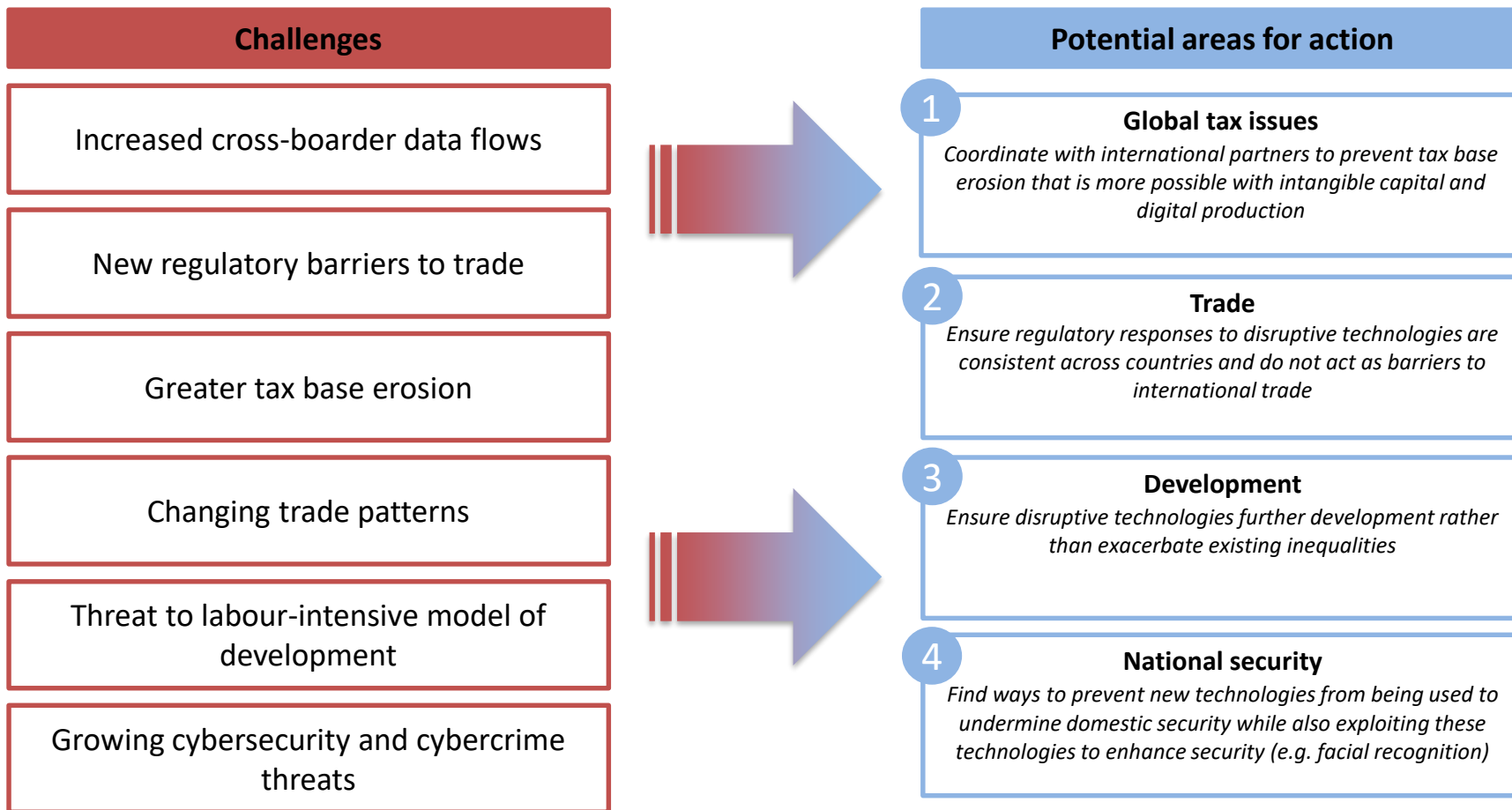
Global cooperation essential to maximizing benefits

Global agenda should focus on fostering cooperation on global tax issues, preventing regulatory barriers to trade and investment, and promoting shared security.

Challenges
Increased cross-boarder data flows
New regulatory barriers to trade
Greater tax base erosion
Changing trade patterns
Threat to labour-intensive model of development
Growing cybersecurity and cybercrime threats

Potential areas for action
1 Global tax issues *Coordinate with international partners to prevent tax base erosion that is more possible with intangible capital and digital production*
2 Trade *Ensure regulatory responses to disruptive technologies are consistent across countries and do not act as barriers to international trade*
3 Development *Ensure disruptive technologies further development rather than exacerbate existing inequalities*
4 National security *Find ways to prevent new technologies from being used to undermine domestic security while also exploiting these technologies to enhance security (e.g. facial recognition)*

Updated international tax standards are needed to prevent tax base erosion and ensure appropriate allocation of taxing rights

Policy considerations

New business models based on digitisation can lead to gaps in taxation and to tax avoidance - adjustments to international tax architecture may be required

Traditional allocation between countries of rights to tax corporate profits based on location of physical operations is challenged by digital business models that involve intensive interaction with users in a jurisdiction without a physical presence

Actions to date

Recommendations from OECD/G20 project on base erosion and profit shifting (BEPS) covered corporate tax areas relevant to digitalization including changes to transfer pricing guidelines (now adopted by Canada) which, for example, improve the framework for allocating returns from intangibles capital

Through funding of bilateral and multilateral programmes, Canada helps increase use of ICTs to facilitate taxation of the informal sector in developing countries

Potential avenues

BEPS project partners (OECD + G20 countries and others) seeking multilateral consensus on corporate tax approach to digitalisation to avoid unilateral actions that could damage growth

Canada

Emergent technologies present new opportunities, as well as risks of protectionism, and require new policy responses

Policy considerations

FTAs should keep provisions promoting cross-boarder data flows, while addressing security/privacy concerns, to facilitate innovation

FTA must address new regulations (data localization, source code access) that disguise protectionism or create regulatory divergence

International efforts must continue to discourage data protection regulations that would impede data flows

Ongoing modernization of balanced international IP standards need to continue through engagement in negotiations and policy forums

Global trade patterns will evolve as new technologies change nations' comparative advantage, e.g. lower labour costs due to automation may lead to on-shoring of manufacturing

Lower-income countries often lack capacity in trade negotiations related to new technologies, yielding unfavourable terms/exclusion
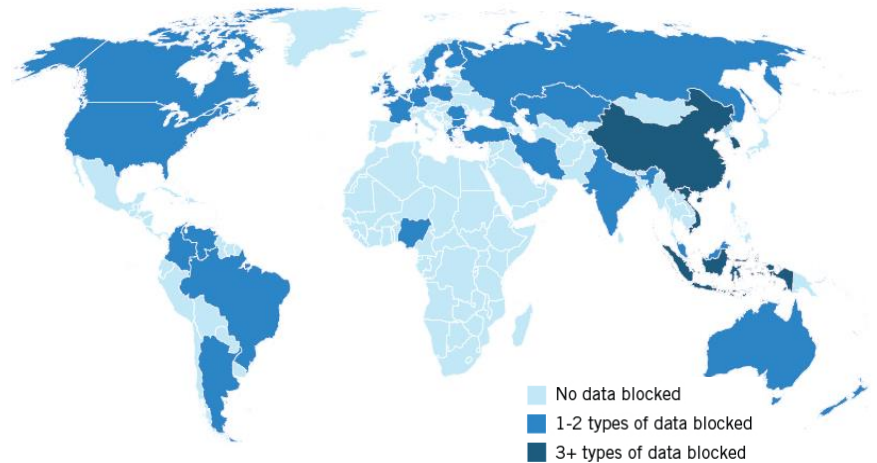
Countries with enacted data localization laws, 2017

- No data blocked
- 1-2 types of data blocked
- 3+ types of data blocked

Source: Information Technology and Innovation Foundation (2017)

Actions to date

In FTA negotiations, Canada aims to facilitate digital trade and cross-border data flows, while ensuring that legitimate privacy and security rights are protected

Canada participates in discussions of the TRIPS Council, World Intellectual Property Organization (WIPO), Asia-Pacific Economic Cooperation (APEC) and in dialogue mechanisms in FTAs

Potential avenues

Advanced economies should coordinate as well as share and promote best practices for adapting to and benefiting from new technologies, including assisting developing countries in harnessing technological disruptions

Canada to work with international partners to develop international best practices in AI

Disruptive technologies present new opportunities for innovation in the development sector but could increase disparity as digital divide persists

Policy considerations

Disruptive technologies hold potential for new, more effective and efficient solutions to persistent development challenges

Developing countries will leap frog developed countries in certain sectors such as use of e-services and tele-payments

Emergent technologies may be unevenly distributed and exacerbate existing inequalities and economic dislocation, notably as women and girls may not benefit equally from advances

New techs may allow governments/institutions to better monitor/manage development investments and make financial flows transparent, but capacity is needed

Development policies need to adapt to ways to grow that are enabled by disruptive/new technologies, and recognize when to embrace and how to measure impact of technology-based development innovation

International development promotion may change as new trade patterns displace labour-intensive development model

Actions to date

Canada committed to advancing gender equality and bridging the gender digital divide by promoting and protecting women and girls' access to and use of digital technologies without being targeted by online violence and abuse

Potential avenues

The increasing importance of partnerships and platforms for innovative development financing to complement international assistance

Empower women innovators and entrepreneurs in developing countries

Better assess the potential for transformative solutions to be identified through investments in development innovation (e.g., last-mile challenges)

International cooperation needed to limit national security threats that new technologies may enable

Policy considerations

Emerging technologies: create new national security risks that require a strong and coordinated global response; enable new malicious acts that harm national interests without crossing threshold to be considered an "attack" (IP theft harming Canadian competitiveness)

Cryptocurrencies may help circumvent sanctions, finance terrorism, buy or sell illicit products, and evade taxes

Cyber risks are increasingly becoming physical risks: Internet of Things devices, smart infrastructure, self-driving cars

Increased prevalence of cybercrimes: hacktivism, corporate espionage, ransomware attacks, cyber bank robberies, terrorist recruitment

Evidence/further study needed to define principles underpinning laws on Lethal Autonomous Weapon Systems (LAWS)

International Humanitarian Law will be key in considering LAWS

Actions to date

Cross-government cyber and economic security proposals under development

Canada ratified the Budapest Convention on Cybercrime, in an effort to increase international cooperation in this area

Continued engagement in international policy fora and domestic consultations with national experts on current state of LAWS development and development of counter-proliferation strategies

Potential avenues

Coordinated government-industry efforts to improve security related to cybersecurity management and digital literacy

Regulations for businesses related to cybersecurity management and policies promoting digital literacy and security best practices may be needed to safeguard individuals and businesses

Coordinate international information sharing and use of facial recognition to enhance global security

Promote cyber-risk insurance market to manage firms' exposure

Canada

Departmental initiatives related to disruptive technologies

ISED

- Toronto Blockchain pilot to help businesses secure permits/licenses
- STEM work through the Canadian Council of Academies

Canadian Heritage

- Automated system to approve microgrants for small organizations

CSE

- Cybersecurity (standards setting, outreach to private sector/academics, etc.) with PS and ISED

ESDC

- Canadian Occupational Projection System (COPS)
- Co-leading working group on HR Council to examine how departments should adjust to future of work

TBS

- Canadian Digital Service
- Developing principles and standards on AI
- Digital ID & Authentication Council of Canada (working to develop a DIA framework)

SSHRC

- Imagining Canada's Future

Justice

- AI Task Force examining legal implications of machines informing/making decisions

CRA

- Optical character recognition to help automate input of information related to tax payer requests options analysis established
- Proof of concept project to feasibility of robotics to automate tasks
- AI used to used to power advanced analytics to help improve compliance efforts
- Advancing Blockchain proof of concept project that would allow user to share digital identity to obtain info from banks and government
- Use Chainalysis to identify digital currency holders and seize currency to pay tax debt
- Established Digital Commerce Team to consider tax implications of digital currencies

DND

- IDEaS Program supports research to address defence and security science and technology challenges
- Workshopping assessment effects of technologies on military capabilities and developing ethics framework on application of AI in defense

IRCC

- Advanced analytics for immigration applications (e.g. Automated decision-making for low risk Chinese TRV)
- AI immigration law tool (e.g. help research, predict litigation outcomes)
- Chatbot to answer client questions and to get feedback
- *CAN GO Mobile*, efficient and secure electronic travel authorization and ePassport renewal

GAC

- Working group to design a government position on AI and human rights for international tables
- Leading a working group to design a government position on AI and human rights for international tables
- Investing in new partnerships that fund technology enabled development innovations (e.g. health)
- Engaged with like-minded donors through the International Development Innovation Alliance (IDIA) to learn from each other and build capacity for innovation in development

Transport

- Investigating Connected and Autonomous Vehicles with ISED

Canada

Medium-term planning on disruptive technologies

- **DM Committee on Inclusive Growth**

  – How to ensure the benefits of disruptive technologies are broadly shared?

- **DM Committee on Economic Trends and Policies**

  – How to harness the growth potential of disruptive technologies?

- **DM Committee on Policy Innovation**

  – How can new technologies be used to strengthen or transform policy development and delivery?

- **Deputy Minister Committee on National Security**

  – How to respond to emerging cybersecurity and counter-proliferation threats, and address the nexus between economic prosperity and national security?

- **Deputy Minister Committee on Governance**

  – How to strike a balance between privacy/security and innovation/efficiency?

Key takeaways

- New technologies will be crucial to sustaining growth and improvements in our standard of living going forward

    - Policymakers have a role in facilitating innovation and broad diffusion on new technologies

    - Great unknown: What will be the pace and scope of technological change?

- Disruptive technologies may also bring new risks and potential side effects

    - Automation of jobs and the changing nature of work

    - Increasing economic disparities

    - Anti-competitive effects

    - Threats to privacy, security and democracy

- Policymakers need to keep pace to mitigate potential risks and ensure the benefits of new technologies are broadly shared

    - This will entail timely but measured responses to actual changes rather than a reaction to potential worst-case scenarios

    - Policymakers' best defence is to protect workers rather than to protect existing jobs and sectors

    - Cooperation with businesses, P/M/T governments and international partners will be critical

Annex

Technological pessimists vs. optimists

Pessimist: The Robert Gordon View	**Optimist: The Brynjolfsson/McAffee View**
Slowing productivity growth indicates that the benefits of ICT are exhausted and technological progress is slowing	Productivity growth now doesn't reflect the current technological wave innovation nor its future acceleration

Prior technological revolutions led to major improvements in productivity and wellbeing that cannot be repeated

- The increase in speed of travel from going from horse to jet plane may not happen again

- All benefits from indoor climate control and plumbing have been exhausted

- The greatest strides in infection control have been made with basic antibiotics

Technological advancement is slowing and is producing innovations with more modest productivity impacts

- Technology continues to improve productivity but only in small parts of the economy (e.g. manufacturing)

- Innovation has recently been focused on a succession of incremental improvements in entertainment and communication devices

The slowdown in productivity growth may not reflect decreasing technological innovation

- Aspects of current progress are not reflected in GDP (e.g. peer-to-peer and zero-priced digital services)

- Productivity gains from general purpose technologies, like those of ICT, tend to arrive in waves

- There is often a significant lag between when innovations arrive and when their benefits show up in the productivity statistics

In the near future, technological progress will accelerate to unprecedented rates

- AI has only recently shown success in unfamiliar tasks and progress in the field is expected pick-up

- As new technologies recombine with each other, they are expected to have a greater impact compared to the technologies of the first machine age

Canada

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Several factors will prevent mass unemployment

Barriers to adoption will slow the pace and scope of technological diffusion, preventing large disruptions, while long-standing adjustment mechanisms will promote the creation of new jobs

|	
Barriers to adoption across firms	Estimated job losses presume that automation will displace workers as soon as technologically feasible, but there are several social, legal and economic barriers that will slow adoption • Societal preferences for the provision of certain tasks by human workers • Ethical or legal hurdles to the utilization of new technologies • Firms' decisions to automate depend on a number of factors: firm size, competitive pressure, the actual capabilities of new technologies, the availability of qualified personnel, and, more importantly, the relative cost of machines over human labour
Adjustment of workplace tasks	Even if new technologies are widely adopted across firms, the impact on job losses depends on how workplaces adjust to the new division of labour • Machines will be able to replace humans in many routine tasks, but will struggle to replace humans in tasks involving high-level reasoning, flexibility and adaptability, creativity, and social intelligence • New technologies will increase the productivity of workers with complementary skills that cannot be performed by machines, increasing demand for their services in the labour market • Firms will also need new workers to implement and oversee automated systems
Macroeconomic adjustment process	Estimated job losses do not account for new jobs created by new technologies or macroeconomic feedback mechanisms that may also lead to an increase in labour demand • The production of new technologies will create new jobs and industries • By improving productivity and reducing costs, automation will lead to lower prices, leading to an increase in demand for products and, in turn, higher employment • By increasing profits and demand for workers with complementary skills, automation will lead to a further increase in economic activity and employment

Canada

Canada lags in active labour market program investment

Canada may need to increase its active labour market programing and the effectiveness of these programs in order to facilitate re-employment for individuals displaced by automation

Government spending on training programs as a share of GDP, selected OECD countries, 2015
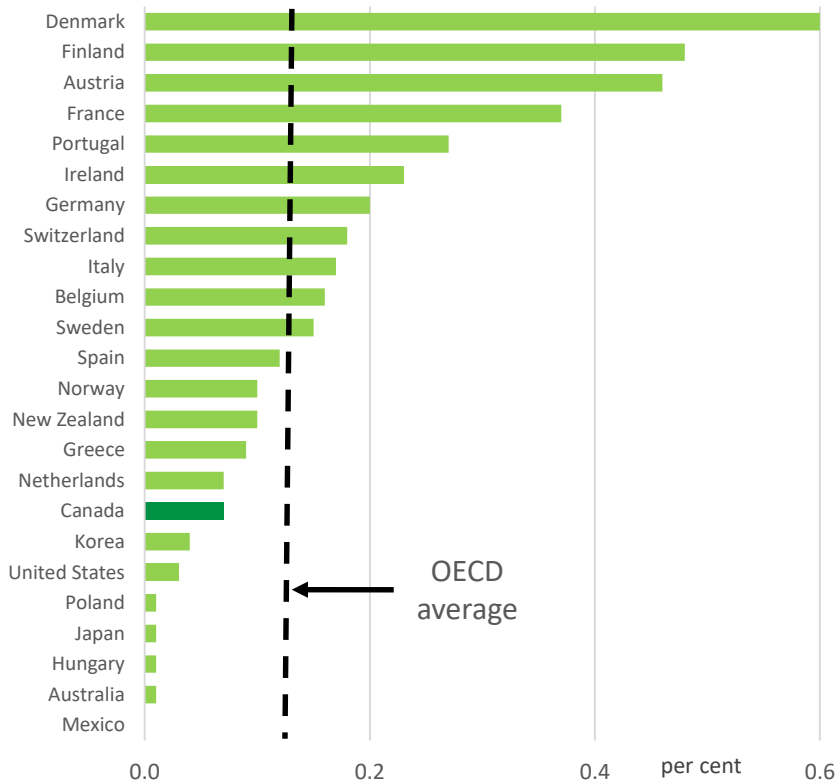
Share of labour force participating in publicly funded institutional training, selected OECD countries, 2015
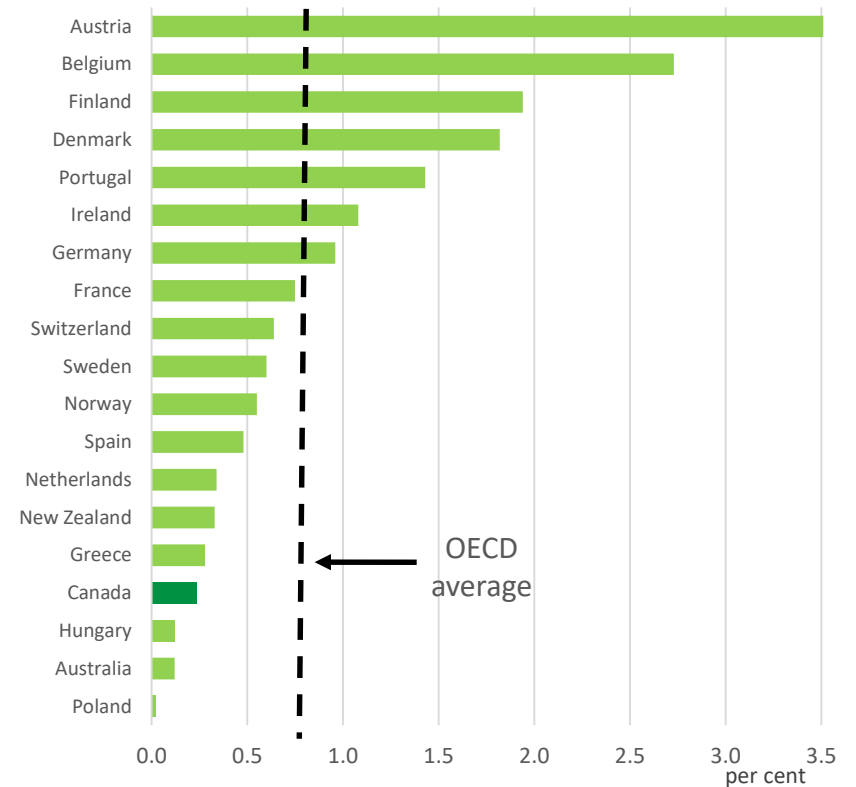
Sources: OECD Education at a Glance (stats.oecd)
Notes: Expenditures are for 2015 or the latest year available.

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We are facing transformative changes due to new and emerging technologies in the transportation sector

Technological and social mega-trends are poised to reshape the way in which people and goods will move in the future

Series of converging mega-trends that also reinforce one another…

- Automation
- Electrification
- Connectivity / Digitalization
- Diverse and Shared Mobility
- Artificial Intelligence

…are leading to promising technology clusters forming around:

- **Vehicles** – automated, connected and zero emissions
- **Infrastructure** – physical, digital and energy
- **Users** – mobility-as-a-service and on-demand transportation

New technologies are inspiring innovation and adoption, resulting in changes to the status-quo:

- New technology-driven solutions and software-driven innovation
- New entrants and spurring new business models/arrangements (e.g. Waymo's self-driving car; Ford's partnership with Lyft)
- Data-driven, user-centered paradigm (with a growing emphasis on analytics and physical assets connected to the Internet of Things via sensor technologies and digitally connected citizens)
- Confluence of ride-hailing and sharing
- Potential for large-scale shifts in freight and parcel delivery services (e.g. Uber Freight, Amazon drone delivery)
- Movement towards smart cities to address urban transportation challenges (e.g. Sidewalk Labs Toronto's port-lands development)
- Need for smart infrastructure to enable wider adoption
- Transition to alternative energy options and supporting energy infrastructure
- Shifts in consumer preferences and public acceptance
- Bold and visionary ideas (e.g. Hyperloop)

Canada

Modernizing Canada's transportation system

- Connected and Automated Vehicles (CV/AV) and Unmanned Aircraft Systems (UAS) are among the biggest innovations in transportation with far-reaching implications
  - Provides significant opportunities for innovation, job creation, investment attraction and growth
  - Strong linkages to Transportation 2030, Innovation and Skills Agenda, Infrastructure Plan, and Smart Cities Challenge

- All countries are trying to figure out policy and legal issues. The challenge for policymakers will be ensuring that policy frameworks and institutions are responsive and flexible – but with a great deal of complexity given that:
  - CV/AV and UAS touch on a broad range of economic and social impacts (which go beyond transportation)
  - Effects of wide-spread adoption are both positive and negative
  - Substantial uncertainty remains about commercialization timelines (especially for CV/AV) – the general consensus that the development of fully automated vehicles and their complete market penetration may take decades

- We are entering a phase where the public will require assurance that these vehicles will be safe on public roads; positive signaling from governments can help spur innovation and deployment

- Through Budget 2017, Transport Canada received funding to:
  - Develop regulations for the safe adoption of CV/AV and UAS
  - Work with industry, provinces, territories and municipalities to establish pilot projects
  - Provide the standards and certifications for industry to safely deploy these technologies in Canada

- Canada has niche areas in CV/AV and UAS where we can provide leadership but will need to ensure a sharp focus on achieving results (e.g. ICT, AI, human factors, and inclement weather)

TAB 2

CANADA

Strong economic growth in the first half of 2017 is set to ease in coming quarters. Growth has been led by household consumption, which should slow as rapid job growth and wealth effects from house price appreciation abate. Earlier robust export increases have weakened substantially, in part because of the stronger Canadian dollar. Consumer price inflation is expected to reach 2% in 2019, as remaining spare capacity is exhausted and exchange rate effects dissipate.

Interest rate rises this year have reduced monetary stimulus. Additional increases are projected in order to stabilise inflation around the midpoint of the 1-3% official target range. Mildly expansionary fiscal policy has supported growth in 2016 and 2017, hastening the economy's return to full employment. However, delays have limited the benefits from planned increases in infrastructure spending. Modest fiscal tightening is projected in 2019, consistent with an absence of spare capacity at that stage of the cycle.

High house prices and associated debt levels remain a substantial financial vulnerability. A disorderly correction would adversely impact growth and could threaten financial stability. The federal government has responded with a number of macro-prudential measures. Provincial government measures have also temporarily slowed house price growth, but some – notably Ontario's expanded rent controls – risk discouraging the supply of new housing. Macro-prudential policies will need to be tightened further if rapid increases in house prices and debt resume.

## *Robust economic growth has strengthened the labour market*

The economy has grown strongly in recent quarters. Adjustment to the fall in commodity prices that commenced in mid-2014 is now complete, with the energy sector rebound boosting growth. Private consumption is expanding solidly, supported by wealth gains from house price appreciation, rapid job growth and accommodative monetary policy. Robust growth in merchandise export volumes reversed course with three

Canada

Robust growth is reducing unemployment
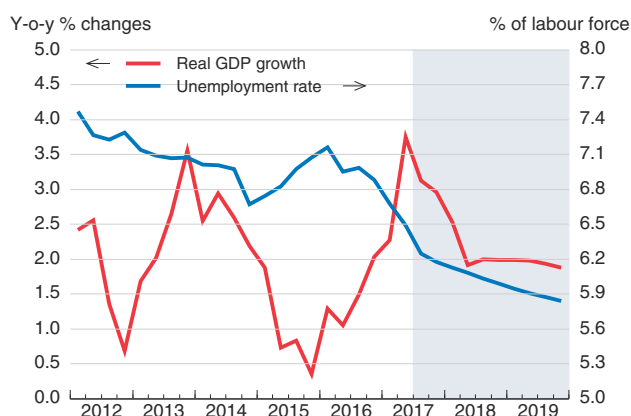
Rapid house price growth has begun to slow
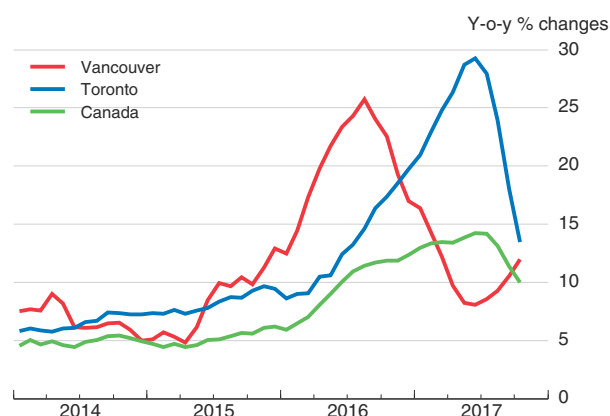
Source: OECD Economic Outlook 102 database; Teranet and National Bank of Canada, House Price Index.

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Canada: **Demand and output**

	2014	2015	2016	2017	2018	2019
	Current prices CAD billion	Percentage changes, volume (2007 prices)				
GDP at market prices	1 983.1	0.9	1.5	3.0	2.1	1.9
Private consumption	1 110.3	1.9	2.3	3.8	2.8	1.9
Government consumption	405.4	1.5	2.0	1.5	1.2	0.5
Gross fixed capital formation	479.4	-4.6	-3.1	2.3	3.8	2.5
Final domestic demand	1 995.1	0.3	1.0	3.0	2.7	1.7
Stockbuilding[1]	8.3	-0.3	-0.2	0.7	-0.1	0.0
Total domestic demand	2 003.4	0.0	0.8	3.6	2.6	1.7
Exports of goods and services	626.3	3.4	1.0	1.7	1.9	4.1
Imports of goods and services	646.6	0.3	-0.9	3.7	3.6	3.2
Net exports[1]	- 20.3	1.0	0.6	-0.7	-0.6	0.2
Memorandum items						
GDP deflator	_	-0.8	0.6	2.4	2.3	2.0
Consumer price index	_	1.1	1.4	1.5	1.9	2.0
Core consumer price index[2]	_	2.2	1.9	1.1	1.4	2.0
Unemployment rate (% of labour force)	_	6.9	7.0	6.4	6.1	5.9
Household saving ratio, net (% of disposable income)	_	4.8	4.9	3.9	3.1	3.5
General government financial balance (% of GDP)	_	-1.1	-1.9	-1.6	-1.4	-1.1
General government gross debt (% of GDP)	_	98.4	99.1	97.4	97.6	97.6
Current account balance (% of GDP)	_	-3.4	-3.3	-3.1	-3.3	-3.1

1. Contributions to changes in real GDP, actual amount in the first column.
2. Bank of Canada definition: consumer price index excluding eight of the most volatile components and the effects of changes in indirect taxes on the remaining components.
Source: OECD Economic Outlook 102 database.

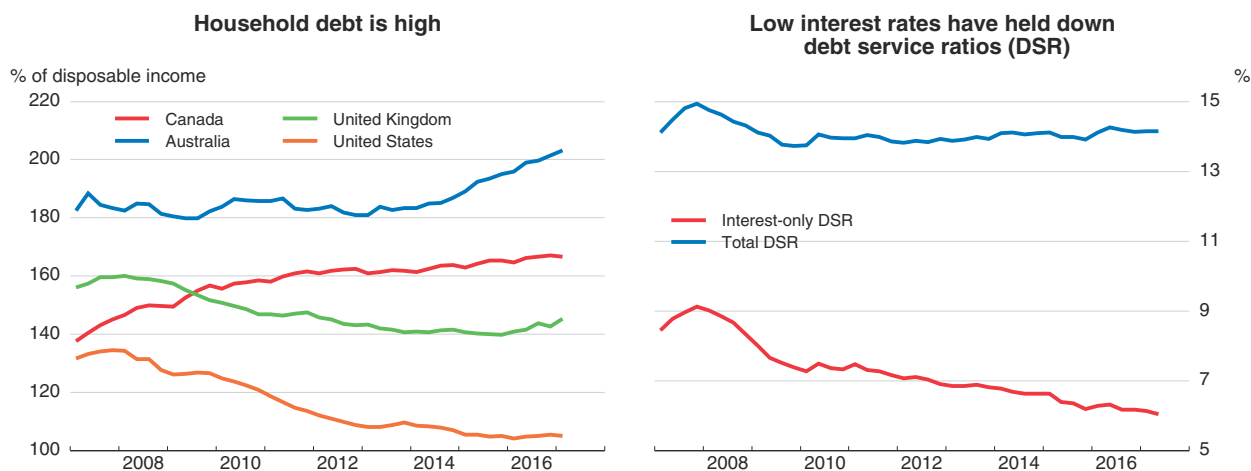*StatLink* ⌷⌸⌷ *http://dx.doi.org/10.1787/888933632387*

successive monthly declines between June and August, contributing to an expectation of more moderate GDP growth in the third quarter. Forward-looking indicators suggest that investment activity will remain firm but grow more gradually than in the first half of 2017. Machinery and equipment investment expectations reached their highest level since 2010 during the first quarter, but have since returned closer to the historical average. The number of housing starts has plateaued, consistent with housing investment remaining elevated as a share of GDP but growing more slowly than in recent years.

The unemployment rate is down by three-quarters of a percentage point from a year earlier, and more people are coming into the labour force. Wage increases are still weak but are beginning to pick up, reaching around 2% over the past 12 months. Consumer price inflation remains below the mid-point of the Bank of Canada's 1-3% target range, with the Bank's preferred measures of core inflation between 1.5% and 1.8%. Consumer price inflation excluding volatile items is below 1%, driven lower by the effect of recent exchange rate appreciation on import prices.

Macroeconomic policy tightening is appropriate

Some monetary stimulus has been withdrawn through interest rate increases in July and September 2017, and the effective exchange rate appreciated 8.5% between May and September. More rate rises are likely to be necessary with excess capacity projected to be

Canada

Household debt is high

% of disposable income

Low interest rates have held down debt service ratios (DSR)

%

Canada — United Kingdom
Australia — United States

Interest-only DSR
Total DSR

Source: OECD, National Accounts - Household Dashboard database; Statistics Canada, Selected Indicators - Household, Table 380-0073.

StatLink *http://dx.doi.org/10.1787/888933631304*

used up by mid-2018. Rising mortgage rates and cooling in the Toronto market following the introduction in April of Ontario's Fair Housing Plan, which included a foreign buyers' transaction tax, contributed to an easing in national price pressures. However, the recent resumption of price escalation in Vancouver, despite the introduction of a similar tax in August 2016, raises the possibility that the cooling in Toronto might be temporary. Ontario's Plan also expanded rent controls, which risk exacerbating medium-term housing market pressures by discouraging the supply of new rental housing. The most recent round of macro-prudential tightening (which comes into effect from January 2018) focuses on uninsured loans, which now constitute almost half of outstanding loans. While all uninsured loans require a minimum 20% deposit, their riskiness has increased as measured by the share of borrowers with high debt-to-income ratios.

The federal government's fiscal stance is mildly expansionary, with the general government deficit expanding on a cyclically adjusted basis in 2016 and 2017. However, the Parliamentary Budget Officer has estimated that only about half of the overall budgeted federal infrastructure stimulus was actually spent in the 2016-17 fiscal year. These delays are assumed to be recovered by the end of 2019. Some fiscal consolidation is projected for 2019 based on forward estimates in federal and provincial budgets, which will be appropriate if solid growth continues. Policy action is needed to address affordability and quality issues in childcare, which contribute to a large (29%) gender earnings gap for women aged 25 to 44 with children. Increased spending announced in the 2017 federal budget is a good first step in this regard.

Growth is projected to ease

Economic growth is projected to ease as private consumption and government spending slows. Recent strong private consumption gains have not been supported by commensurate increases in wages and thus are set to ease with further interest rate rises, slowing job growth, the absence of further substantial increases in government transfers and house price appreciation that is assumed to return to a more historical average annual rate of around 3% in real terms. Investment will be supported by capacity constraints,

recent oil price increases, high profitability and low, but increasing, financing costs. Export growth will, however, be constrained over the next few quarters by exchange rate appreciation but should subsequently be driven higher by strengthening global demand, including a pick-up in US investment. Declines in unemployment are likely to moderate along with growth.

A disorderly housing market correction would push growth sharply lower through weaker residential investment, household wealth and private consumption. A sufficiently large shock could even threaten financial stability. Conversely, a resumption of rapid house price growth would boost growth, at least in the short-term. There are risks to trade from the ongoing renegotiation of the North American Free Trade Agreement and also from increases in specific barriers, such as countervailing duties imposed by the United States on certain Canadian products. Faster growth is possible if private consumption gains do not slow to the extent anticipated or if business investment and export growth remain high as part of a stronger synchronised global upturn.

TAB 3

Biotech R&D in the business enterprise sector as a % of total business enterprise R&D, selected countries, 2006-15

Percentages
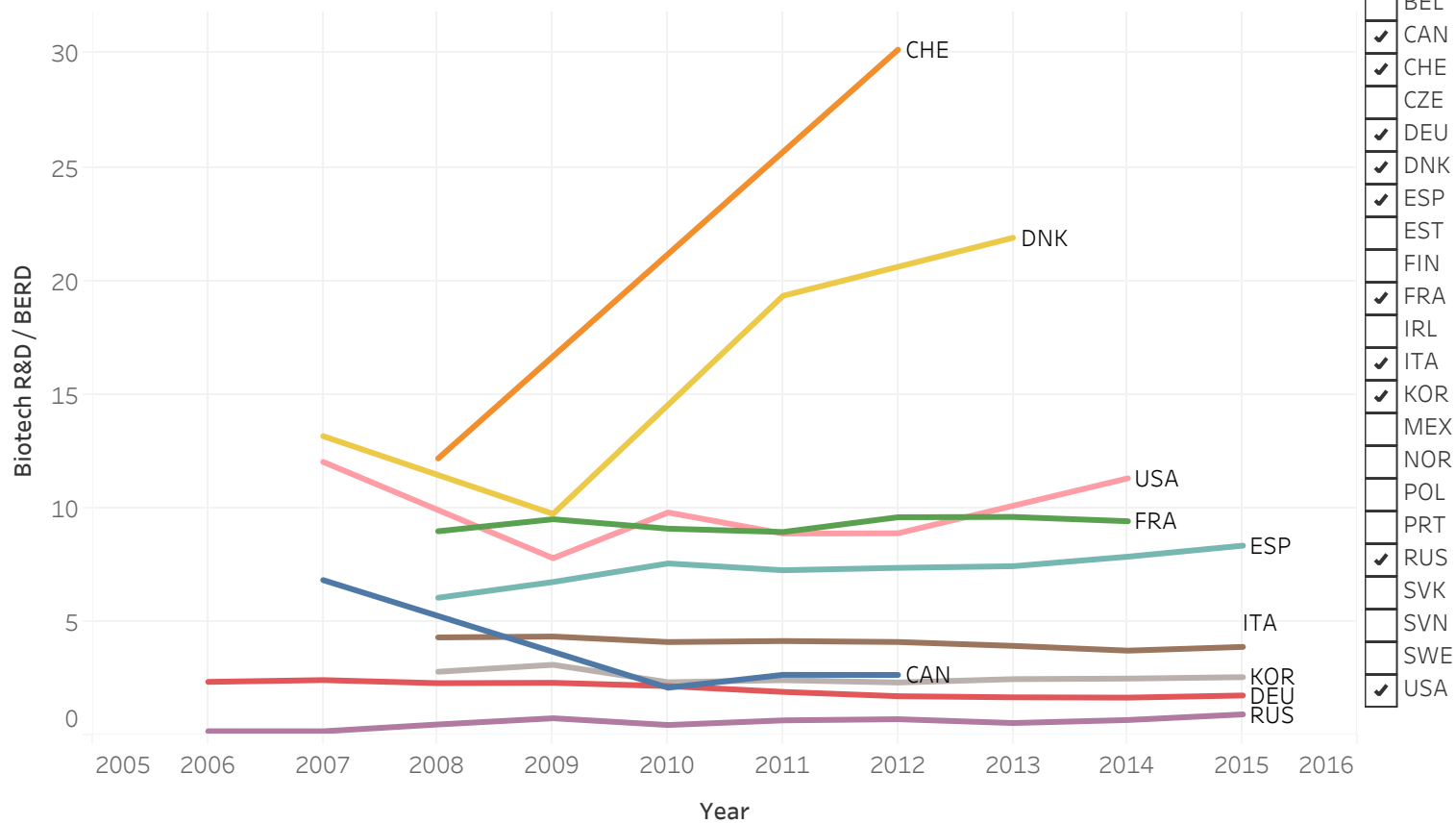
Biotech R&D / BERD

0.184992839 to 30.179319343

Source: OECD, Key Biotechnology Indicators, http://oe.cd/kbi; and OECD, Main Science and Technology Indicators Database, http://oe.cd/msti, May 2017.

TAB 4

THE ECONOMIC IMPACT OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence is fundamentally transforming how our world works.

AI's impact will be felt almost everywhere — and the global economy will get a $15.7 trillion boost from AI as it shapes entire industries.

But what is the scope of AI technology, and what can it accomplish?

A BRIEF OVERVIEW OF AI

ARTIFICIAL INTELLIGENCE (AI)
A branch of computer science that aims to create intelligent machines that can mimic human decision-making processes.
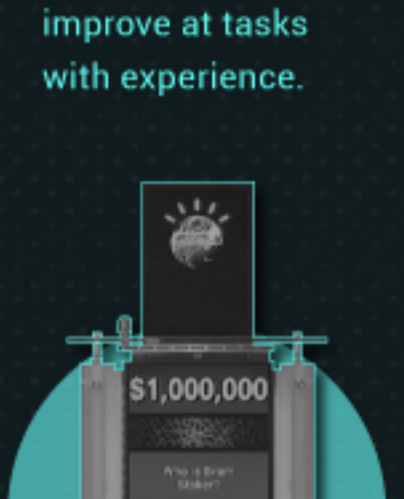
MACHINE LEARNING (ML)
Machines take data and "learn" for themselves, allowing them to improve with experience.

DEEP LEARNING (DL)
Multilayered neural networks are exposed to vast amounts of data, training machines to solve any problem which requires "thought".

1956
The term Artificial Intelligence is first coined by John McCarthy.
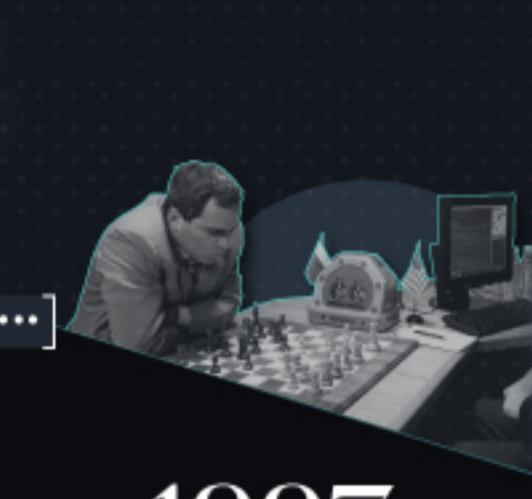
1997
IBM's Deep Blue Computer beats Russian chess master Garry Kasparov (AI)

2011
IBM's Watson beats human players on US game show Jeopardy. (ML)
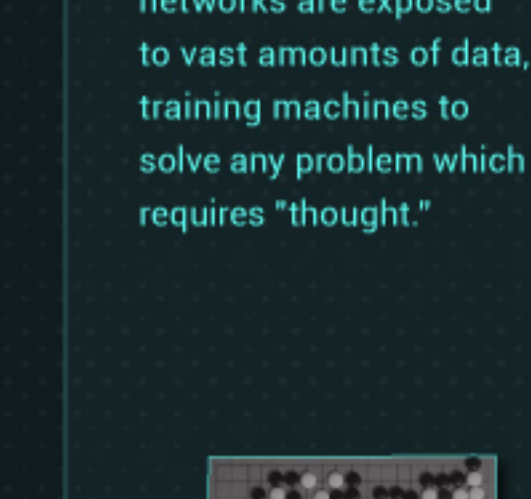
2016
Google's AlphaGo beats boardgame Go master Lee Sedol (DL)

> "Just as 100 years ago electricity transformed industry after industry, AI will now do the same."
> — **ANDREW NG**
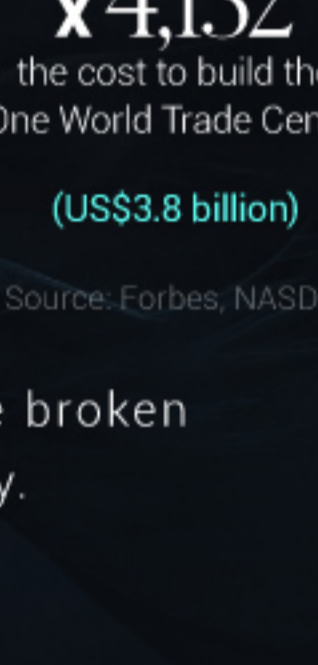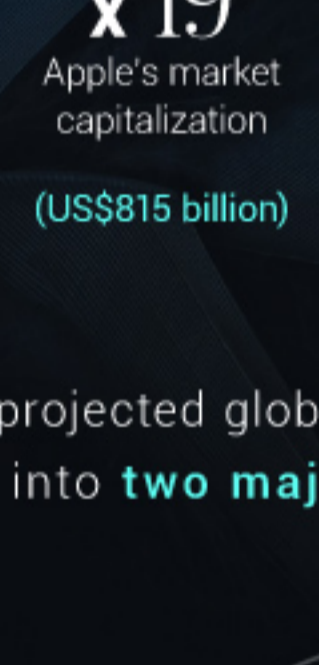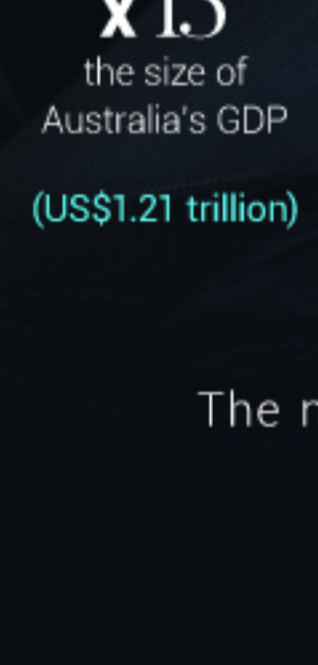> Former chief scientist at Chinese web service company Baidu

AI has achieved some incredible feats. But how do these translate into economic growth?

A report by PwC sees AI **as the biggest commercial opportunity** in today's fast-paced world.

By 2030, Artificial Intelligence will add **$15.7 trillion** to the global economy.

That's roughly:

x13 the size of Australia's GDP (US$1.21 trillion)

x19 Apple's market capitalization (US$815 billion)

x186 Bill Gates' net worth (US$84.6 billion)

x4,132 the cost to build the One World Trade Center (US$3.8 billion)

Source: Forbes, NASDAQ

The massive projected global economic increase can be broken down into **two major impacts** of AI technology.

LABOR PRODUCTIVITY IMPROVEMENTS $6.6 TR

GLOBAL ECONOMIC IMPACT $15.7 TR

INCREASED CONSUMER DEMAND $9.1 TR

The complex web of AI is made up of many threads.

Which regions of the world will benefit the most from AI?

AI'S TRANSFORMATIVE POTENTIAL

Projected Global Economic Effects of AI by 2030

CHINA'S AI ASPIRATIONS
- China aims to lead the world in AI technologies by 2030.
- The Chinese government to build a US$16 billion AI market by 2018.
- However, by 2030, AI will generate an impressive 26% boost to GDP.

Source: CNBC, Techcrunch, PwC

NORTH AMERICA $3.7 TR

NORTHERN EUROPE $1.8 TR

CHINA $7 TR

SOUTHERN EUROPE $0.7 TR

LATIN AMERICA $0.5 TR

DEVELOPED ASIA $0.9 TR

REST OF WORLD $1.2 TR

Source: PwC

> "No sector or business is in any way immune from the impact of AI."
> — **GERARD VERWEIJ**
> Global Data & Analytics Leader, PwC

The four sectors which stand to reap the most out of adopting AI technology are:

PROFESSIONAL SERVICES
Baseline 2035e* $7.5 TR
2035e** $8.3 TR

MANUFACTURING
Baseline 2035e* $12.2 TR
2035e**

FINANCIAL SERVICES
Baseline 2035e* $3.4 TR
2035e** $4.6 TR

WHOLESALE & RETAIL
Baseline 2035e* $6.2 TR
2035e** $8.4 TR

*"Baseline" = Estimated growth without AI in 2035e
**"2035e" = Estimated growth with AI in 2035e
Source: Accenture

The machines might not be taking over just yet, but they're certainly taking the world by storm.

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- The Future of Health
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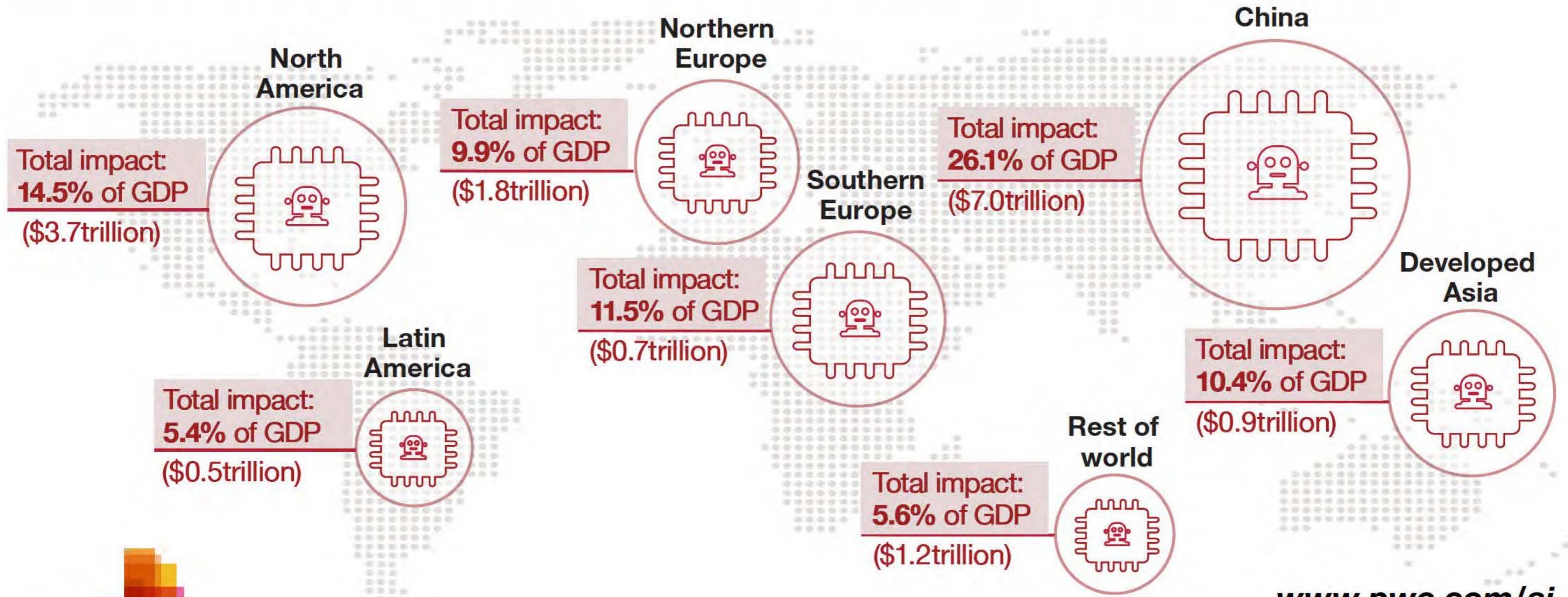**EXTRAORDINARYFUTURE.COM**
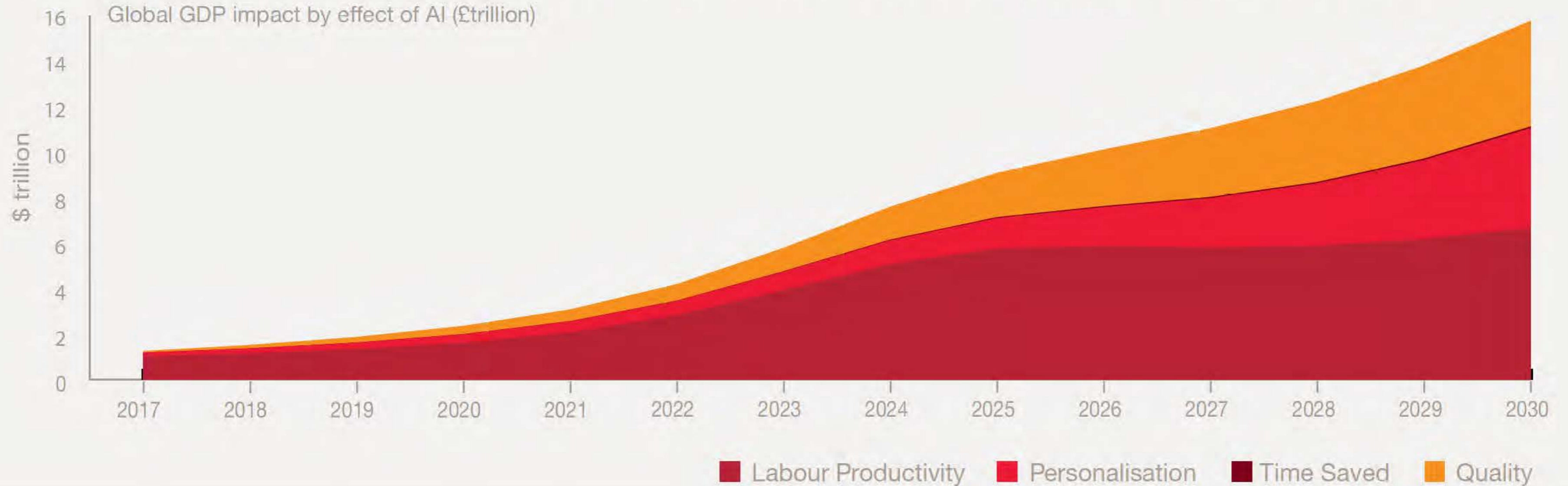
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TAB 5

Sizing the prize – Which regions gain the most from AI?

North America

Total impact:
14.5% of GDP
($3.7trillion)

Northern Europe

Total impact:
9.9% of GDP
($1.8trillion)

Southern Europe

Total impact:
11.5% of GDP
($0.7trillion)

China

Total impact:
26.1% of GDP
($7.0trillion)

Developed Asia

Total impact:
10.4% of GDP
($0.9trillion)

Latin America

Total impact:
5.4% of GDP
($0.5trillion)

Rest of world

Total impact:
5.6% of GDP
($1.2trillion)

www.pwc.com/ai

#AIrevolution

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Sizing the prize – Where will the value gains come from?

Global GDP impact by effect of AI (£trillion)

$ trillion (y-axis: 0, 2, 4, 6, 8, 10, 12, 14, 16)

(x-axis: 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030)

■ Labour Productivity ■ Personalisation ■ Time Saved ■ Quality

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Sizing the prize – What's the potential for AI to impact your sector?

Healthcare: 3.7

38% 23% 40%

Automotive: 3.7

35% 47% 18%

Financial Services: 3.3

41% 59% 0%

Transportation and Logistics: 3.2

42% 42% 17%

Technology, Communications and Entertainment: 3.1

48% 36% 17%

Retail: 3.0

54% 38% 8%

Energy: 2.2

39% 44% 17%

Manufacturing: 2.2

14% 83% 3%

● % Adoption Maturity - Near Term (0-3 yr)

● % Adoption Maturity - Mid Term (3-7 yr)

● % Adoption Maturity - Long Term (7+ yr)
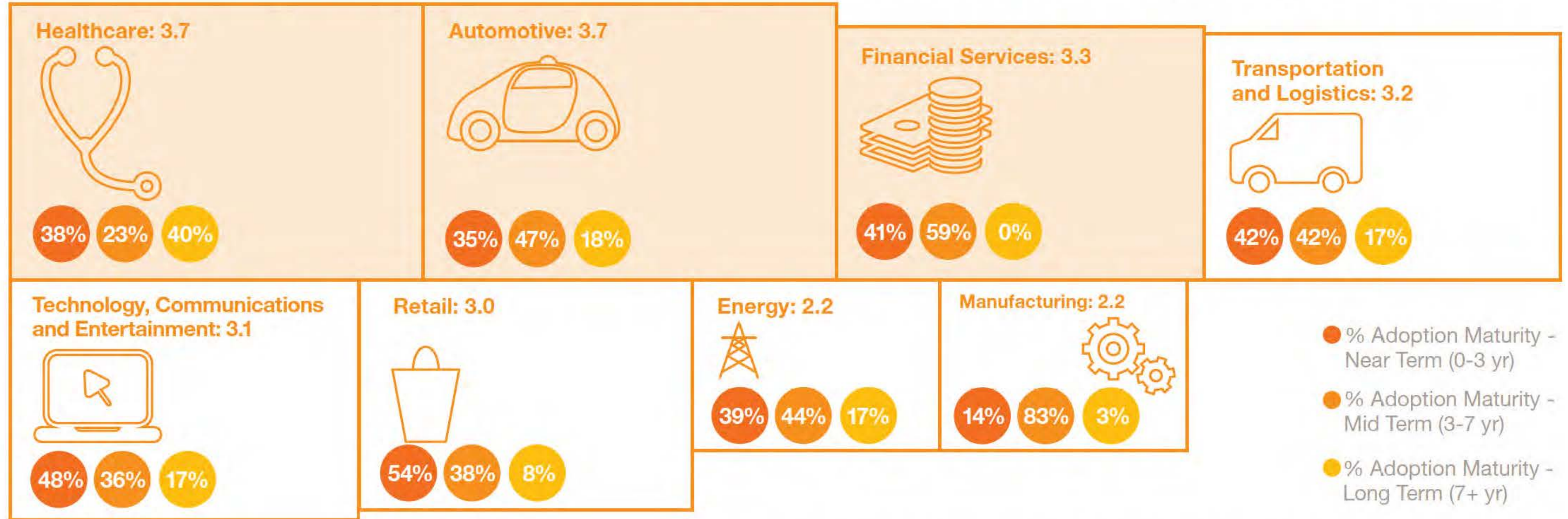
Scores based on PwC's AI Impact Index evaluation. Potential scores range from 1-5, with 5 indicating the highest potential impact due to AI, and 1 being the lowest.

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TAB 6

How blockchains could change the world

May 2016

Ignore Bitcoin's challenges. In this interview, Don Tapscott explains why blockchains, the technology underpinning the cryptocurrency, have the potential to revolutionize the world economy.

What impact could the technology behind Bitcoin have? According to Tapscott Group CEO Don Tapscott, blockchains, the technology underpinning the cryptocurrency, could revolutionize the world economy. In this interview with McKinsey's Rik Kirkland, Tapscott explains how blockchains—an open-source distributed database using state-of-the-art cryptography—may facilitate collaboration and tracking of all kinds of transactions and interactions. Tapscott, coauthor of the new book *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World*, also believes the technology could offer genuine privacy protection and "a platform for truth and trust." An edited and extended transcript of Tapscott's comments follows.

Interview transcript

In the early 1990s, we said the old media is centralized. It's one way, it's one to many; it's controlled by powerful forces, and everyone is a passive recipient. The new web, the new media, we said, is one to one, it's many to many; it's highly distributed, and it's not centralized. Everyone's a participant, not an inert recipient. This has an awesome neutrality. It will be what we want it to be, and we can craft a much more egalitarian, prosperous society where everyone gets to share in the wealth that they create. Lots of great things have happened, but overall the benefits of the digital age have been asymmetrical. For example, we have this great asset of data that's been created by us, and yet we don't get to keep it. It's owned by a tiny handful of powerful companies or governments. They monetize that data or, in the case of governments, use it to spy on us, and our privacy is undermined.

What if there were a second generation of the Internet that enabled the true, peer-to-peer exchange of value? We don't have that now. If I'm going to send some money to somebody else, I have to go through an intermediary—a powerful bank, a credit-card company—or I need

a government to authenticate who I am and who you are. What if we could do that peer to peer? What if there was a protocol—call it the trust protocol—that enabled us to do transactions, to do commerce, to exchange money, without a powerful third party? This would be amazing.

Several years ago, an unknown person or persons named Satoshi Nakamoto came up with the Bitcoin protocol. Once again, the technology genie has been unleashed from its bottle. It gives us another kick at the can, another go, to try and rethink the economic power grid and the old order of things. That, to me, is how big this is. It feels like 1993.

How the blockchain works

The blockchain is basically a distributed database. Think of a giant, global spreadsheet that runs on millions and millions of computers. It's distributed. It's open source, so anyone can change the underlying code, and they can see what's going on. It's truly peer to peer; it doesn't require powerful intermediaries to authenticate or to settle transactions.

It uses state-of-the-art cryptography, so if we have a global, distributed database that can record the fact that we've done this transaction, what else could it record? Well, it could record any structured information, not just who paid whom but also who married whom or who owns what land or what light bought power from what power source. In the case of the Internet of Things, we're going to need a blockchain-settlement system underneath. Banks won't be able to settle trillions of real-time transactions between things.

So this is an extraordinary thing. An immutable, unhackable distributed database of digital assets. This is a platform for truth and it's a platform for trust. The implications are staggering, not just for the financial-services industry but also right across virtually every aspect of society.

Most blockchains—and Bitcoin is the biggest—are what you call permission-less systems. We can do transactions and satisfy each other's economic needs without knowing who the other party is and independent from central authorities. These blockchains all have a digital currency of some kind associated with them, which is why everybody talks about Bitcoin in the same breath as the blockchain, because the Bitcoin blockchain is the biggest.

But to me, the blockchain, the underlying technology, is the biggest innovation in computer science—the idea of a distributed database where trust is established through mass collaboration and clever code rather than through a powerful institution that does the authentication and the settlement.

The way it works is, if I owe you $20, we do the transaction. There's a huge community called miners, and they have a powerful computing resource. Some people have estimated that the entire computing power of Google would be 5 percent of this blockchain-computing power, for the Bitcoin blockchain. That platform solves this big, big problem called the double-payment problem. If I send you an MP3 file and I send it to somebody else, it's a problem for the record industry, but it's not a massive problem. If I send you $20, and I send the same file to somebody else, that's a big problem. It's called fraud, and the economy stops if you have a monetary

system based on that. What happens is, I send you the $20, and these miners, to make a long story short, go about authenticating that the transaction occurred.

Each miner is motivated to be the first one to find the truth, and once you find the truth, it's evidence to everybody else. When you find the truth and you solve a complex mathematical problem, you get paid some money, some Bitcoin. For me to hack that and try and send the same money to somebody else, or for me to come in and try and take your $20 worth of Bitcoins, is not practically possible because I'd have to hack that ten-minute block. That's why it's called blockchain, and that block is linked to the previous block, and the previous block—ergo, chain. This blockchain is running across countless numbers of computers. I would have to commit fraud in the light of the most powerful computing resource in the world, not just for that ten-minute block but for the entire history of commerce, on a distributed platform. This is not practically feasible.

So, sure, there have been lots of problems with Bitcoin. You had big exchanges like Mt. Gox fail. You had the Silk Road, where Bitcoin was the payment system for all kinds of horrific, illegal activity. But don't be confused by that. Many people make the mistake of thinking, "Bitcoin? Well, that's an asset. Should I invest? Is it going to go up or down?" Well, that's not of interest to me, just like speculating in gold is not of interest to me.

Something that's of bigger interest is Bitcoin as a digital currency that enables us to do these kinds of transactions. A cryptocurrency that's not based on nation-states. The most important thing that we focus on in our work, is the much bigger question, this underlying, distributed-database technology that enables us to have a truthful and immutable record of everything.

How disruption can occur

The financial-services industry is up for serious disruption—or transformation, depending on how it approaches this issue. For the research for *Blockchain Revolution*, we went through and identified eight different things that the industry does: it moves money, it stores money, it lends money, it trades money, it attests to money, it accounts for money, and so on.

Every one of those can be challenged.

You pick any industry, and this technology holds huge potential to disrupt it, creating a more prosperous world where people get to participate in the value that they create. The music industry, for example, is a disaster, at least from the point of view of the musicians. They used to have most of the value taken by the big labels. Then, along came the technology companies, which took a whole bunch of value, and the songwriters and musicians are left with crumbs at the end. What if the new music industry was a distributed app on the blockchain, where I, as a songwriter, could post my song onto the blockchain with a smart contract specifying how it is to be used?

Maybe as a recording artist posting my music on a blockchain music platform, I'll say, "You listen to the music, it's free. You want to put it in your movie? It's going to cost you this much,

and here's how that works. You put it in the movie, the smart contract pays me." Or how about using it for a ring tone? There's the smart contract for that.

This is not a pipe dream. Imogen Heap, who's a brilliant singer-songwriter in the United Kingdom, a best-selling recording artist, has now been part of creating Mycelia, and they're working with an amazing company called Consensus Systems, that's all around the world, blockchain developers, using the Ethereum platform; Ethereum is one blockchain. She has already posted her first song onto the Internet. I fully expect that many big recording artists will be seriously investigating a whole new paradigm whereby the musicians get compensated for the value that they create.

What could go wrong?

I'm not a futurist. I think the future's not something to be predicted—it's something to be achieved. What we're arguing is that this technology is revolutionary and holds vast potential to change society.

What could go wrong? We identified ten showstoppers and we went through them in detail in our research and in the book. There are showstoppers such as the energy that's consumed to do this, which is massive. Another showstopper is that this technology is going to be the platform for a lot of smart agents that are going to displace a lot of humans from jobs. Maybe this whole new platform is the ultimate job-killer.

The biggest problems, though, have to do with governance. Any controversy that you read about today is going to revolve around these governance issues. This new community is in its infancy. Unlike the Internet, which has a sophisticated governance ecosystem, the whole world of blockchain and digital currencies is the Wild West.

It's a place of recklessness and chaos and calamity. This could kill it if we don't find the leadership to come together and to create the equivalent organizations that we have for governance of the Internet. We have the Internet Engineering Task Force, which creates standards for the Net. We have Internet Governance Forum, which creates policies for governments. We have the W3C Consortium, which creates standards for the Web. There's the Internet Society; that's an advocacy group. There's the Internet Corporation for Assigned Names and Numbers (ICANN), an operational network that just delivers the domain names. There's a structure and a process to figure out things. Right now, there's a big debate that continues about the block size. We need a bigger block size to be able to handle all of the transactions that will be arising. There are big differences. There are legitimate points of view, but the problem is, there's no process to be able to come up with an optimal solution.

I'm hopeful, even optimistic, that this will proceed. It feels a lot like the early '90s to me. You've got all the smartest venture capitalists, the smartest programmers, the smartest business executives, the smartest people in banking, the smartest government of people, the smartest

entrepreneurs all over this thing. That's always a sign that something big is going on. Is it an irrational exuberance? I don't know. Last year, $1 billion went into venture alone in this area. I'm more hopeful because I can see the power of the applications to disrupt things for the good. Rather than just redistributing wealth, maybe we could change the way wealth is distributed in the first place. Imagine a Kickstarter-like campaign to launch a company where you have 50 million investors and everybody puts in a couple of dollars, or very small amounts.

Imagine all those people who have a supercomputer in their pocket, who are connected to a network but don't have a bank account, because they only own a couple of pigs and a chicken. That's their bank account. Imagine if they could be brought in, 2 billion people, into the global financial system. What could that do? Seventy percent of all people who own land have a tenuous title to that land. And you're in a developing-world country in Latin America, and some dictator comes to power and he says, "Well, you may have a piece of paper that says you own your little farm, but my central computer says my friend owns your farm."

Imagine a world where foreign aid didn't get consumed in the bureaucracy but went directly to the beneficiary under a smart contract? Rather than a $60 billion car-service aggregation, why couldn't we have a distributed app on the blockchain that manages all these vehicles and handles everything from reputation to payments? Ultimately, they'll be autonomous vehicles moving around. Or blockchain Airbnb? This is all about the value going to the creators of value rather than to powerful forces that capture it. In the process, we can protect our privacy. Privacy is a basic human right, and people who say "It's dead—get over it" are deeply misinformed. It's the foundation of a free society.

Imagine each of us having our own identity in a black box on the blockchain. When you go to do a transaction, it gives away a shred of information required to do that transaction and it collects data. You get to keep your data and monetize it if you want, or not. This could be the foundation of a whole new era whereby our basic right to privacy is protected, because identity is the foundation of freedom and it needs to be managed responsibly.

We've been unable to do that, so far. I'm compelled most by the power of this opportunity. I've been at this 35 years, writing about the digital age. I've never seen a technology that I thought had greater potential for humanity. ☐

For more about *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World*, visit penguinrandomhouse.com.

Don Tapscott, CEO of the Tapscott Group, is coauthor, with his son, **Alex,** of *Blockchain Revolution*. **Rik Kirkland** is the senior managing editor of McKinsey Publishing and is based in McKinsey's New York office.

TAB 7

Sénat | Senate
CANADA

PAVER LA VOIE

Technologie et le futur du véhicule automatisé

Rapport du
Comité sénatorial permanent
des transports et des communications

L'honorable David Tkachuk, président
L'honorable Dennis Dawson, vice-président
L'honorable Patricia Bovey, vice-présidente

SÉNAT | SENATE
CANADA

TABLE DES MATIÈRES

PRÉFACE

« Nous approchons de la fin de l'ère automobile. […] c'est la fin de l'automobile, car les déplacements seront effectués par des modules normalisés. Au final, nous aurons des modules totalement autonomes ne permettant au conducteur d'effectuer aucune manœuvre. » – Bob Lutz (ancien vice-président de General Motors), « Kiss the good times goodbye », Automotive News, novembre 2017 [TRADUCTION].

À la demande du ministre des Transports, le Comité sénatorial permanent des transports et des communications a mené une étude intitulée « La technologie des véhicules automatisés et son avenir : Paver la voie » portant sur les questions techniques et réglementaires liées à l'arrivée des véhicules branchés et automatisés (c.-à-d. sans conducteur). Le Comité a entendu 78 témoins venant du Canada et des États-Unis, a reçu un bon nombre de mémoires écrits de la part des différents secteurs touchés et a assisté à de nombreuses démonstrations de cette technologie qui évolue rapidement.

En raison de la convergence entre les secteurs automobile et technologique, les véhicules modernes contiennent déjà des niveaux d'automatisation importants, y compris des millions de lignes de code. Des nouveaux venus, dont Tesla et Google, ont bouleversé l'industrie automobile et ont franchi des étapes importantes vers le lancement de véhicules sans conducteur et branchés.

Nous approchons de la fin d'une époque en ce qui a trait à l'automobile traditionnelle, privée et conduite par une personne. Dans un avenir assez rapproché, les gens pourront réserver un taxi sans conducteur à partir de leur téléphone intelligent et décider de troquer leur automobile pour ce mode de transport.

Le secteur du camionnage sera aussi grandement touché par cette technologie. L'automatisation et la connectivité permettront aux camions de circuler en pelotons. Un conducteur se trouvera dans le premier véhicule. Les autres camions, sans conducteur, suivront automatiquement le premier à une distance prédéterminée.

Ces technologies apporteront de nombreux avantages, dont les plus importants sont liés à la sécurité. Puisqu'une erreur humaine est responsable de la grande majorité (94 %) des collisions sur la route,

il ne fait aucun doute que les véhicules automatisés et branchés sauveront des vies.

Toutefois, ces technologies soulèvent de nombreuses préoccupations sur le plan des pertes d'emploi, de la protection des renseignements personnels, de la cybersécurité, de l'étalement urbain et de l'infrastructure. Plus particulièrement, ces véhicules recueillent une quantité importante de données et pourraient être ciblés par des pirates informatiques qui veulent utiliser les véhicules à des fins malveillantes.

Les trois ordres de gouvernement doivent absolument commencer à planifier l'arrivée de ces technologies pour répondre aux diverses préoccupations et s'assurer que les Canadiens comprennent le plein potentiel des véhicules automatisés et branchés. En effet, s'ils ne prennent pas les mesures nécessaires, les gouvernements accuseront un retard sur cette technologie.

Puisque le gouvernement doit prendre des mesures le plus rapidement possible, le Comité a formulé 16 recommandations à l'intention du gouvernement fédéral. Nous croyons que ces recommandations contribueront à établir une stratégie nationale coordonnée sur les véhicules automatisés et branchés.

Au nom des membres du Comité, nous remercions le personnel du Comité de son travail remarquable. Nous remercions plus particulièrement Jed Chong et Nicole Sweeney, analystes de la Bibliothèque du Parlement, Victor Senna et Barbara Reynolds, greffiers du Comité, et Lyne Héroux, adjointe administrative.

L'honorable David Tkachuk, président
L'honorable Dennis Dawson, vice-président
L'honorable Patricia Bovey, vice-présidente
L'honorable Michael L. MacDonald, membre du Comité

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Peter Harder, C.P. (ou Diane Bellemare),
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Larry W. Smith (ou Yonah Martin)
Yuen Pau Woo (ou Raymonde Saint-Germain)
Joseph Day (ou Terry M. Mercer)

Autres sénateurs qui ont, à l'occasion, participé à cette étude :

Lynn Beyak, Jean-Guy Dagenais, Tony Dean,
Norman E. Doyle, Michael Duffy, Art Eggleton, C.P.,
Marc Gold, Stephen Greene, Nancy J. Hartling,
Ghislain Maltais, Bob Runciman,
Raymonde Saint-Germain, Betty Unger
et Ratna Omidvar.

Service d'information et de recherche parlementaires, Bibliothèque du Parlement :

Jed Chong, analyste
Nicole Sweeney, analyste

Greffier du comité :

Victor Senna

Direction des comités du Sénat :

Daniel Charbonneau, greffier à la procédure
Barbara Reynolds, greffière à la procédure
Lyne Héroux, adjointe administrative

ORDRE DE RENVOI

Extrait des *Journaux du Sénat* du
mercredi 9 mars 2016 :

L'honorable sénateur Dawson propose, appuyé par
l'honorable sénateur Moore,

Que le Comité sénatorial permanent des
transports et des communications soit autorisé
à examiner, pour en faire rapport, les questions
techniques et réglementaires liées à l'arrivée
des véhicules branchés et automatisés. L'étude
portera notamment sur les défis et les incidences
à long terme de ces technologies, comme les
répercussions sur la vie privée, l'énergie, l'utilisation
du territoire, la demande en transport et l'emploi;

Que le comité présente son rapport final au Sénat
au plus tard le 30 mars 2017 et qu'il conserve
tous les pouvoirs nécessaires pour diffuser ses
conclusions dans les 180 jours suivant le dépôt
du rapport final.

La motion, mise aux voix, est adoptée.

Le greffier du Sénat
Charles Robert

Extrait des *Journaux du Sénat* du
jeudi 9 mars 2017 :

L'honorable sénateur MacDonald propose, appuyé
par l'honorable sénatrice Marshall,

Que, nonobstant l'ordre du Sénat adopté le
mercredi 9 mars 2016, la date du rapport final du
Comité sénatorial permanent des transports et
des communications relativement à son étude sur
les questions techniques et réglementaires liées à
l'arrivée des véhicules branchés et automatisés soit
reportée du 30 mars 2017 au 31 décembre 2017.

La motion, mise aux voix, est adoptée.

Le greffier du Sénat
Charles Robert

Extrait des *Journaux du Sénat* du
mardi 5 décembre 2017 :

L'honorable sénateur Tkachuk propose, appuyé par
l'honorable sénateur Patterson,

Que, nonobstant l'ordre du Sénat adopté le jeudi
9 mars 2017, la date du rapport final du Comité
sénatorial permanent des transports et des
communications relativement à son étude sur les
questions techniques et réglementaires liées à
l'arrivée des véhicules branchés et automatisés soit
reportée du 31 décembre 2017 au 1er mars 2018.

Après débat,
La motion, mise aux voix est adoptée.

La greffière du Sénat
Nicole Proulx

FAITS SAILLANTS DU RAPPORT

VÉHICULES AUTOMATISÉS

Ces véhicules utilisent des capteurs et des analyses informatiques pour évaluer leur environnement et exécuter des manœuvres de conduite plus ou moins complexes. Il existe cinq niveaux d'automatisation, allant des systèmes d'aide à la conduite actionnant le volant, aux systèmes totalement automatisés des voitures autonomes, qui ne nécessitent aucune intervention des passagers.

VÉHICULES BRANCHÉS

Il y a deux types de technologies branchées : celles vouées à l'infodivertissement et à la commodité des services pour les consommateurs, et celles vouées aux communications de véhicule à véhicule et de véhicule à infrastructure. En pratique, cela signifie que votre voiture pourrait recevoir des recommandations de restaurants en fonction d'un itinéraire donné, afficher un décompte annonçant le prochain feu rouge, ou recevoir un avertissement de la voiture qui vous précède si elle juge que vous la suivez de trop près.

- Le Canada n'est pas prêt à affronter l'évolution fulgurante des transports.

- Les premières générations de véhicules autonomes sont déjà sur nos routes et les voitures récentes sont munies de technologies branchées, tandis que les recherches se poursuivent pour accroître les possibilités qu'offrent ces technologies.

- Selon les experts, les transports autonomes pourraient s'implanter dans les régions urbaines d'ici 10 ou 15 ans à peine.

- Ce pourrait être le début d'une ère nouvelle dans le domaine des transports. Grâce à des voitures sillonnant les artères du pays avec l'efficacité d'un ordinateur, les quelque 1 700 décès et 117 000 blessures graves attribuables à l'erreur humaine déplorés sur les routes en 2015 pourraient bien devenir les vestiges d'un passé primitif.

- Ce pourrait aussi être un cauchemar : pertes d'emplois massives, piratage des véhicules et érosion de la protection de la vie privée.

- Le Comité sénatorial des transports et des communications a étudié soigneusement le grand potentiel et les risques réels que présentent les technologies des véhicules branchés et automatisés.

- Les avantages potentiels sont astronomiques; selon une estimation, les retombées économiques des véhicules automatisés pourraient à elles seules s'élever à 65 milliards de dollars par année, si on pense aux collisions évitées, à la productivité accrue, aux économies de carburant et à l'élimination de la congestion.

- Les voitures automatisées pourraient aussi offrir plus de liberté aux aînés et aux personnes à mobilité réduite, de même que réduire radicalement le taux de collisions.

- Cependant, beaucoup d'entreprises (pas toutes issues du secteur automobile) travaillent sur ces technologies. Il faudra donc élaborer des lignes directrices afin que toutes les entreprises aient les mêmes attentes relativement à la sécurité des véhicules.

- Un tel avènement pourrait par ailleurs entraîner la perte de centaines de milliers d'emplois. Les secteurs menacés par la montée de ces technologies – industries du taxi, des transports et du stationnement, par exemple – emploient plus de 1,1 million de personnes.

- Le tout soulève également d'importantes questions concernant la sécurité et la confidentialité.

- En l'absence de mesures de protection rigoureuses, des cyberterroristes pourraient prendre le contrôle de voitures canadiennes depuis l'autre bout de la planète.

- Dans un scénario moins dramatique, mais tout aussi sérieux, il y a lieu de s'interroger sur ce que feront les entreprises des données stockées par les véhicules automatisés et branchés.

- Grâce à ces technologies, les fabricants automobiles pourront connaître les itinéraires des utilisateurs, envoyer des publicités ciblées directement dans leur voiture et peut-être vendre ces données à profit.

- Il est encore temps pour le Canada de mettre en place un plan ferme qui permettra de maximiser les avantages des technologies branchées et automatisées, tout en atténuant les risques.

- Mais le gouvernement doit agir maintenant.

- À cette fin, le comité a formulé 16 recommandations qui visent à assurer la réussite du Canada.

PRINCIPALES RECOMMANDATIONS

Des témoins ont laissé entendre au comité que les deux principales entités du gouvernement concernées dans ce dossier pourraient travailler à contre-courant.

Un témoin a indiqué que le gouvernement fédéral tente d'aller de l'avant, un pied sur l'accélérateur et l'autre sur le frein. En effet, Innovation, Sciences et Développement économique Canada cherche à stimuler la recherche, alors que Transports Canada se concentre sur la sécurité des véhicules.

Le comité recommande que ces organisations créent une unité conjointe chargée de coordonner les efforts fédéraux qui visent à mettre en place une stratégie nationale sur les véhicules branchés et automatisés.

Si le Canada espère attirer des promoteurs, il devra adopter des politiques harmonisées encadrant l'utilisation des véhicules branchés et automatisés sur les voies publiques. Il sera également crucial de mettre en place des lignes directrices rigoureuses en matière de sécurité afin d'assurer la protection des Canadiens.

Le comité recommande que Transports Canada travaille de concert avec les gouvernements provinciaux et territoriaux à l'élaboration d'une politique provinciale type sur l'utilisation des véhicules branchés et automatisés sur les voies publiques.

Le comité recommande également que Transports Canada élabore des lignes directrices en matière de sécurité, qui dicteraient entre autres les aspects liés à la conception à envisager lors du développement, de la mise à l'essai et du déploiement de tels véhicules sur les routes canadiennes.

Les sénateurs sont d'avis que des mesures fermes en matière de cybersécurité sont essentielles au maintien de la sécurité publique et à la confiance du public à l'égard de ces nouvelles technologies.

Le comité recommande que Transports Canada, le Centre de la sécurité des télécommunications et Sécurité publique Canada produisent un guide sur la cybersécurité fondé sur les pratiques exemplaires et les principes reconnus en la matière.

Les Canadiens devraient être maîtres de leurs renseignements personnels; leur voiture ne devrait donc pas se transformer en outil d'espionnage. Une surveillance étroite sera nécessaire pour veiller à ce que les entreprises traitent adéquatement les données reçues des véhicules branchés et automatisés, de façon à ce qu'elles soient conservées de façon sécuritaire et à ce qu'elles ne soient pas exploitées indûment.

Le comité recommande que le gouvernement dépose un projet de loi qui vise à donner au Commissariat à la protection de la vie privée le pouvoir d'enquêter de façon proactive sur les pratiques de l'industrie et de faire appliquer la législation relative à la protection de la vie privée dans les cas de non-conformité.

PROCHAINES ÉTAPES

- Il ne s'agit pas de savoir « si » mais bien « quand » une nouvelle génération de véhicules branchés et automatisés fera son arrivée sur les routes du Canada.

- Ce ne serait pas la première technologie à créer des remous dans une administration non préparée à sa venue. Il n'y a qu'à penser aux services de covoiturage, devenus omniprésents. D'autres exemples de ce genre nous ont appris que la confusion découle d'un manque de planification.

- Les technologies des véhicules branchés et automatisés pourraient être avantageuses pour le Canada, mais seulement si le gouvernement est prêt à faire ce qu'il faut pour minimiser les complications attendues avant qu'elles ne deviennent enracinées.

- Les sénateurs continueront de faire pression sur le gouvernement pour qu'il mette en œuvre les recommandations du comité, afin que les Canadiens profitent pleinement de la prochaine génération de modes de transport.

LISTE DES RECOMMANDATIONS

Le comité recommande :

RECOMMANDATION 1 :

Que Transports Canada et Innovation, Sciences et Développement économique Canada créent sans tarder une entité conjointe chargée de la politique pour coordonner les mesures prises par le gouvernement fédéral et mettre en œuvre une stratégie nationale visant les véhicules automatisés et branchés.

RECOMMANDATION 2 :

Que Transports Canada collabore avec les gouvernements provinciaux et territoriaux, par l'intermédiaire du Conseil canadien des administrateurs en transport motorisé, à l'élaboration d'une politique provinciale modèle portant sur l'utilisation des véhicules automatisés et branchés sur la voie publique. Le Ministère devrait aussi convier les municipalités à participer à cet effort de collaboration.

RECOMMANDATION 3 :

Que Transports Canada renforce sa collaboration avec les États-Unis au sujet des véhicules automatisés et branchés par l'entremise du Conseil de coopération en matière de réglementation, pour que ces véhicules fonctionnent de manière intégrée dans les deux pays.

RECOMMANDATION 4 :

Que Transports Canada prépare de toute urgence des lignes directrices sur la sécurité entourant la conception des véhicules automatisés et branchés. Ces lignes directrices devraient énoncer les aspects conceptuels dont l'industrie devrait tenir compte lors du développement, de la mise à l'essai et du déploiement de ces véhicules sur les routes canadiennes. De plus, les lignes directrices devraient être mises à jour régulièrement pour suivre l'évolution de la technologie des véhicules automatisés et branchés.

RECOMMANDATION 5 :

Qu'Innovation, Sciences et Développement économique Canada assigne la fréquence de 5,9 gigahertz qu'il a réservée aux systèmes de communications dédiées à courte portée et qu'il continue de réserver cette fréquence aux véhicules branchés.

RECOMMANDATION 6 :

Que Transports Canada, en collaboration avec le Centre de la sécurité des télécommunications et Sécurité publique Canada, mette au point des lignes directrices sur la cybersécurité pour le secteur des transports inspirées des pratiques exemplaires et des principes reconnus en matière de cybersécurité. Les lignes directrices devraient comporter des conseils sur l'équipement d'origine, sur l'équipement de remplacement et sur les mises à jour logicielles.

RECOMMANDATION 7 :

Que Transports Canada travaille avec Sécurité publique Canada, le Centre de la sécurité des télécommunications et les intervenants de l'industrie pour remédier aux problèmes de cybersécurité et pour créer un réseau de connexion en cas de crise en temps réel, et que Transports Canada fasse régulièrement rapport des progrès réalisés à cet égard.

RECOMMANDATION 8 :

Que le gouvernement du Canada présente un projet de loi visant à donner au Commissariat à la protection de la vie privée le pouvoir d'enquêter de façon proactive sur le respect de la *Loi sur la protection des renseignements personnels et les documents électroniques* par l'industrie et de faire observer la *Loi*.

RECOMMANDATION 9 :

Que le gouvernement du Canada continue d'évaluer la nécessité de prendre des règlements sur la protection des renseignements personnels propres aux véhicules branchés.

RECOMMANDATION 10 :

Que Transports Canada rassemble les intervenants concernés – les gouvernements, les constructeurs d'automobiles et les consommateurs – afin d'élaborer un cadre de travail sur les véhicules branchés, dont l'un des principaux éléments sera la protection des renseignements personnels.

RECOMMANDATION 11 :

Qu'Innovation, Sciences et Développement économique Canada surveille les répercussions de la technologie des véhicules automatisés et branchés sur la concurrence entre les divers secteurs des industries liées à l'automobile et aux transports, afin de veiller à ce que les secteurs comme le marché secondaire et la location de voitures conservent l'accès aux données dont ils ont besoin pour offrir leurs services.

RECOMMANDATION 12 :

Que le gouvernement du Canada investisse davantage dans la recherche développement sur les véhicules automatisés et branchés par la création d'un nouveau Centre d'essais et de recherche pour la mobilité intelligente et l'innovation, qui serait situé sur les lieux de l'actuel Centre de test et de recherche pour les véhicules motorisés. Il faudrait accorder une attention particulière aux projets portant sur la cybersécurité et la protection des renseignements personnels, en plus de veiller à ce que ces véhicules soient mis à l'essai dans une combinaison de milieux urbains et ruraux et dans des climats froids.

RECOMMANDATION 13 :

Qu'Innovation, Sciences et Développement économique Canada collabore avec les Réseaux de centres d'excellence (RCE) pour réexaminer la règle qui exige la cessation des activités de ces réseaux à l'échéance du financement du programme.

RECOMMANDATION 14 :

Que Transports Canada surveille l'incidence des technologies des VA et des VB sur l'assurance automobile, les infrastructures et les transports en commun au Canada.

RECOMMANDATION 15 :

Qu'Emploi et Développement social Canada continue de travailler en étroite collaboration avec les provinces et les territoires afin de renforcer le recyclage professionnel, la mise à niveau des compétences et le soutien à l'emploi pour les Canadiens touchés par des perturbations du marché du travail.

RECOMMANDATION 16 :

Que Sécurité publique Canada et le Centre de la sécurité des télécommunications travaillent en étroite collaboration avec les provinces et les territoires pour créer des documents et des programmes de formation sur la cybersécurité afin que le public comprenne mieux les enjeux liés à la cybersécurité.

GLOSSAIRE

Circulation en peloton : Utilisation des technologies de véhicule automatisé (VA) et de véhicule branché (VB) pour réduire la traînée aérodynamique en regroupant les véhicules et en réduisant la distance qui les sépare, ce qui permet à plusieurs véhicules d'accélérer ou de freiner en même temps [1].

LIDAR (détection et télémétrie par ondes lumineuses) : Laser pulsé qui mesure la distance. Dans les VA, les lidars font réfléchir un faisceau laser sur les objets environnants (comme les piétons et les autres véhicules) pour en faire une représentation 3D et ainsi permettre au VA de déterminer où il se trouve par rapport à ces objets.

Premier et dernier segment des transports en commun : Trajet de la maison à la station de métro ou l'arrêt de bus le plus près, et de la station de métro ou l'arrêt de bus final à la destination finale.

Spectre : Ondes qui transmettent les signaux sans fil (des appareils comme les véhicules branchés et les téléphones cellulaires) [2].

Système de communications dédiées à courte portée (CDCP) : Technologie sans fil qui permet des communications rapides (jusqu'à 10 fois par seconde) entre les éléments d'un réseau de véhicules branchés à l'intérieur d'une distance de 300 à 500 mètres [3].

Véhicule automatisé (VA) : Véhicule qui utilise des capteurs et l'analyse informatique pour reconnaître son environnement et accomplir différentes tâches liées à la conduite. Il y a six niveaux d'automatisation des véhicules, allant du niveau zéro (aucune automatisation) au niveau cinq (automatisation complète).

Véhicule branché (VB) : Véhicule qui est connecté à Internet afin d'offrir des services de confort et d'infodivertissement aux passagers et/ou véhicule relié à d'autres véhicules (véhicule à véhicule) ou à l'infrastructure (véhicule à infrastructure) au moyen de systèmes de communications dédiées à courte portée.

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1   Jed Chong, *Véhicules autonomes et connectés : état d'avancement de la technologie et principaux enjeux stratégiques pour les pouvoirs publics au Canada*, Étude générale nº 2016-98-F, Ottawa, Service d'information et de recherche parlementaires, Bibliothèque du Parlement, 29 septembre 2016.

2   Gouvernement du Canada, *Qu'est-ce que le spectre?*

3   Jed Chong, *Véhicules autonomes et connectés : état d'avancement de la technologie et principaux enjeux stratégiques pour les pouvoirs publics au Canada*, Étude générale nº 2016-98-F, Ottawa, Service d'information et de recherche parlementaires, Bibliothèque du Parlement, 29 septembre 2016.

INTRODUCTION

Le secteur de l'automobile connaît une période de rapides changements technologiques, avec l'intégration de plus en plus marquée d'ordinateurs, de logiciels, de capteurs et de réseaux dans la conception des véhicules afin qu'ils soient plus sécuritaires tant pour les conducteurs que pour les passagers. Aujourd'hui, les véhicules peuvent être qualifiés d'ordinateurs roulants, une révolution semblable à celle du passage de la voiture tirée par un cheval à l'automobile.

Les consommateurs canadiens ont déjà accès à des véhicules ayant un faible degré d'automatisation et de connexion, souvent sous la forme de systèmes avancés d'aide à la conduite (SAAC), comme les régulateurs de vitesse et d'espacement et le stationnement automatisé. On s'attend à ce que des véhicules automatisés (VA) et des véhicules branchés (VB) plus sophistiqués fassent leur apparition sur le marché dans un proche avenir.

Le Conference Board du Canada estime [4] que les avantages économiques des VA pourraient atteindre 65 milliards de dollars par année grâce à l'évitement des collisions, à l'augmentation de la productivité, aux économies sur le coût du carburant et à l'évitement de la congestion. Cependant, la technologie des VA et des VB soulèvera certaines questions, comme la protection de la quantité de plus en plus importante de données recueillies par les véhicules sur les conducteurs, la cybersécurité des véhicules et la gestion efficace de la période de transition, au cours de laquelle des VA partageront la route avec des véhicules traditionnels.

Compte tenu des avantages potentiels et des défis que représente cette technologie, le Comité sénatorial permanent des transports et des communications (le comité) a décidé, à la demande du ministre des Transports, d'étudier les questions techniques et réglementaires liées à la venue des véhicules branchés et automatisés. Au cours de 30 réunions, le comité a entendu 78 témoins et a reçu de nombreux mémoires. Parmi les témoins, mentionnons des représentants des gouvernements canadien et américain ainsi que des représentants d'associations de l'industrie, de la société civile et du milieu universitaire.

La première partie du présent rapport contient des renseignements généraux décrivant ce que sont les VA et les VB, leur utilisation possible, le moment de leur arrivée sur le marché, ainsi que les avantages et les défis qui pourraient les accompagner. On y traite également des initiatives en place au Canada et ailleurs pour encourager le déploiement de cette technologie.

La seconde partie du rapport contient les recommandations du comité sur le rôle du gouvernement fédéral dans la planification en vue de l'avènement des technologies des VA et des VB. Cette partie du rapport porte sur plusieurs considérations, dont le leadership du gouvernement fédéral en ce qui concerne les VA et les VB, la réglementation sur la sécurité des véhicules, l'attribution du spectre, la cybersécurité, la protection des renseignements personnels, la recherche-développement, l'infrastructure et les transports en commun.

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4   Dans tout le rapport, le texte souligné correspond à des hyperliens vers d'autres renseignements en ligne.

PARTIE 1 :
RENSEIGNEMENTS GÉNÉRAUX

QU'EST-CE QU'UN VÉHICULE AUTOMATISÉ?

Les VA – parfois appelés véhicules autonomes ou véhicules sans conducteur – utilisent des capteurs (p. ex. des radars, des lidars [5] et des caméras) et l'analyse informatique pour reconnaître leur environnement et accomplir différentes tâches liées à la conduite [6].

Les témoins du secteur de la construction automobile ont indiqué qu'ils préfèrent utiliser l'échelle de niveaux d'automatisation définie par la norme J3016 de la Society of Automotive Engineers (SAE) International [7]. Le tableau 1 résume dans les grandes lignes cette norme technique.

TABLEAU 1 – NIVEAUX D'AUTOMATISATION DES VÉHICULES

NIVEAU D'AUTOMATISATION	DESCRIPTION
Niveau 0 : **Aucune automatisation**	Un conducteur humain contrôle tous les aspects de la conduite.
Niveau 1 : **Aide à la conduite**	Un système avancé d'aide à la conduite (SAAC) aide un conducteur humain soit à diriger le véhicule, soit à accélérer ou à freiner.
Niveau 2 : **Automatisation partielle**	Le SAAC contrôle à la fois la direction et l'accélération/le freinage dans certaines circonstances. Le conducteur humain doit porter toute son attention (c.-à-d. surveiller l'environnement de conduite) et effectuer les autres tâches liées à la conduite.
Niveau 3 : **Automatisation conditionnelle**	Un système de conduite automatisée (SCA) prend en charge tous les aspects de la conduite dans certaines circonstances. Lorsque le SCA est activé, on s'attend à ce que le conducteur humain réagisse convenablement si le système lui demande d'intervenir. Dans les circonstances où le SCA n'est pas conçu pour prendre en charge le véhicule, le conducteur humain est responsable de la conduite.
Niveau 4 : **Automatisation élevée**	Un SCA peut s'acquitter de toutes les tâches liées à la conduite et surveiller l'environnement (en d'autres termes, l'ACS s'occupe de tous les aspects de la conduite) dans des circonstances précises. Lorsque le SCA est activé, le conducteur humain n'a pas à porter attention à l'environnement.
Niveau 5 : **Automatisation complète**	Un SCA peut conduire le véhicule dans toutes les circonstances. Les personnes dans le véhicule sont de simples passagers et n'ont jamais à intervenir dans la conduite.

Sources : États-Unis, Département des Transports, Administration nationale de la sécurité du trafic routier, Automated Vehicles for Safety; SAE International, Surface Vehicle Recommended Practice J3016: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, septembre 2016; SAE International, Automated Driving: Levels of Driving Automation Are Defined in New SAE International Standard J3016, 2014.

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5. Les lidars (détection et télémétrie par ondes lumineuses) utilisent un laser pour mesurer la distance. Dans les VA, les lidars font réfléchir un faisceau laser sur les objets de l'entourage (comme les piétons et les autres véhicules) pour en faire une représentation en 3D et ainsi permettre au VA de déterminer où il se trouve par rapport à ces objets. Voir : Service national des océans des États-Unis, *What is LIDAR?*; Tom Simonite, « Self-Driving Cars' Spinning-Laser Problem », MIT Technology Review, 20 mars 2017.

6. Ontario Centres of Excellence, « How it Works », Connected Vehicle/Automated Vehicle (CVAV) Program, 2016. Voir également Département des transports du Michigan et Centre sur la recherche automobile, *International Survey of Best Practices in Connected and Automated Vehicle Technologies: 2015 Update*, 7 décembre 2015.

7. La norme est disponible ici, en anglais seulement : SAE International, *Surface Vehicle Recommended Practice J3016: Taxonomy and Definitions for Terms related to Driving Automation Systems for On-Road Motor Vehicles*, septembre 2016.

Par souci de simplicité, le comité utilise le terme « véhicule automatisé », ou VA, pour faire référence à ces types de véhicules au sens général [8]. Les VA offerts actuellement sur le marché correspondent en général aux niveaux 1 et 2 de la norme.

Certains témoins, comme Robert Love, avocat et associé chez Borden Ladner Gervais LLP, ont indiqué au comité que les constructeurs décideront peut-être de ne pas commercialiser de véhicules de niveau 3 en raison de préoccupations sur la rapidité d'intervention de l'humain dans le cas où le système demande au conducteur de reprendre le contrôle. Comme l'a expliqué M. Love, les attentes sur le délai d'intervention risquent de « placer les conducteurs en situation d'échec ».

Pour évaluer les progrès réalisés dans le développement de la technologie des VA, le comité a visité BlackBerry QNX et l'Université de Waterloo; tous deux font partie de la première cohorte d'organismes autorisés à mener des tests sur les VA conformément à un règlement de l'Ontario. Au cours de ces visites, les membres du comité ont pu observer la technologie derrière l'*Autonomoose* de l'Université de Waterloo, un VA de niveau 2 équipé d'un radar, d'un sonar, d'un lidar, de capteurs inertiels et de capteurs visuels, et d'en faire l'expérience. Au fil de ce projet de recherche, les chercheurs de l'Université espèrent atteindre le niveau d'automatisation 3 et, ultimement, le niveau 4.

En raison de la pluie, les membres du comité n'ont pas pu assister à une démonstration du véhicule d'essai de BlackBerry, ce qui illustre peut-être les défis techniques qui devront être surmontés avant que l'on puisse diffuser largement cette technologie.

Deux membres du comité ont également accompagné le ministre des Transports au sein de la délégation qui a rencontré des acteurs de l'industrie à San Francisco, en Californie, en octobre 2017. Les membres du comité ont notamment visité l'installation de fabrication de Tesla Motors et assisté à une démonstration du VA de ce constructeur sur une voie publique. Ils ont aussi rencontré des chercheurs du Centre de recherche automobile de Stanford, dont certains sont Canadiens.

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8   SAE International recommande de ne pas utiliser de termes qui accrochent le concept d'automatisation aux *véhicules* plutôt qu'à la *conduite*.

Des membres du Comité sénatorial des transports et des communications examinent l'Autonomoose, une automobile munie de technologie de véhicule automatisé mise au point par des étudiants en génie au Centre de recherche automobile de l'Université de Waterloo.

QU'EST-CE QU'UN VÉHICULE BRANCHÉ?

Le comité a appris des témoignages qu'il existe deux types de technologie de connectivité dans le secteur automobile : (1) services et infodivertissement dans les véhicules connectés à Internet (habituellement par le même réseau mobile que celui emprunté par les téléphones intelligents) et (2) la communication véhicule à véhicule et la communication véhicule à infrastructure au moyen de systèmes de communications dédiées à courte portée (CDCP). Innovation, Sciences et Développement économique Canada (ISDE), de même que ses homologues américains, a attribué le spectre sans fil de 5,9 gigahertz (GHz) aux systèmes de CDCP.

Les représentants de BlackBerry ont indiqué au comité qu'un débat est en cours pour déterminer si les CDCP ou les réseaux cellulaires 5G représentent la meilleure technologie de connectivité des VB. Cependant, Sandeep Chennakeshu, président de BlackBerry Technology Solutions, a fait valoir qu'on se trouvera probablement avec un mélange des deux technologies : les CDCP fonctionnent bien pour les applications de courte portée, et les réseaux cellulaires 5G sont la solution idéale pour les applications nécessitant une vaste zone de couverture.

En septembre 2016, des membres du comité se sont rendus à l'Université de l'Alberta pour assister à une démonstration de la technologie des VB. Les membres ont fait un essai à bord d'un autobus local équipé de technologies de communication véhicule à véhicule et de communication véhicule à infrastructure. L'autobus suivait une voiture d'essai (elle aussi équipée de la

technologie de communication véhicule à véhicule) fourni par Transports Canada. La technologie a permis d'avertir le conducteur de l'autobus lorsqu'il se trouvait trop près de la voiture de Transports Canada. La technologie de communication véhicule à infrastructure a permis à l'infrastructure routière d'informer le chauffeur lorsque l'autobus arrivait dans une zone de risque de collision. En outre, cette technologie indiquait au chauffeur la durée des feux de circulation aux intersections et affichait de l'information sur les conditions météorologiques et l'état de la circulation.

Les VB et les VA sont des technologies différentes, mais complémentaires. Par ailleurs, des témoins ont expliqué que, dans les niveaux supérieurs d'automatisation, la distinction entre les deux pourrait se brouiller puisque la connectivité des technologies de communication véhicule à véhicule et véhicule à infrastructure permettra aux VA d'obtenir des renseignements autres que ceux qui sont détectés par les capteurs. En fait, certains témoins ont utilisé les termes VB et VA comme synonymes.

Les technologies des VA et des VB peuvent être déployées tant dans les véhicules de particuliers que dans les véhicules partagés, comme les autobus et les taxis. Des témoins ont souligné que les entreprises de covoiturage, comme Uber, investissent intensément dans les technologies des VA et des VB dans l'espoir de permettre aux consommateurs de commander un taxi sans conducteur au moyen de leur téléphone intelligent.

http://bit.ly/2qTDRdt

Des représentants de l'Association canadienne du transport urbain (ACTU) et de Transdev Canada ont fait la démonstration aux membres du comité d'un minibus automatisé sur la Colline du Parlement. Le bus était un VA de niveau 3, c'est-à-dire qu'un chauffeur à bord pouvait prendre le contrôle en cas d'urgence et que la conduite était automatisée seulement sur le trajet défini d'avance aux fins de la démonstration.

Il a fallu préprogrammer certaines données dans le véhicule. Par exemple, le minibus a été préprogrammé pour s'arrêter à certains endroits, notamment aux panneaux d'arrêt, au lieu de laisser les capteurs et les caméras détecter ces panneaux. L'entreprise a signalé que le minibus n'était pas programmé pour reculer automatiquement si un véhicule situé devant lui reculait subitement, mais qu'il était possible de le faire. Cependant, le minibus s'arrêtait lorsque des personnes ou d'autres véhicules passaient devant lui à courte distance.

L'organisation de l'activité s'est avérée difficile. En effet, compte tenu de la nouveauté de cette technologie, il n'existe pas de procédure permettant la circulation des VA sur la Colline du Parlement. Les défis logistiques entourant l'aspect sécuritaire de la démonstration de ce VA reflètent, à petite échelle, les défis que doivent relever les entreprises qui tentent de démontrer l'utilisation de ces véhicules sur la voie publique.

Comme le mentionne le présent rapport dans les sections ultérieures, bon nombre des avantages et des défis que présentent ces technologies dépendront de la mesure dans laquelle elles encourageront les personnes à délaisser les véhicules personnels au profit des véhicules partagés.

INTÉGRATION DES VÉHICULES AUTOMATISÉS ET BRANCHÉS DANS LES SECTEURS DU CAMIONNAGE ET DES RESSOURCES NATURELLES

Outre leur intégration dans les automobiles et les autobus, les technologies des VA et des VB pourraient être utilisées dans les secteurs du camionnage et des ressources naturelles, selon certains témoins. Des représentants du secteur du camionnage ont fait valoir qu'il est important d'utiliser la bonne terminologie lorsqu'il est question de camions équipés de la technologie d'automatisation et de connectivité. En effet, les représentants de l'Alliance canadienne du camionnage et de l'Association du camionnage des provinces de l'Atlantique préfèrent utiliser le terme « véhicules semi-autonomes » ou de préciser la technologie SAAC.

Ces témoins ont fait valoir que la conduite n'est qu'une des tâches qu'accomplissent les conducteurs de camions. Comme l'a expliqué Marco Beghetto, vice-président, Communications et Nouveaux médias de l'Alliance canadienne du camionnage :

> Les chauffeurs de camion ont bien plus à faire que de tenir le volant de leur véhicule. Ils doivent, entre autres, contrôler l'accès au véhicule, veiller à la sécurité, équilibrer les charges, arrimer les cargaisons, gérer le transport des marchandises dangereuses, communiquer avec les premiers intervenants, procéder aux vérifications nécessaires avant le départ, s'acquitter de certaines tâches mécaniques en route, avoir des contacts avec les clients et s'occuper d'innombrables processus lorsqu'ils franchissent les frontières.
>
> (Marco Beghetto, vice-président, Communications et Nouveaux médias, Alliance canadienne du camionnage, 20 septembre 2017)

Autrement dit, selon les témoins du secteur du camionnage, l'humain aura toujours un rôle à remplir dans la conduite de camions, bien que les tâches des conducteurs soient probablement appelées à évoluer avec l'installation progressive des SAAC sur ces véhicules.

Selon les témoins entendus, les technologies des VA et des VB permettront la « circulation en peloton » (en convoi) des camions semi-automatisés, c'est-à-dire que le véhicule de tête sera conduit par un humain et que les véhicules suivants seront automatisés et suivront le premier à une distance déterminée. La circulation en peloton devrait réduire l'espace qu'occupent les camions sur la route et améliorerait l'utilisation efficiente du carburant. Jean-Marc Picard, directeur exécutif, Association du camionnage des provinces de l'Atlantique, a indiqué que les économies en carburant pourraient atteindre 20 %, ce qui signifierait des économies annuelles se chiffrant à des millions de dollars.

La technologie de circulation en peloton comporte son lot de défis qui lui sont propres. Par exemple, selon certains témoins, la circulation en peloton pourrait ne pas fonctionner sur les routes glacées parce que la proximité des camions causerait une concentration du poids trop élevée pour les routes qui sont dans cet état. Des témoins ont également signalé que la présence de plusieurs pelotons de camions dans la voie la plus à droite d'une autoroute pourrait faire en sorte qu'il soit plus difficile d'entrer sur l'autoroute ou d'en sortir.

En plus de démonstrations aux États-Unis et en Europe, la technologie de circulation de camions en peloton a été mise à l'essai au Canada. Franck N'Diaye Bonny, directeur général, Centre de test et de recherche pour les véhicules motorisés (CTRVM) de Blainville, au Québec, a affirmé au comité que Transports Canada et le Conseil national de recherches (CNR) ont mis à l'essai la technologie de circulation en peloton au CTRVM en 2016 dans le cadre d'un projet collaboratif avec des participants américains. Selon un mémoire du CNR, ce test a montré que la combinaison de la circulation en peloton et des appareils d'aérodynamisme des remorques a permis de réaliser des économies nettes de carburant allant jusqu'à 14 % dans les cas où la distance entre les véhicules était la plus courte (17,4 mètres). Dans son mémoire, le CNR a indiqué qu'un autre test de circulation en peloton a été effectué au CTRVM en août 2017 et qu'il est en train d'analyser les données recueillies à ce moment.

Le comité a entendu le témoignage de représentants de la Central North American Trade Corridor

Association (CNATCA), qui encourage la création d'un couloir commercial nord-sud adapté à la technologie des VA qui relierait le Canada au centre des États-Unis et au Mexique. En plus de pelotons de camions automatisés, ce couloir serait également utilisé par des drones autonomes volant dans un couloir aérien réservé au-dessus de l'autoroute. Les représentants de la CNATCA ont indiqué au comité qu'un couloir est-ouest similaire pourrait également être construit. La CNATCA cherche à obtenir des fonds publics pour effectuer une étude de faisabilité de ces projets.

En ce qui concerne le secteur des ressources naturelles, des témoins ont fait valoir que certaines industries ont des environnements fermés (où circulent peu de piétons et d'autres véhicules) qui sont idéaux pour la mise à l'essai des technologies des VA et des VB. François Adam, directeur général, Institut du véhicule innovant (IVI), a indiqué au comité que son organisme étudie, sur des terrains privés, l'application de la technologie des VA hors route dans les domaines de l'agriculture, de la manutention industrielle et du transport de personnes. Frederick Prigge, directeur, Recherche et Développement, IVI, a ajouté que les tracteurs de ferme se trouvent au niveau 4 d'automatisation; une fois que le trajet est programmé dans le système du véhicule, le tracteur laboure les champs et revient sans intervention humaine nécessaire.

David Michelson, coprésident, Société des systèmes de transport intelligents du Canada et professeur à l'Université de la Colombie-Britannique, est d'avis que les routes de transport des ressources du Canada ont un potentiel inexploité pour la mise à l'essai des technologies des VA et des VB. Selon M. Michelson, on compte plus de 620 000 km de routes de transport des ressources en Colombie-Britannique, une distance supérieure à celle des voies publiques traditionnelles.

En outre, M. Michelson a noté que FPInnovations, l'organisme national de recherche-développement de l'industrie forestière du Canada, a mis sur pied un programme visant le développement d'une architecture de système de transport forestier intelligent qui tirera profit de la technologie des VB actuelle.

Selon le mémoire du ministère des Routes et de l'Infrastructure de la Saskatchewan, l'intégration hors route dans les secteurs agricole et minier semble être l'avenue la plus prometteuse pour les innovations des VA dans la province.
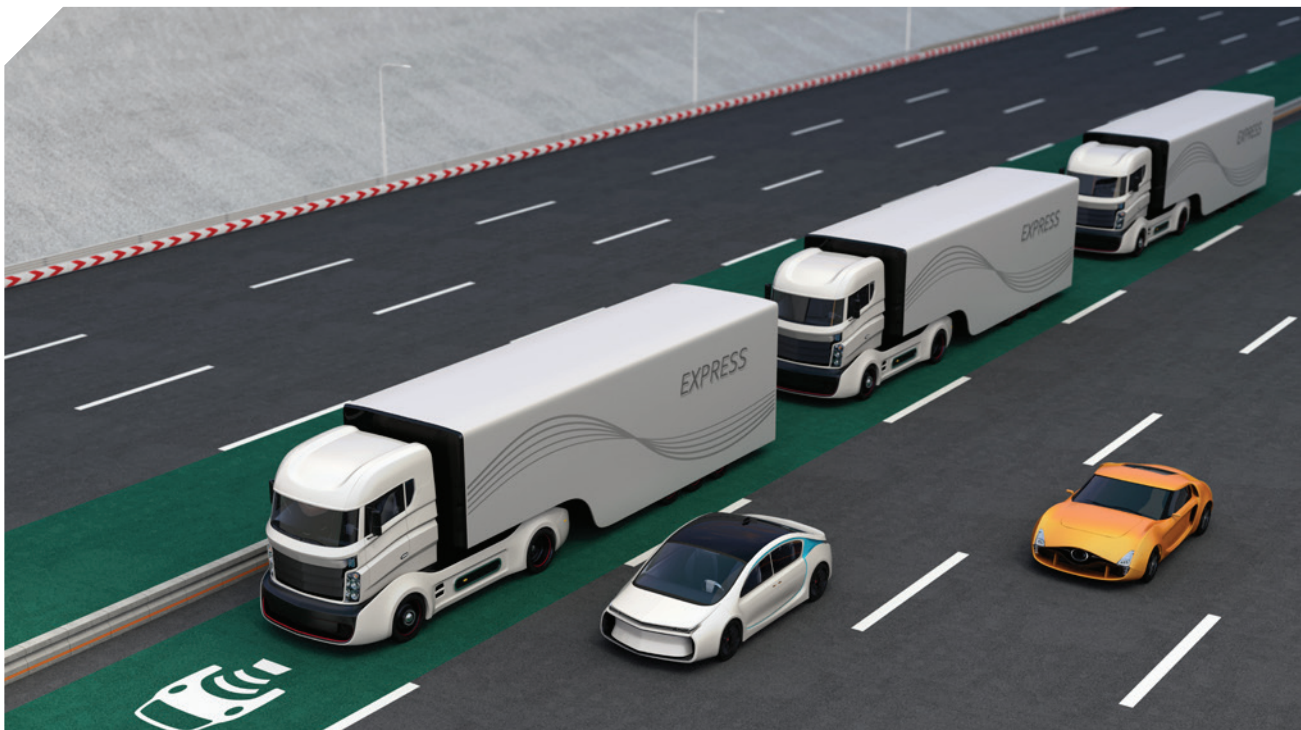
ARRIVÉE DES TECHNOLOGIES DES VÉHICULES AUTOMATISÉS ET BRANCHÉS

Le comité a entendu diverses prévisions quant au moment où les véhicules automatisés et branchés de niveaux supérieurs seront offerts sur le marché au Canada. Le comité estime toutefois que l'absence de politiques et d'approbation du public à cet égard constituera un plus grand obstacle que les difficultés techniques associées aux technologies des VA et des VB. Autrement dit, pour reprendre les propos de Thomas Small, directeur du Développement de nouveaux produits à New Flyer Industries Canada, « la technologie évoluera plus rapidement que la réglementation ».

En règle générale, les témoins étaient d'avis que les VA seraient d'abord déployés en parcs (p. ex. taxis, autobus, véhicules de livraison) et/ou dans des environnements fermés (p. ex. campus universitaires, parcs d'affaires ou – comme en ont été témoins les membres du comité – la Colline du Parlement). Kirk Steudle, directeur au Département des transports du Michigan, et Bernard Soriano, directeur adjoint du Département des véhicules motorisés de la Californie, ont indiqué que des navettes automatisées pourrait être utilisées pour le premier et le dernier segment des transports en commun (c.-à-d. pour le trajet de la maison à la station de métro ou l'arrêt d'autobus le plus près, et de la dernière station de métro, ou du dernier arrêt d'autobus à la destination finale).

> ## La technologie devancera la réglementation.
>
> – Thomas Small

Une des prévisions plus optimistes concernant l'arrivée des VA sur les voies publiques provenait de Barrie Kirk, directeur général, Centre d'excellence des véhicules automatisés du Canada (CAVCOE), qui estime que les véhicules entièrement autonomes adaptés aux voies publiques seront disponibles vers l'année 2020. Selon M. Kirk, la technologie des VA pourrait d'abord faire son arrivée sous forme de taxis.

Dans la même veine, Dominique Lemay, chef de la direction, Transdev Canada, a expliqué au comité que des véhicules de niveaux d'automatisation inférieurs ont déjà été commercialisés, et ce, plus tôt que prévu. À titre d'exemple, M. Lemay a indiqué que, il y a deux ans, son entreprise pensait pouvoir exploiter un VA de niveau inférieur dans cinq

ans, un objectif qu'elle a déjà atteint. M. Lemay a fait valoir que la même situation pourrait se répéter avec des véhicules ayant un niveau d'autonomisation supérieur, précisant que des VA de niveau 5 à faible vitesse pourraient être offerts sur le marché d'ici cinq ans seulement.

D'autres témoins ont parlé des défis techniques de la technologie des VA qu'il faudra surmonter. Comme l'a expliqué Denis Gingras, professeur, Laboratoire en intelligence véhiculaire, Université de Sherbrooke :

> *Typiquement, pour un véhicule qui roule à 100 kilomètres-heure, l'environnement du véhicule change toutes les trois secondes. C'est déjà énorme et cela demande donc des applications et des systèmes en temps réel qui sont très performants, et qui ont des temps de réponse très rapides. De plus, il y a un grand nombre de paramètres comme la météo, les conditions de trafic et les conditions routières. Tout cela mène à de nombreux scénarios de conduite qu'on ne peut pas tous prévoir ni envisager. On ne peut pas programmer un véhicule autonome de la même façon qu'on programme un système traditionnel tel qu'on le connaît aujourd'hui. Cela exige un système extrêmement robuste pour faire face à toutes ces variantes.*

> *(Denis Gingras, professeur, Laboratoire en intelligence véhiculaire, Université de Sherbrooke, 16 mai 2017)*

Dans un mémoire présenté au comité, le gouvernement des Territoires du Nord-Ouest indique que les routes de la région sont enneigées ou glacées de huit à dix mois par année, ce qui pourrait rendre difficile la reconnaissance de l'environnement par les capteurs des VA. En raison de ces différents défis techniques, Stephen Beatty, vice-président, Entreprise, Toyota Canada Inc., a dit croire que « nous sommes encore plus loin que ne le pensent les plus optimistes de voir des véhicules entièrement autonomes sur la route ».

Ross McKenzie, directeur général, Centre de recherche automobile de l'Université de Waterloo, a indiqué que les VA pouvant transporter des personnes à même une ville pourraient faire leur apparition dans 10 ou 15 ans, mais qu'il faudra probablement attendre de 20 à 30 ans avant de voir des VA assurant le transport interurbain des personnes.

Il y a aussi lieu de faire une distinction entre l'avènement des VA et leur intégration à une grande échelle. Todd Litman, directeur général, Victoria Transport Policy Institute, a expliqué que les familles de la classe moyenne ne pourront pas se permettre l'achat de VA pouvant fonctionner dans toutes les conditions avant les années 2040 ou 2050, et que les familles à faible revenu devront attendre encore plus longtemps pour pouvoir se procurer ces véhicules. Cela dit, comme il a été mentionné précédemment, les VA pourraient être déployés d'abord en parcs, ce qui pourrait permettre à une plus grande diversité de personnes d'y avoir recours au moyen de taxis ou d'autobus automatisés.

Des témoins ont expliqué au comité que le renouvellement des parcs de véhicules est habituellement un processus lent, ce qui signifie que les technologies des VA et des VB pourraient être intégrées de manière itérative au fil des prochaines décennies. Par exemple, Blake Smith, directeur, Durabilité, Environnement et Ingénierie de la sécurité, Ford Canada Limitée, a indiqué que, dans une année moyenne, c'est 8 % des parcs de véhicules qui est renouvelé, la moyenne d'âge des véhicules au Canada se situant à 10 ans. George Iny, directeur au siège social de l'Association pour la protection des automobilistes, a souligné qu'il a fallu de 12 à 30 ans pour que d'autres technologies automobiles, comme l'air conditionné et la transmission automatique, se retrouvent dans la moitié des véhicules circulant sur les routes.

Compte tenu des coûts probablement élevés des VA lors de leur commercialisation, certains témoins ont indiqué que le déploiement de cette technologie risque d'être plus lent dans les régions rurales puisque la faible densité de population ne permettra pas de répartir les coûts de la même manière que dans les régions urbaines.

Cela dit, certains témoins, comme M. Steudle, ont souligné que les VA pourront améliorer les déplacements dans les régions rurales une fois que la cartographie des lieux aura été établie pour les véhicules. En effet, Brenda Vrkljan, professeure agrégée, ergothérapie, École des sciences de la réadaptation, Université McMaster, a expliqué au comité que les VA et les VB ont le potentiel de « révolutionn[er] la promotion d'une mobilité sûre et viable, particulièrement pour les personnes âgées des régions rurales ».

AVANTAGES POTENTIELS DES VÉHICULES AUTOMATISÉS ET BRANCHÉS

Au cours des témoignages, le comité a entendu en détail la description des nombreux avantages que représentent les VA et les VB. Tous les témoins étaient d'avis que les technologies des VA et des VB sont hautement prometteuses, mais les opinions divergeaient en ce qui a trait au moment où se concrétiserait ce potentiel et à l'efficacité de son intégration. Les témoins ont abordé dans leurs interventions les principaux avantages suivants :

Avantages en matière de sécurité

En 1984, les routes du Canada ont fait 4 120 morts et 237 455 blessés, des chiffres ahurissants. Toutefois, en 2015, leur nombre avait respectivement chuté à 1 669 et 116 735 [9]. En dépit de cette tendance positive, il reste encore beaucoup à faire. Les collisions routières demeurent la principale cause de décès évitable chez les enfants et les adolescents, et elles imposent un lourd fardeau financier et affectif à de nombreuses familles au pays [10].

Le recul constant du nombre de décès et de collisions au cours des quarante dernières années peut être attribuable à une combinaison de facteurs, dont l'innovation industrielle (p. ex. la mise au point de la technologie des coussins gonflables) et les mesures gouvernementales (p. ex. l'adoption de lois provinciales obligeant tous les passagers d'un véhicule à porter une ceinture de sécurité). L'avènement des technologies des VA et des VB offrira à l'industrie et au gouvernement d'autres occasions d'améliorer considérablement la sécurité routière.

Aujourd'hui, on attribue jusqu'à 94 % des accidents de la route à l'erreur humaine et à de mauvaises décisions. Or, à mesure que les technologies des VA et des VB prendront en charge de plus en plus de fonctions assumées par le conducteur, l'importance de la faillibilité humaine diminuera radicalement.

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9   Transports Canada, *Statistiques sur les collisions de la route au Canada : 2015*, combiné à des statistiques antérieures de Transports Canada fournies par l'Institut d'assurance, *Les véhicules automatisés : conséquences pour l'industrie de l'assurance au Canada*, p. 19

10   Institut d'assurance, *Les véhicules automatisés : conséquences pour l'industrie de l'assurance au Canada*, p. 19.
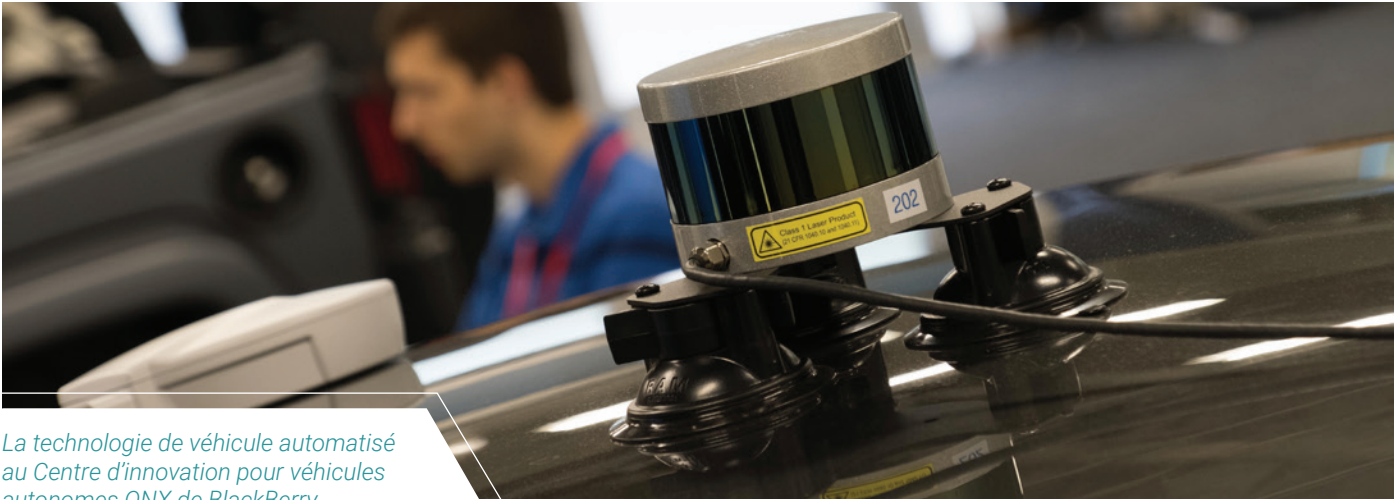
La technologie de véhicule automatisé au Centre d'innovation pour véhicules autonomes QNX de BlackBerry, à Kanata, en Ontario.

Par conséquent, bien que des témoins aient fait valoir que les technologies des VA et des VB n'élimineront pas totalement les accidents de la route, on s'attend quand même à ce qu'elles entraînent une réduction considérable du nombre de collisions sur les routes au Canada.

Plus concrètement, selon une <u>étude conjointe</u> du CAVCOE et du Conference Board du Canada, les VA pourraient prévenir jusqu'à 80 % des collisions routières et des décès causés par les accidents de la route. Même si ces améliorations ne se manifesteront pas immédiatement, David Ticoll, agrégé supérieur distingué, Innovation Policy Lab de la Munk School of Global Affairs de l'Université de Toronto, est d'avis qu'une adoption des VA et des VB «de l'ordre de 75 % pourrait presque mettre fin à l'ensemble des blessures et des décès liés à la circulation [11] ».

Les constructeurs offrent déjà des éléments de technologie automatisée dans leurs véhicules et ils sont nombreux à clamer haut et fort que la sécurité s'améliorera au cours des 10 prochaines années [12]. Nissan, par exemple, s'est fixé un double objectif : zéro émission et « virtuellement zéro » décès et blessure grave dans des collisions impliquant de nouveaux véhicules Nissan.

Les témoins ont cependant souligné que la période de transition – où les véhicules traditionnels et les véhicules automatisés partageront la route – sera probablement très difficile. (En effet, Ian Jack,

directeur général, Association canadienne des automobilistes (ACA), a <u>dit</u> ignorer si les routes seront plus sécuritaires ou plus dangereuses au cours de cette période.) Les dangers accrus pendant la période de transition découlent, en partie, du risque que les conducteurs en viennent à dépendre trop de la technologie et à prendre des décisions qu'ils n'auraient pas prises dans d'autres circonstances. Par ailleurs, certains conducteurs pourraient tout simplement choisir de désactiver les nouveaux dispositifs de sécurité [13].

Malgré leurs préoccupations au sujet du comportement des consommateurs, les représentants de l'Institut d'assurance du Canada se sont <u>dits</u> « fort impressionnés par le potentiel de la technologie qui existe actuellement, […] sans parler des améliorations […] fascinantes attendues dans les prochaines années ». D'après l'Institut, la coopération entre l'industrie et le gouvernement est essentielle pour tirer profit des avantages offerts par les technologies des VA et des VB sur le plan de la sécurité :

> *Aspect important, il faudra du temps aussi pour enseigner aux conducteurs la meilleure façon d'utiliser la nouvelle technologie. Il faudra remanier les programmes de formation des conducteurs et les rendre obligatoires. La combinaison d'une exigence prochaine, qui obligera les fabricants à installer les systèmes automatisés à bord des véhicules neufs, et de la formation des conducteurs*

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11 *Ibid*.

12 Institut d'assurance, *Les véhicules automatisés : conséquences pour l'industrie de l'assurance au Canada*, p. 24.

13 *Ibid*., p. 26.

pourrait permettre, au cours de la prochaine décennie, d'éliminer en grande partie les pertes de vie dues aux collisions.

(Paul Kovacs, chercheur et auteur, Institut d'assurance du Canada, 4 octobre 2017)

Avantages pour l'environnement

De nombreux témoins ont décrit au comité les avantages possibles des VA et des VB pour l'environnement. Plus particulièrement, bon nombre de témoins ont expliqué que les VA pourront réduire la congestion routière et, par conséquent, réduire la consommation de combustibles fossiles et la pollution qu'engendre la marche au ralenti causée par la circulation dense. Cet avantage s'explique par le fait que, combinées, l'automatisation des véhicules et la connexion aux infrastructures peuvent atténuer de nombreux facteurs qui causent la congestion, comme les incidents de circulation et la mauvaise synchronisation des feux de circulation [14].

Malgré cet avantage potentiel, des témoins ont fait valoir que la réduction de la congestion n'est pas un résultat garanti, mais qu'elle dépend plutôt de l'adoption de politiques gouvernementales adéquates. Par exemple, Patrick Leclerc, président-directeur général, ACTU, a expliqué que les VA inoccupés en route vers la maison ou pour passer prendre des passagers créeraient «un nouveau type de circulation composée de véhicules sans occupants», ce qui minerait les objectifs de durabilité environnementale. Compte tenu de cette préoccupation et d'autres facteurs, M. Ticoll a encouragé le gouvernement à se pencher sur la question du contrôle de l'usage des véhicules dans un contexte où les déplacements sur demande seront peu coûteux et pratiques. M. Litman a exprimé le même point de vue, indiquant que les VA risquent d'augmenter les déplacements routiers si l'on n'adopte pas de politiques efficaces concernant le réseau routier et les droits de péage.

M. Litman a en outre soulevé la question de l'équité sociale. Bien qu'il estime «peu probable» que les VA réduisent la circulation dans les rues des villes dans un proche avenir, il a fait valoir que l'installation de voies réservées aux VA réduiraient la congestion sur les autoroutes. Il a néanmoins indiqué que le financement public de ces voies réservées pourrait

être problématique sur le plan de l'équité sociale, puisque seuls ceux ayant les moyens d'acheter un VA pourraient les utiliser (comme mentionné précédemment, on s'attend à ce que les VA soient relativement chers lors de leur arrivée sur le marché).

M. Leclerc a indiqué que les avantages environnementaux des VA pourraient également être minés par la courte durée de vie de ces véhicules. Citant une récente étude de Goldman Sachs, il a expliqué que la valeur des taxis autonomes risque de se déprécier sur une période de trois ans seulement, après quoi leur valeur résiduelle serait nulle. Si, comme le prédisent certains, le recours aux services de transport devient plus populaire que l'achat d'un véhicule privé, il en découle qu'on remplacera un plus grand nombre de voitures à une fréquence plus élevée.

On s'attend à ce que les avantages environnementaux d'une plus grande automatisation et connectivité soient accentués par l'adoption parallèle d'un plus grand nombre de véhicules électriques. Plusieurs témoins, dont David Paterson, vice-président, Affaires corporatives et environnementales, Compagnie General Motors du Canada (GM), estiment que l'avenir de la mobilité réside dans la propulsion électrique. Par conséquent, selon des représentants de Ressources naturelles Canada (RNCan), une tendance plus marquée vers l'électrification des transports pourrait grandement contribuer à la réduction des émissions de gaz à effet de serre dans le secteur des transports au Canada.

Avantages sur le plan humain et social

Des témoins ont parlé du rôle que peuvent jouer les VA et les VB pour favoriser l'inclusion sociale. Une société inclusive du point de vue social donne à toutes les personnes et à toutes les communautés la chance de participer pleinement à la vie politique, culturelle, citoyenne et économique. Selon des études, une société inclusive favorise une cohésion sociale accrue et des normes supérieures en santé, tandis que l'exclusion sociale et le manque d'interaction avec la collectivité sont associés à des résultats inférieurs en matière de santé et à une vie plus courte [15].

L'exclusion sociale touche un large éventail de personnes et de communautés, bien que certains groupes, comme les personnes âgées et les personnes

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14   Voir David Ticoll, *Driving Changes: Automated Vehicles in Toronto*, 15 octobre 2015, par. 5.5.

15   Healthy Spaces and Places, *Social Inclusion*.

aux prises avec des contraintes à l'emploi, soient particulièrement vulnérables. De nombreux facteurs contribuent à l'exclusion sociale, et on estime que l'insuffisance de transports en est un des principaux. En effet, ne pas avoir accès aux transports en commun ou ne pas pouvoir utiliser un moyen de transport personnel peut empêcher certaines personnes de recevoir des soins de santé, de trouver un emploi ou de participer à des activités sociales. Ce problème peut être particulièrement grave dans les régions rurales.

Des témoins ont dit au comité que les technologies des VA et des VB ont beaucoup à offrir aux gens qui n'ont jamais pu conduire et à ceux qui ne peuvent plus le faire. Mme Vrkljan a parlé du « désarroi » de certains de ses patients lorsqu'ils ont dû renoncer à leur permis de conduire, et elle a remarqué que le fait de cesser de conduire est lié à « un isolement social, à la détérioration de l'état de santé, à un taux accru de dépression et même à une institutionnalisation ». Elle a reconnu que les technologies des VA et des VB pourraient offrir une « mobilité sûre et viable », surtout aux Canadiens âgés des régions rurales.

Cela étant dit, des témoins ont aussi convenu que les VA et les VB ne sont pas une panacée pour les personnes âgées et les personnes handicapées. Bob Brown, président du Comité des transports du Conseil des Canadiens avec déficiences, a expliqué que la technologie, à elle seule, ne pourrait pas résoudre tous les problèmes liés au transport. En guise d'exemple, il a souligné que de nombreux passagers handicapés ont besoin d'aide pour utiliser le système de retenue du véhicule et que d'autres ont de la difficulté à effectuer un paiement de façon autonome. En outre, certains témoins ont souligné qu'il faudrait que les VA soient abordables pour les communautés que l'on cherche à aider.

Des témoins ont précisé qu'on pourrait toutefois remédier à bon nombre de ces difficultés par l'application de principes de conception universelle aux VA et aux VB. Les produits qui respectent ces principes peuvent être utilisés par tout le monde – dans la plus grande mesure possible – sans qu'il soit nécessaire de les adapter ou d'adopter des solutions stigmatisantes. M. Brown a déclaré au comité que les principes de conception universelle doivent être incorporés non seulement à la conception des véhicules, mais aussi à la conception des infrastructures connexes, comme les bornes de recharge pour les véhicules électriques.

On s'attend à ce que l'amélioration de la mobilité ne découle pas uniquement de l'achat de VA privés, mais aussi de la mise en place de services de covoiturage. Au cours de son témoignage devant le comité, Uber a expliqué qu'il cherchait à établir des partenariats publics-privés avec le gouvernement pour inciter les conducteurs à mieux répondre aux besoins des personnes handicapées. Des projets similaires sont déjà en place ailleurs. Par exemple, en septembre 2016, le département des Transports du Massachusetts a lancé un programme pilote en collaboration avec Uber et Lyft afin d'offrir des services de transport à des usagers du transport adapté.

Par ailleurs, des témoins ont indiqué que les services de transport partagé sur demande pourraient améliorer la mobilité dans les collectivités où l'accès aux transports en commun est limité. Rick Baker, président du chapitre d'Ottawa de CARP (anciennement appelée la Canadian Association for Retired Persons), a fait remarquer que de nombreux Canadiens de tous âges conduisent non pas parce qu'ils le souhaitent, mais « parce qu'ils n'ont pas d'autre choix raisonnable ». M. Leclerc, quant à lui, estimait que les navettes électriques automatisées sur demande pourraient remédier à ce problème en offrant aux administrations locales une solution de rechange plus économique que les transports en commun classiques. Le partenariat en transport partagé conclu entre Uber et le village d'Innisfil, en Ontario, est un exemple concret de ce type d'initiative.

Comme on le verra plus loin dans le rapport, ces nouvelles technologies pourraient être intégrées aux réseaux de transport en commun actuels tout en offrant de nouveaux modes de transport qui pourraient être incorporés aux réseaux classiques.

Avantages économiques

Le comité a entendu de nombreux témoignages sur les avantages économiques potentiels des technologies des VA et des VB. Toutefois, comme on est loin de savoir quand les VA auront pénétré le marché complètement et quel effet ils auront sur l'économie une fois qu'ils seront adoptés par tout le monde, les témoins ont souvent fait preuve de prudence dans leurs projections et leurs estimations.

Cela dit, plusieurs témoins ont cité les prévisions du Conference Board du Canada, mentionnées précédemment, selon lesquelles les avantages

Le vice-président du comité, le sénateur Dennis Dawson, à gauche, et un membre du comité, le sénateur Art Eggleton, font l'essai d'une navette automatisée sur la Colline du Parlement lors d'une démonstration en septembre 2017.

potentiels cumulatifs pour le Canada pourraient atteindre environ 65 milliards de dollars par année. Dans son mémoire, Brian Flemming, de l'Institut Van Horne (un des coauteurs du rapport du Conference Board du Canada), précise que ces économies potentielles proviendraient de l'évitement des collisions, de la réduction de la consommation de carburant, de l'évitement de la congestion et de l'augmentation de la productivité. Cette productivité accrue serait attribuable au fait que les personnes passeraient moins de temps dans leur voiture, mais aussi au fait que les voitures seraient utilisées de manière plus productive (selon un représentant de RNCan, à l'heure actuelle, les voitures sont stationnées 96 % du temps).

Au-delà des gains de productivité individuelle, des témoins ont également parlé des gains de productivité globale que pourraient engendrer les technologies des VA et des VB dans certains secteurs de l'économie. Par exemple, M. Prigge a expliqué que les technologies des VA et des VB pourraient améliorer la productivité dans les secteurs minier, agricole et forestier, et M. Ticoll prévoyait une augmentation de la productivité ainsi qu'une croissance dans les secteurs de la technologie, de l'automobile, de la vente au détail et des transports.

Soulignant que les ménages canadiens consacrent en moyenne 11 000 $ au transport chaque année, M. Flemming a indiqué au comité, dans son mémoire, que les VA et les VB engendreraient des économies considérables pour les consommateurs. Dans la même veine, M. Ticoll a fait valoir que les VA et les VB pourraient réduire le coût total de l'achat et de l'entretien des véhicules de 50 % ou plus. Cependant, plusieurs témoins, dont M. Litman, ont indiqué que les VA resteront inabordables pour les familles à revenu moyen ou faible dans un avenir prévisible.

PROBLÈMES POTENTIELS LIÉS AUX VÉHICULES AUTOMATISÉS ET BRANCHÉS

Le comité a également entendu de nombreux témoignages sur les problèmes potentiels associés aux VA et aux VB, quoique bon nombre de témoins aient ajouté qu'une planification attentive, des décisions éclairées et un solide leadership de la part du gouvernement fédéral pourraient atténuer les effets les plus appréhendés. Les témoins ont abordé dans leurs interventions les principaux problèmes suivants :

Perte d'emplois

Les technologies perturbatrices comme les VA et les VB bouleversent le paysage socioéconomique et sont, partout dans le monde, la source de préoccupations en ce qui concerne les pertes d'emplois et l'inégalité économique. M. Ticoll a affirmé que, bien que ses effets sur l'économie canadienne ne soient pas entièrement connus, la révolution des VA pourrait «provoquer des pertes d'emplois dans des secteurs ou des domaines qui emploient plus de 1,1 million de Canadiens». Les témoins ont affirmé que le déplacement d'emplois directs toucherait notamment les occupations suivantes :

- Camionneurs et messagers
- Chauffeurs de taxi, de bus, de déneigeuse
- Agents de police de la circulation et brigadiers
- Instructeurs de conduite
- Conducteurs de dépanneuse et personnel d'atelier de réparation automobile
- Professionnels de la santé et avocats (en raison de la diminution du nombre de collisions)
- Agents d'assurance automobile et représentants en assurance automobile
- Préposés au stationnement
- Employés de station-service

Tous les témoins ont indiqué qu'il y aurait des pertes d'emplois, mais certains ont fait valoir que ces pertes seraient partiellement contrebalancées par la modification des tâches des emplois concernés. Par exemple, le surintendant principal Eric Stubbs, directeur général, Service national des enquêtes criminelles, Services de police contractuels et autochtones de la Gendarmerie royale du Canada, était d'avis que la redistribution des ressources est un scénario plus probable que la perte d'emplois dans le secteur des services policiers. Dans la même veine, Jonathan Will, directeur général, Direction de la politique économique, Direction générale des politiques stratégiques et de service, Emploi et Développement social Canada (EDSC), a indiqué que de nouveaux emplois pourraient être créés dans les secteurs touchés, soulignant, par exemple, que le secteur du transport routier devra peut-être embaucher du personnel responsable du contrôle des parcs de camions autonomes. En outre, certains témoins étaient d'avis que les effets ne se feraient pas sentir dans un proche avenir. Wendy Doyle, coprésidente, Groupe de travail sur les véhicules automatisés, Conseil canadien des administrateurs en transport motorisé (CCATM), a fait observer ce qui suit :

> Dans l'industrie commerciale, en raison de la tâche complexe que constitue le transport des gros chargements, il faudra beaucoup de temps avant que la technologie puisse faire tout ce que les conducteurs doivent faire et les remplacer. J'ai mentionné un peu plus tôt une partie des exigences en matière d'arrimage des cargaisons et d'entretien pour les véhicules commerciaux. Si les phares ne fonctionnent plus ou qu'un problème de freinage survient, l'humain fait les réparations. Ce serait encore ce à quoi nous nous attendrions, car nous voulons toujours nous assurer que les véhicules qui circulent sur nos routes sont sécuritaires, qu'ils soient hautement automatisés ou non. Il y a encore de la place pour les conducteurs de véhicules commerciaux. La technologie remplacera une partie des tâches liées à la conduite. Je crois qu'il faudra beaucoup de temps avant que cela ait des conséquences sur le travail des conducteurs de véhicules commerciaux. Nous savons qu'il y a une pénurie de conducteurs de véhicules commerciaux également, et c'est donc un avantage.

> (Wendy Doyle, coprésidente, Groupe de travail sur les véhicules automatisés, CCATM; ministère des Transports de l'Alberta, gouvernement de l'Alberta, 5 avril 2017)

De plus, des témoins ont fait valoir que les nouvelles technologies pourraient remédier, dans certains cas, à la pénurie de main-d'œuvre actuelle. Par exemple, des témoins représentant le secteur du camionnage ont indiqué qu'on s'attend à une pénurie de 25 000 à 30 000 camionneurs d'ici 2024, mais que ce problème pourrait être atténué par l'arrivée des VA et des VB.

D'autres témoins, toutefois, étaient moins optimistes. M. Ticoll a affirmé qu'il «est difficile de prédire si le résultat net sera positif », et d'autres ont fait état de la vulnérabilité de certaines compétences et aptitudes. Par exemple, Tony Qiu, professeur, Faculté de génie, Université de l'Alberta, a décrit pour le comité le projet pilote d'un centre de villégiature dans le cadre duquel on a mis à l'essai un service de navette automatisée pour les clients. Bien que ce service n'ait entraîné aucune perte d'emploi nette, puisque l'entreprise a embauché des techniciens responsables de l'entretien du VA, le chauffeur a tout de même perdu son emploi.

Enfin, Phil Benson, lobbyiste pour Teamsters Canada, a soulevé la question du déplacement des pensions et des prestations de retraite des chauffeurs. Dans le mémoire qu'il a présenté au comité, il a indiqué que, si l'arrivée des VA entraîne une baisse du nombre de chauffeurs et, donc, du nombre de personnes contribuant aux régimes de retraite, «plus grande sera la probabilité que ces régimes ne tiennent pas leurs promesses en raison d'un sous-financement ».

> **Les chauffeurs du secteur commercial ont encore leur place. La technologie remplacera une partie de la conduite du véhicule.**
>
> – Wendy Doyle

Protection des renseignements personnels

De nombreux témoins ont indiqué que les VA carburent aux données. Le commissaire à la protection de la vie privée du Canada, Daniel Therrien, a expliqué au comité qu'il existe deux flux de données dans ces véhicules :

> Le premier vient de la « télématique », c'est-à-dire les capteurs qui saisissent un large éventail de renseignements sur les systèmes de véhicule. À partir de ces renseignements, on peut extrapoler d'autres données concernant le conducteur, par exemple son mode de conduite et ses allées et venues. Le deuxième flux vient des « systèmes d'infodivertissement ». Ces systèmes permettent la transmission de renseignements concernant la navigation, la circulation, la météo ou des divertissements, par exemple la diffusion audio en continu. Ils peuvent aussi être jumelés avec le téléphone du conducteur pour permettre les communications mains libres, ce qui donne accès à sa liste de contact de même qu'à ses appels entrants, à ses messages texte et à ses courriels.
>
> (Daniel Therrien, commissaire à la protection de la vie privée du Canada, Commissariat à la protection de la vie privée du Canada, 28 mars 2017)

Les constructeurs d'automobiles utilisent les données produites par les systèmes télématiques pour améliorer leurs produits et pour d'autres utilisations bénéfiques. Par exemple, M. Adam a expliqué au comité que les constructeurs d'automobiles utilisent les données pour établir des « réseaux neuronaux », qui constituent les fondements de l'avenir des VA. En outre, M. Adam a indiqué que les données peuvent être utilisées pour analyser les accidents et mieux comprendre la circulation. Pour ces raisons, certains témoins, dont M. Adam et M. Smith, ont affirmé que les données peuvent servir l'intérêt public puisqu'elles améliorent le fonctionnement des écosystèmes de transport.

Toutefois, comme l'a expliqué la British Columbia Freedom of Information and Privacy Association (BC FIPA), les données produites par les VA et les VB peuvent également servir à établir le profil des utilisateurs et à les catégoriser aux fins de marketing ciblé [16]. M. Jack a indiqué au comité que les constructeurs d'automobiles recueillent de vastes quantités de données « dans l'espoir de les monnayer », ajoutant que les nouveaux arrivants sur le marché se positionneraient plus rapidement que les constructeurs d'automobiles traditionnels pour exploiter les occasions financières que représentent les données sur les consommateurs.

Compte tenu des occasions financières potentielles que représentent les données sur les consommateurs, des témoins ont soulevé d'importantes questions sur la propriété des données. M. Jack a attiré l'attention du comité sur une enquête de KPMG qui a démontré que 84 % des consommateurs souhaitent obtenir une compensation financière directe en échange de leurs données, alors que 45 % des dirigeants du monde automobile sont d'avis qu'il ne leur appartient pas d'offrir quoi que ce soit en échange des données [17]. Plusieurs témoins ont fait valoir que, au sujet de la propriété des données, il est important d'établir une distinction entre les données essentielles au fonctionnement du véhicule et les données recueillies à d'autres fins.

Au cours des témoignages, le comité a entendu à plusieurs reprises des préoccupations sur le caractère adéquat des processus employés par les constructeurs d'automobiles et leurs partenaires afin d'informer les consommateurs sur l'utilisation qui est faite de leurs données et des tiers avec lesquels elles sont partagées. Plusieurs témoins, dont le commissaire à la protection de la vie privée, ont dit que le fait que les agences de location de voitures n'effacent pas les données des consommateurs au retour d'une voiture est une source de préoccupation. Tomi Gerber, vice-présidente adjointe, Affaires gouvernementales et publiques, Enterprise Holdings, a reconnu ce problème et a expliqué que son industrie tente de trouver une solution de concert avec les constructeurs d'automobiles.

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16 Philippa Lawson, Brenda McPhail et Eric Lawson, *The Connected Car: Who Is in the Driver's Seat? – A study on privacy and onboard vehicle telematics technology*, BC FIPA, Vancouver, 2015, p. 29.

17 KPMG, *Global Automotive Executive Survey* 2017, p. 39.

Cybersécurité

Il n'y a pas que les constructeurs d'automobiles et leurs partenaires qui trouvent utiles les données produites par les VA et les VB; les pirates informatiques aux intentions malveillantes les trouvent eux aussi alléchantes. Scott Jones, chef adjoint, Sécurité des TI, Centre de la sécurité des télécommunications (CST), a décrit la menace à la cybersécurité comme suit :

[L]a jonction de ces technologies pourrait représenter pour le Canada et les Canadiens de nombreux avantages économiques et sociaux. On pense entre autres à l'amélioration des déplacements des biens et services, et à une plus grande sécurité sur nos routes. D'un autre côté, nous risquons d'être plus vulnérables en nous exposant aux cybermenaces d'États-nations, de criminels, de terroristes et de pirates informatiques qui chercheront à exploiter ces nouvelles technologies du transport pour des motifs différents : pour l'argent, pour créer le chaos, ou seulement parce qu'ils en ont l'occasion.

(Scott Jones, chef adjoint, Sécurité des TI, CST, 4 avril 2017)

M. Jones a indiqué que les Canadiens sous-estiment souvent les menaces à la cybersécurité puisque les atteintes à la sécurité ne semblent pas avoir d'incidence sur leur vie. Il a expliqué, par exemple, que lorsqu'un pirate dérobe de l'argent dans un compte bancaire, la banque rembourse habituellement le montant volé au client. Puisque les conséquences d'une cyberattaque contre un VA ou un VB pourraient être plus immédiates, M. Jones s'est dit d'avis que l'intégration des VA pourrait amener les consommateurs à prendre conscience de la gravité de la menace à la cybersécurité et à réfléchir aux conséquences que peuvent engendrer des mesures de précautions inadéquates. Selon lui, il faudra tenir des discussions de fond avec les intervenants afin d'établir un bon équilibre entre la sécurité et les services aux clients.

Tout en reconnaissant la gravité de la cybermenace, plusieurs témoins se sont dits sûrs que la cybersécurité est une priorité pour l'industrie. M. Chennakeshu a expliqué au comité que les constructeurs d'automobiles et leurs fournisseurs sont tout à fait conscients que toute faille dans la sécurité des véhicules pourrait miner l'adoption des VA et des VB et entacher leur réputation. M. Chennakeshu a également indiqué au comité que BlackBerry a établi un cadre visant à mettre au point des solutions holistiques en matière de cybersécurité.

M. McKenzie a expliqué que la cybersécurité est «quelque chose dont [les chercheurs] s'occupe[nt] énergiquement et qu'[ils] étudie[nt] activement». Par exemple, le comité a pris connaissance de technologies, comme les chaînes de blocs et les infrastructures à clés publiques (ICP), qui peuvent renforcer l'intégrité de l'écosystème des transports. En outre, M. McKenzie a noté qu'il existe des

technologies qui facilitent la détection d'activités louches, mais a reconnu qu'aucune technologie n'est infaillible. Cela dit, M. Qiu a fait valoir au comité que le principal défi ne consiste pas à surmonter les obstacles techniques, mais bien à veiller à l'élaboration de politiques qui appuieront efficacement les mesures mises en place.

En ce qui concerne les activités de l'industrie, M. McKenzie a indiqué au comité que GM s'est dotée d'une équipe de cybersécurité collaborant avec des « hackeurs éthiques [18] » pour mieux comprendre les intentions des pirates informatiques. Mark Nantais, président, Association canadienne des constructeurs de véhicules, a expliqué au comité que l'industrie automobile a créé en juillet 2015 l'Automotive Information Sharing and Analysis Centre (Auto ISAC) chargé de recueillir et partager de l'information sur les cybermenaces et de veiller à la protection des systèmes et réseaux électroniques. M. Paterson a également mentionné l'Auto ISAC et l'importance de l'échange de l'information pour assurer la sécurité. Il a souligné que les constructeurs d'automobiles et leurs fournisseurs ne cherchent pas à se donner un avantage concurrentiel dans les questions liées à la cybersécurité.

Étalement urbain

On s'attend à ce que l'intégration à grande échelle des VA et des VB modifie la manière dont les villes grandissent et se développent. Des témoins ont souligné deux grandes tendances possibles : l'augmentation de l'étalement urbain et la densification urbaine. Le modèle de la densification urbaine compte sur la disparition des espaces de stationnement, dont les terrains serviront à bâtir de nouveaux logements, alors que le modèle de l'étalement urbain suppose que les gens accepteront de plus longs déplacements s'ils sont en mesure d'être productifs durant le trajet [19]. Ces deux modèles ne sont pas mutuellement exclusifs. Des témoins ont ajouté que les anciens terrains de stationnement pourraient être convertis en autre chose que des logements, par exemple des promenades piétonnières, des pistes cyclables et des espaces verts.

Globalement, les témoins étaient d'avis que la manière dont se concrétiseront ces avantages et ces inconvénients dépendra de la façon dont l'automatisation et la connectivité de niveaux supérieurs seront déployées, plus particulièrement en ce qui a trait au débat sur les véhicules partagés et les véhicules privés.

Infrastructure

Comme nous le verrons plus loin dans le rapport, des témoins ont parlé de l'ampleur de l'aménagement en infrastructure nécessaire pour que l'intégration des VA et des VB soit réussie. Bien que les constructeurs de VA s'efforcent de construire des véhicules qui peuvent utiliser l'infrastructure existante, des témoins ont indiqué que de nouvelles infrastructures permettraient de tirer le maximum de ces véhicules à long terme. Selon des témoins, deux des grands problèmes qui se poseront consisteront à déterminer qui devra financer ces infrastructures ainsi que l'intégration des considérations liées aux VA et aux VB dans la planification des infrastructures.

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18 Un « hackeur éthique », aussi appelé « white hat », est un expert de la sécurité informatique qui effectue des tests d'intrusion afin d'assurer la sécurité des systèmes informatiques d'un organisme.

19 Brian Flemming (l'Institut Van Horne), Les véhicules automatisés : L'avènement de la prochaine technologie perturbatrice, 28 janvier 2016, p.9.

Un véhicule automatisé, construit par la compagnie française Transdev, a conduit les membres du comité et le ministre fédéral des Transports sur les terrains de la Colline du Parlement lors d'une démonstration en septembre 2017.

INITIATIVES EN PLACE AU CANADA

De manière générale, le gouvernement fédéral est responsable de la réglementation de la sécurité des véhicules, tandis que les gouvernements provinciaux et territoriaux sont responsables de la réglementation des routes où circulent ces véhicules. Comme nous le verrons dans la partie 2 du rapport, le gouvernement fédéral peut jouer lui aussi un rôle dans plusieurs autres domaines liés aux VA et aux VB.

Des témoins ont présenté au comité les travaux en cours, tant à l'échelle fédérale que provinciale, pour se préparer à l'arrivée des technologies des VA et des VB.

Gouvernement fédéral

Le ministre des Transports a proposé au comité ce sujet d'étude afin d'aider Transports Canada à mettre au point des mesures tenant compte des technologies des VA et des VB. D'après de nombreux témoins, ce travail est déjà en cours.

Des témoins ont également expliqué au comité que Transports Canada collabore avec les États-Unis sur le dossier des VA et des VB par l'intermédiaire du Conseil de coopération en matière de réglementation (CCR). Le CCR s'est doté d'un groupe de travail sur les VB et d'un groupe de travail sur les normes de sécurité des véhicules motorisés, qui abordent tous deux des enjeux liés aux VA et aux VB.

Le CTRVM de Transports Canada à Blainville, au Québec, effectue des tests pour s'assurer que les véhicules respectent les normes de sécurité du Canada [20]. Le CTRVM mène également des tests de recherche avec Transports Canada pour aider le ministère dans l'élaboration de nouvelles normes ou la modification de normes existantes. Les constructeurs d'automobiles peuvent également faire appel aux services du CTRVM pour effectuer des tests de conformité afin de s'assurer que leurs véhicules satisfont aux normes de sécurité canadiennes. Comme il a été mentionné précédemment, Transports Canada a fait partie du partenariat qui a mis à l'essai au CTRVM la technologie de circulation de camions en pelotons.

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20   Le CTRVM est la propriété de Transports Canada, mais PMG Technologies inc. détient un contrat pour en faire l'exploitation.

Les représentants d'ISDE ont fait la description du Programme d'innovation pour les fournisseurs du secteur de l'automobile et du Fonds d'innovation pour le secteur de l'automobile, qui visent tous deux la recherche-développement dans le secteur de l'automobile et qui pourraient appuyer la technologie des VA et des VB.

Des témoins ont également mentionné l'Initiative des supergrappes d'innovation d'ISDE, un programme de 950 millions de dollars qui vise à « renforcer les grappes existantes de forces commerciales, attirant un éventail d'industries hautement innovantes, de petites et moyennes entreprises (PME) ainsi que des talents en recherche pertinents pour l'industrie, et ce, dans le but de réunir les conditions nécessaires à l'élaboration d'une supergrappe qui incarne l'excellence et le leadership mondial du Canada ». On compte parmi les demandeurs présélectionnés invités à la deuxième phase du processus de demande une « supergrappe des chaînes d'approvisionnement axées sur l'IA » au Québec et une « supergrappe des systèmes et des technologies de mobilité du XXIᵉ siècle » au Québec, en Ontario, en Colombie-Britannique et au Canada atlantique.

Le mémoire du CNR souligne le Programme Flottes futures 2020, qui vise à améliorer l'efficience des parcs de véhicules et à réduire les émissions des véhicules utilitaires lourds. Les tests de circulation de camions en pelotons menés au CTRVM faisaient partie de ce programme du CNR. Dans le cadre de ce même programme, le CNR a également mis à l'essai une technologie de VB qui informe les véhicules circulant dans un secteur de l'arrivée d'un train avant qu'ils n'arrivent au passage à niveau.

Dans son mémoire, le CNR indique qu'il compte ouvrir un centre de collaboration automobile dans ses installations de London, en Ontario. Cet espace de travail collaboratif, dont l'ouverture est prévue en avril 2018, devrait aider les constructeurs d'automobiles à adopter des approches de construction de pointe et à utiliser de nouveaux matériaux et de nouvelles technologies, comme les VA et les VB.

Comme l'a noté M. Ticoll dans son mémoire, le budget de 2017 octroyait 125 millions de dollars à l'Institut canadien de recherches avancées (ICRA) pour le développement d'une stratégie pancanadienne sur l'intelligence artificielle (IA). Le site Web de l'ICRA indique que la stratégie vise à faire croître le nombre de chercheurs et de diplômés spécialisés dans le domaine de l'IA et à établir des centres d'excellence scientifique dans trois régions du Canada (Edmonton, en Alberta; le couloir Toronto-Waterloo, en Ontario; et Montréal, au Québec) qui possèdent déjà des grappes d'expertise en intelligence artificielle.

Des témoins ont en outre mentionné le Défi des villes intelligentes d'Infrastructure Canada, dans le cadre duquel le gouvernement fédéral « travaillera en collaboration avec les villes et les collectivités qui sont prêtes à innover et à prendre des risques, en leur offrant du soutien financier et non financier pour les aider à devenir des villes encore plus intelligentes ». Le programme comprend trois rondes, et à l'issue de chacune seront remis un grand prix de 50 millions de dollars, deux prix de 10 millions de dollars à des collectivités de taille moyenne, un prix de 5 millions de dollars à une collectivité de petite taille et un prix de 5 millions de dollars à une communauté autochtone. M. Qiu était d'avis que ce défi représente « une bonne occasion de favoriser l'avènement, ou du moins l'essai, des véhicules automatisés et branchés ».

Dans son mémoire, le Conseil de recherches en sciences naturelles et en génie du Canada (CRSNGC) dit que l'on a également octroyé aux chercheurs canadiens des fonds fédéraux pour la recherche sur les VA et les VB. De 2007 à 2016, le CRSNGC a accordé 40 249 696 $ par l'intermédiaire de 327 bourses distinctes remises à des chercheurs canadiens œuvrant dans la conception ou la mise à l'essai des technologies des VA et des VB.

Dans son mémoire, le Conseil de recherches en sciences humaines du Canada (CRSHC) affirme que, depuis 2007, il a versé 5 201 115 $ en bourses à cinq projets de recherche comprenant un volet sur les VA et/ou les VB et leurs répercussions économiques, juridiques, sociales ou stratégiques. Le CRSHC note, toutefois, que la majorité de ce financement (5 054 750 $) a été versé à deux grandes initiatives (Réseau Auto21 et Partenariat automobile du Canada) qui englobaient des projets de recherche sur divers sujets et que, par conséquent, il est difficile de déterminer la part de financement qui a servi à appuyer les recherches sur les VA ou les VB.

Les membres du comité écoutent les représentants du centre de véhicules autonomes QNX de BlackBerry expliquer leur travail. La sénatrice Rosa Galvez, quatrième à partir de la gauche, le vice-président, le sénateur Dennis Dawson, au centre, et le sénateur Terry Mercer, troisième à partir de la droite, étaient parmi les membres du comité qui ont entrepris une mission d'étude à l'installation située à Kanata, en Ontario, en juin 2017.

Gouvernements provinciaux et territoriaux

Les provinces et les territoires du Canada traitent eux aussi des enjeux liés aux VA et aux VB par l'intermédiaire du Conseil des ministres et des sous-ministres responsables des transports et de la sécurité routière (CMT). Le Conseil canadien des administrateurs en transport motorisé, un sous-comité du CMT, coordonne les questions fédérales, provinciales et territoriales liées à l'administration, à la réglementation et au contrôle des transports motorisés et de la sécurité routière. Comme l'a expliqué au comité un représentant du CCATM :

Nous offrons un forum où les représentants des administrations provinciales, territoriales et fédérales peuvent communiquer, travailler en coordination et examiner des questions d'importance nationale en matière de compétences, et où nos membres peuvent soulever des enjeux et de sorte que nous puissions proposer des idées et trouver les solutions ayant les meilleurs effets. En tant que forum, nous recherchons l'harmonisation à l'échelle nationale dans tous les cas possibles, mais nous voulons aussi reconnaître l'autonomie des provinces, des territoires et du fédéral compte tenu des compétences de chacun.

(Allison Fradette, directrice générale, CCATM, 5 avril 2017)

En juin 2014, le CCATM a mis sur pied un groupe de travail coprésidé par des représentants de l'Alberta et de la Colombie-Britannique et chargé d'élaborer des lignes directrices et de diffuser des pratiques exemplaires liées à l'arrivée des VA sur les voies publiques. Dans la même veine, le comité de soutien de la politique et la planification du CMT a créé un groupe de travail, coprésidé par Transports Canada et des représentants provinciaux de l'Ontario, chargé d'étudier les enjeux liés aux VA et aux VB de manière à faire connaître les pratiques exemplaires et à trouver des liens avec les initiatives déjà déployées dans le domaine.

À ce jour, seul l'Ontario a adopté un règlement sur les VA. Le Règlement de l'Ontario 306/15 établit un programme pilote de 10 ans permettant la mise à l'essai des VA. Ce programme permet l'utilisation de VA à des fins d'essai seulement, et les participants doivent répondre à des critères d'admissibilité et présenter une demande au ministère des Transports de la province.

En ce qui concerne les VB, le gouvernement de l'Alberta est un des nombreux partenaires, en plus de la Ville d'Edmonton et de Transports Canada, du centre de recherche de l'Université de l'Alberta qu'ont visité les membres du comité. Par ailleurs, il existe un réseau de recherche sur les VB affilié à l'Université de la Colombie-Britannique (UBC), réseau dont fait partie le ministère des Transports et de l'Infrastructure de la Colombie-Britannique.

Dans son mémoire, le ministère des Transports et de l'Infrastructure de la Colombie-Britannique a indiqué qu'il a un groupe de travail sur les véhicules autonomes responsable de surveiller les progrès dans le domaine des VA et des VB. L'Insurance Corporation of British Columbia suit également de près les questions relatives à ces véhicules.

Dans son mémoire au comité, Infrastructure Manitoba indique que la province a adopté, dans un premier temps, une approche «attentiste» compte tenu de l'incertitude entourant les technologies des VA et des VB et la trajectoire que celles-ci prendront. Par conséquent, la province n'a pas encore entrepris de grande initiative dans ce dossier, bien que les autorités surveillent de près le développement de cette technologie et analysent les pratiques exemplaires appliquées ailleurs. Par exemple, Infrastructure Manitoba a mis sur pied un groupe de travail de concert avec la Société d'assurance publique du Manitoba (soit la société d'État d'assurance automobile de la province) afin d'examiner les VA dans le contexte provincial et d'échanger de l'information.

Dans la même veine, le ministère des Routes et de l'Infrastructure de la Saskatchewan a indiqué, dans son mémoire, que la «province de la Saskatchewan surveille la recherche et le développement en matière de VA et de [VB] tant sur le plan national qu'international et a tenu des discussions internes sur leur utilisation future et les répercussions possibles». Le Ministère a également indiqué que les villes de Saskatoon et de Regina ont tenu des discussions initiales avec SaskTech, un regroupement d'entreprises en technologie de la Saskatchewan qui comptent établir un banc d'essai pour les VA et les VB utilisés dans des conditions météorologiques extrêmes en milieu rural et en milieu urbain de moindre taille.

Selon le mémoire du gouvernement de Terre-Neuve-et-Labrador, la province participe activement à des forums comme le CCATM et le CMT, où des questions liées aux VA et aux VB sont étudiées en profondeur.

En outre, le comité a reçu un mémoire du ministère des Transports, de l'Infrastructure et de l'Énergie de l'Île-du-Prince-Édouard. Le Ministère affirme que le gouvernement provincial n'a pas mis en place d'initiative concernant les VA et les VB, mais qu'il «suit avec intérêt les initiatives envisagées ou mises en œuvre par d'autres administrations».

Enfin, dans son mémoire, le gouvernement des Territoires du Nord-Ouest indique qu'il n'a pas adopté d'initiative relativement aux VA et aux VB, mais qu'il «continue de surveiller les tendances et les développements à l'échelle nationale et internationale concernant ces véhicules».

Le vice-président du comité, le sénateur Dennis Dawson, discute avec le ministre fédéral des Transports, Marc Garneau, lors de la démonstration d'un véhicule automatisé sur la Colline du Parlement en septembre 2017.

INITIATIVES EN PLACE DANS D'AUTRES PAYS

États-Unis

Des représentants du Département des Transports américain (U.S. DOT) ont présenté la politique nationale sur les VA des États-Unis, adoptée en septembre 2016 et modifiée en septembre 2017 en fonction des commentaires des intervenants. Selon les représentants, la politique vise les niveaux d'automatisation 3, 4 et 5 et établit des lignes directrices volontaires sur 12 éléments de conception prioritaires en matière de sécurité dont les constructeurs d'automobiles devraient tenir compte dans la production de VA.

Les représentants de l'U.S. DOT ont expliqué au comité que le gouvernement américain a adopté une démarche volontaire (c'est-à-dire cerner les éléments de conception clés en matière de sécurité sans *imposer* à l'industrie une méthode pour traiter ces éléments) afin d'établir un cadre flexible favorisant l'innovation. Selon les représentants, il est encore trop tôt pour imposer une réglementation dans ce secteur puisque la technologie des VA en est encore à ses balbutiements. Pendant leur témoignage, des représentants des gouvernements des États de l'Arizona et du Michigan ont exprimé le même point de vue, ajoutant qu'il est important d'établir un équilibre entre la sécurité et l'innovation dans la réglementation de l'utilisation des VA sur les voies publiques.

La politique nationale de l'U.S. DOT sur les VA comprend également un ensemble de pratiques exemplaires que les gouvernements des États peuvent intégrer dans leur législation respective sur les VA (dans la version originale des lignes directrices de l'U.S. DOT, cet ensemble s'appelle « Politique étatique modèle »). Selon la National Conference of State Legislatures, 21 États ainsi que Washington, D.C. ont adopté une loi sur les VA, et les gouverneurs de quatre autres États ont pris des décrets sur les VA.

En outre, des témoins ont indiqué au comité que plusieurs projets de loi sur les VA franchissent à l'heure actuelle les diverses étapes du processus législatif au Congrès des États-Unis. Cependant, au moment de la rédaction du présent rapport, aucun de ces projets de loi n'avait encore franchi le processus en entier.

En ce qui concerne les VB, l'U.S. DOT a publié en 2016 un avis de règlement visant l'adoption d'une nouvelle norme fédérale sur les véhicules motorisés de manière à obliger l'utilisation des communications véhicule à véhicule dans les nouveaux véhicules légers et à uniformiser le format des messages transmis. Les représentants de l'U.S. DOT ont affirmé au comité que des discussions sont en cours avec des intervenants sur l'avenir de ce projet de règlement.

Par ailleurs, l'Administration nationale de la sécurité du trafic routier de l'U.S. DOT a publié en octobre 2016 des pratiques exemplaires en matière de cybersécurité pour les véhicules modernes. Ces lignes directrices visent les véhicules en usage à l'heure actuelle, dont un nombre croissant sont dotés d'ordinateurs, mais les témoins ont indiqué au comité que la cybersécurité deviendra une question de plus en plus importante à mesure que les véhicules passeront à des niveaux d'automatisation

et de connectivité supérieurs. La question de la cybersécurité sera abordée plus en profondeur dans une section ultérieure du présent rapport.

Royaume-Uni

En 2015, le ministère des Transports du Royaume-Uni a publié un [rapport sommaire et un plan d'action](#) sur les VA. Selon ce rapport, le cadre juridique et réglementaire du pays ne constitue pas un obstacle à la mise à l'essai de VA sur les voies publiques. Par conséquent, le gouvernement du Royaume-Uni a décidé d'adopter une approche non réglementaire et non contraignante par rapport à la mise à l'essai et au développement de ces technologies au moyen d'un code de pratique. Le [code](#) a été publié en juillet 2015.

Des témoins ont mentionné le [Centre for Connected and Autonomous Vehicles](#) (CCAV) du RoyaumeUni, une entité de politique conjointe créée en 2015 par le ministère des Transports et le ministère des Affaires, de l'Énergie et des Stratégies industrielles (à l'instar de l'ISDE au Canada, le mandat de ce ministère inclut les questions liées à l'innovation). Le CCAV travaille à tous les niveaux du gouvernement pour appuyer le marché naissant des VA et des VB; il offre plus de 250 millions de livres (environ 416,1 millions de dollars canadiens) en financement de contrepartie afin de faire du Royaume-Uni un chef de file de la recherche sur les VA et les VB.

En outre, le gouvernement du Royaume-Uni a adopté des mesures concernant la cybersécurité, notamment une [stratégie nationale sur la cybersécurité](#). De plus, [Cyber Security Challenge UK](#), un organisme sans but lucratif, a établi un partenariat de travail avec la National Crime Agency du Royaume-Uni afin de produire du matériel pédagogique gratuit que pourront utiliser les parents et les enseignants du pays pour sensibiliser les jeunes aux enjeux de la cybercriminalité.

Autres pays

Dans le cadre de son initiative [Nouvelle France Industrielle](#) de septembre 2013, le gouvernement de la France a annoncé un projet de VA qui vise à faire du pays un leader mondial de la mise à l'essai des VA. La France a adopté des [modifications législatives](#) en août 2016 afin de permettre la mise à l'essai de ces véhicules sur les voies publiques sous certaines conditions.

En mai 2017, la Commission nationale du transport de l'Australie – un organisme consultatif indépendant qui formule des conseils et des propositions de réforme du transport terrestre national par l'intermédiaire d'un conseil sur les transports et l'infrastructure (similaire au CMT du Canada) – a publié des [lignes directrices sur la mise à l'essai des véhicules automatisés en Australie](#). Ces lignes directrices ont pour but de faire du pays un banc d'essai pour la technologie des VA et d'aider les organismes à assurer la sécurité des tests des VA sur les voies publiques.

Le Japon est un des premiers pays à avoir adopté la technologie des VB, instaurant la connexion véhicule à infrastructure par l'adoption en 1996 du [système d'information et de communication des véhicules](#). Selon un [livre blanc](#) publié par le CCATM, la police nationale japonaise a établi en 2016 des lignes directrices sur les essais de VA sur les voies publiques.

La Commission européenne a proposé une réforme de son cadre de protection des données en janvier 2012 et, en avril 2016, le Parlement européen a adopté un nouveau [règlement](#) sur le traitement et la libre circulation des données à caractère personnel. Le règlement vise à renforcer les droits fondamentaux des citoyens à l'ère numérique et à faciliter la conduite des affaires en simplifiant les règles visant les entreprises du marché unique numérique. Une nouvelle [directive](#) à l'intention des services policiers et du secteur de la justice pénale a été adoptée parallèlement au règlement. Celle-ci vise à protéger le droit fondamental des citoyens à la protection des données dans les cas où des renseignements personnels sont utilisés par les services d'application du droit pénal. Sharon Polsky, présidente, Conseil du Canada de l'accès et la vie privée, a décrit positivement la nouvelle directive européenne, soulignant qu'elle place la barre très haute en ce qui concerne le consentement et le contrôle que peuvent exercer les personnes sur leurs renseignements personnels.

D'après le mémoire soumis par Krzysztof Czarnecki, professeur de génie électrique et de génie informatique à l'Université de Waterloo, l'Allemagne a modifié ses lois de manière à permettre la circulation des VA de niveaux 3 et 4 sur la voie publique. La loi allemande exige toujours la présence d'un conducteur humain qui peut prendre le relais si nécessaire (comme nous l'avons indiqué précédemment, au Canada, l'utilisation du réseau routier relève des provinces).

PARTIE 2 :

PLANIFICATION EN VUE DE L'ARRIVÉE DES TECHNOLOGIES DES VÉHICULES AUTOMATISÉS ET BRANCHÉS

Bien qu'on ignore quand les technologies des VA et des VB arriveront sur les routes canadiennes, on sait que ce moment viendra. Les autorités provinciales, territoriales et fédérales ont déjà commencé à s'y préparer.

Cependant, le comité partage l'opinion de M. Michelson, qui a indiqué que « le Canada ne pourra profiter de ces efforts que si une stratégie nationale coordonnée » est mise au point. Les sous-sections ci-après portent sur les recommandations du comité concernant les principaux éléments qui devraient figurer dans cette stratégie.

LEADERSHIP FÉDÉRAL

De nombreux témoins ont affirmé qu'il est important que le gouvernement fédéral joue un rôle de leadership en ce qui a trait aux VA et aux VB. Comme l'a expliqué M. Love, « il faudra entreprendre un volume sans précédent d'activités de coordination et de collaboration dans les divers secteurs industriels, mais aussi – et c'est sans doute le plus important – dans tous les organismes gouvernementaux et à tous les ordres de gouvernement […] Cela appelle un leadership proactif. »

Les technologies des VA et des VB pourraient avoir une incidence sur le mandat de plusieurs ministères fédéraux. À ce chapitre, des témoins ont dit craindre que les ministères et les organismes fédéraux œuvrent de manière contradictoire en raison de leur cloisonnement. Par exemple, M. Kirk a expliqué ceci :

> Les activités d'Innovation, Sciences et Développement économique Canada visant à favoriser le développement de cette technologie représentent l'accélérateur, tandis que les activités de Transports Canada, qui sont ciblées sur les aspects liés à la sécurité, représentent la pédale de frein. Le gouvernement tente malheureusement d'aller de l'avant en appuyant simultanément sur l'accélérateur et la pédale de frein.
>
> (Barrie Kirk, directeur général, Centre d'excellence des véhicules automatisés du Canada, 3 mai 2017)

Un document de suivi présenté par Transports Canada fait état de sept ministères et organismes fédéraux, autres que Transports Canada et ISDE, dont le mandat pourrait être touché par le dossier des VA et des VB, comme EDSC, Sécurité publique Canada et le Centre de la sécurité des télécommunications.

> *Pour profiter pleinement des efforts dans ce domaine, le Canada doit concevoir une stratégie nationale coordonnée.*
>
> – David Michelson

M. Chennakeshu a quant à lui fait remarquer qu'il serait utile que le gouvernement fédéral adopte une approche à guichet unique afin d'offrir aux parties intéressées un seul point de contact principal. M. Kirk et M. Ticoll ont donné l'exemple du Centre for Connected and Autonomous Vehicles (CCAV) au Royaume-Uni, une entité politique qui regroupe les équivalents de Transports Canada et d'ISDE. Par conséquent, le comité recommande :

RECOMMANDATION 1

Que Transports Canada et Innovation, Sciences et Développement économique Canada créent sans tarder une entité conjointe chargée de la politique pour coordonner les mesures prises par le gouvernement fédéral et mettre en œuvre une stratégie nationale visant les véhicules automatisés et branchés.

Même si le comité estime que cette entité politique conjointe devrait être l'organisme responsable de mettre en œuvre les recommandations présentées ci-après, il adresse celles-ci aux ministères fédéraux existants afin de faciliter le processus qui consiste à demander au gouvernement de répondre au rapport.

Étant donné que la réglementation sur l'utilisation des VA et des VB sur la voie publique relève des provinces et des territoires, des témoins ont dit craindre qu'il y ait un ensemble d'exigences disparates d'une province ou d'un territoire à l'autre. Par exemple, M. Leclerc a indiqué que, « [s]i nous souhaitons attirer des investisseurs et lancer cette technologie, nous devons veiller à harmoniser tous ces éléments, et selon nos observations, ce n'est pas nécessairement le cas en ce moment ».

Le comité croit que cette technologie aura aussi une incidence sur les administrations municipales, compte tenu des effets des VA et des VB dans des domaines comme la planification des infrastructures et du transport, l'étalement urbain, l'utilisation des terres et les transports en commun.

Certains témoins, comme M. Kirk, Mme Gerber, M. Paterson et Craig Hirota, viceprésident des Relations gouvernementales et des services aux membres de l'Associated Canadian Car Rental Operators, ont recommandé au gouvernement fédéral de mettre au point une politique provinciale modèle afin de garantir un certain degré d'uniformité. Comme il a été mentionné précédemment, le CCATM dispose déjà d'un groupe de travail qui œuvre à l'élaboration de lignes directrices et publie des pratiques exemplaires sur l'intégration des VA sur la voie publique. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 2

Que Transports Canada collabore avec les gouvernements provinciaux et territoriaux, par l'intermédiaire du Conseil canadien des administrateurs en transport motorisé, à l'élaboration d'une politique provinciale modèle portant sur l'utilisation des véhicules automatisés et branchés sur la voie publique. Le Ministère devrait aussi convier les municipalités à participer à cet effort de collaboration.

Des témoins ont souligné l'importance de la collaboration avec les autorités américaines, car les VA et les VB devront pouvoir fonctionner de part et d'autre de la frontière canado-américaine. Comme on l'a mentionné précédemment, Transports Canada travaille déjà avec ses homologues américains par l'entremise du CCR. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 3

Que Transports Canada renforce sa collaboration avec les États-Unis au sujet des véhicules automatisés et branchés par l'entremise du Conseil de coopération en matière de réglementation, pour que ces véhicules fonctionnent de manière intégrée dans les deux pays.

SÉCURITÉ DES VÉHICULES

C'est au gouvernement fédéral qu'il incombe de veiller à ce que les normes de sécurité soient respectées à l'étape de la conception et de la construction des véhicules fabriqués ou importés au Canada. À cet égard, le _Règlement sur la sécurité des véhicules automobiles_ (pris en vertu de la _Loi sur la sécurité automobile_) comporte des exigences détaillées pour la conception et la construction des véhicules automobiles.

Des témoins ont fait observer que la situation et le moment de l'arrivée des technologies des VA et des VB sont encore incertains et que l'imposition d'exigences de sécurité trop normatives pourrait comporter plusieurs risques. À ce propos, M. Iny a expliqué qu'« [o]n a l'impression à l'heure actuelle que le secteur change trop rapidement pour permettre à la réglementation d'être efficace et fait en sorte de la rendre désuète rapidement ».

Des témoins et des organismes qui ont soumis des mémoires, comme Infrastructure Manitoba, abondaient dans le même sens et ont signalé que les règlements normatifs risqueraient d'être trop restrictifs et de freiner l'innovation dans l'industrie de même que l'intégration au marché. Par exemple, Justin Kintz, directeur principal des Politiques et communications (Amériques) pour Uber, a précisé que le logiciel qui sera installé sur les véhicules d'essai de sa compagnie est mis à jour plusieurs fois par jour et que de nombreuses versions seront vraisemblablement nécessaires avant qu'il soit prêt pour les consommateurs. Par conséquent, M. Kintz a affirmé que « [c]ela nuirait énormément à la technologie si un organisme gouvernemental ou une tierce partie devait approuver en cours de route l'évolution du logiciel ».

D'après le mémoire de M. Czarnecki, SAE International et l'Organisation internationale de normalisation travaillent actuellement à l'élaboration de normes permettant de vérifier et de valider la sécurité des VA; ces normes devraient être prêtes d'ici deux ans. M. Czarnecki signale que toute réglementation détaillée devrait alors être mise à jour en conséquence.

Malgré tout, le comité estime que le gouvernement fédéral a un rôle à jouer pour assurer la sécurité des VA et des VB. Il partage les préoccupations soulevées par Ata Khan, membre du conseil d'administration de l'organisme ONE-ITS et professeur au Département de génie civil et environnemental de l'Université Carleton, qui a signalé « qu'il arrivera que la technologie soit en avance sur la réglementation, qui devra faire du rattrapage ».

Comme il a été indiqué précédemment, les technologies des VA et des VB pourraient présenter d'énormes avantages en matière de sécurité, mais comme l'a souligné M. Bonny, un plan est nécessaire pour garantir le bon fonctionnement et la sécurité de ces véhicules. M. Love a fait valoir qu'il faut « exprimer clairement ce qu'on attend [des intervenants] et les normes qu'ils devront respecter ». Selon le mémoire soumis au comité par Infrastructure Manitoba, Transports Canada devrait « établir une politique énonçant les attentes, les pratiques et les procédures que les constructeurs, les fournisseurs et les autres parties devront observer dans le cadre du développement et du déploiement des VA et des [VB] ».

En se fondant sur l'expérience d'autres pays, le comité estime que la création d'un ensemble de lignes directrices sur la sécurité des véhicules permettrait de trouver le juste milieu entre l'importance de la sécurité des véhicules et les risques encourus par une réglementation excessive alors que l'orientation des technologies des VA et des VB est encore imprécise. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 4

Que Transports Canada prépare de toute urgence des lignes directrices sur la sécurité entourant la conception des véhicules automatisés et branchés. Ces lignes directrices devraient énoncer les aspects conceptuels dont l'industrie devrait tenir compte lors du développement, de la mise à l'essai et du déploiement de ces véhicules sur les routes canadiennes. De plus, les lignes directrices devraient être mises à jour régulièrement pour suivre l'évolution de la technologie des véhicules automatisés et branchés.

ATTRIBUTION DE FRÉQUENCES

L'attribution de radiofréquences relève également de la compétence fédérale. M. Michelson a informé le comité qu'ISDE n'a pas encore assigné la portion du spectre qu'il a réservée aux communications dédiées à courte portée (CDCP) pour les VB :

> Toute entreprise qui veut mettre à l'essai une technologie de véhicules connectés doit obtenir un permis de développement octroyé par le ministère de l'Innovation, des Sciences et du Développement économique. On ne peut pas simplement installer l'équipement et l'utiliser directement comme aux États-Unis. C'est d'ailleurs un obstacle qui freine le développement et l'innovation. […] Le processus d'approbation est assez exigeant et requiert beaucoup de temps.
>
> (David Michelson, coprésident, Société des systèmes de transport intelligents du Canada, et professeur, Université de la Colombie-Britannique, à titre personnel, 14 juin 2017).

David Adams, président des Constructeurs mondiaux d'automobiles du Canada, a souligné l'importance de continuer à réserver une portion de fréquences aux fins des CDCP; il a fait remarquer que ce spectre « est actuellement convoité par les entreprises de télécommunications » aux États-Unis. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 5

Qu'Innovation, Sciences et Développement économique Canada assigne la fréquence de 5,9 gigahertz qu'il a réservée aux systèmes de communications dédiées à courte portée et qu'il continue de réserver cette fréquence aux véhicules branchés.
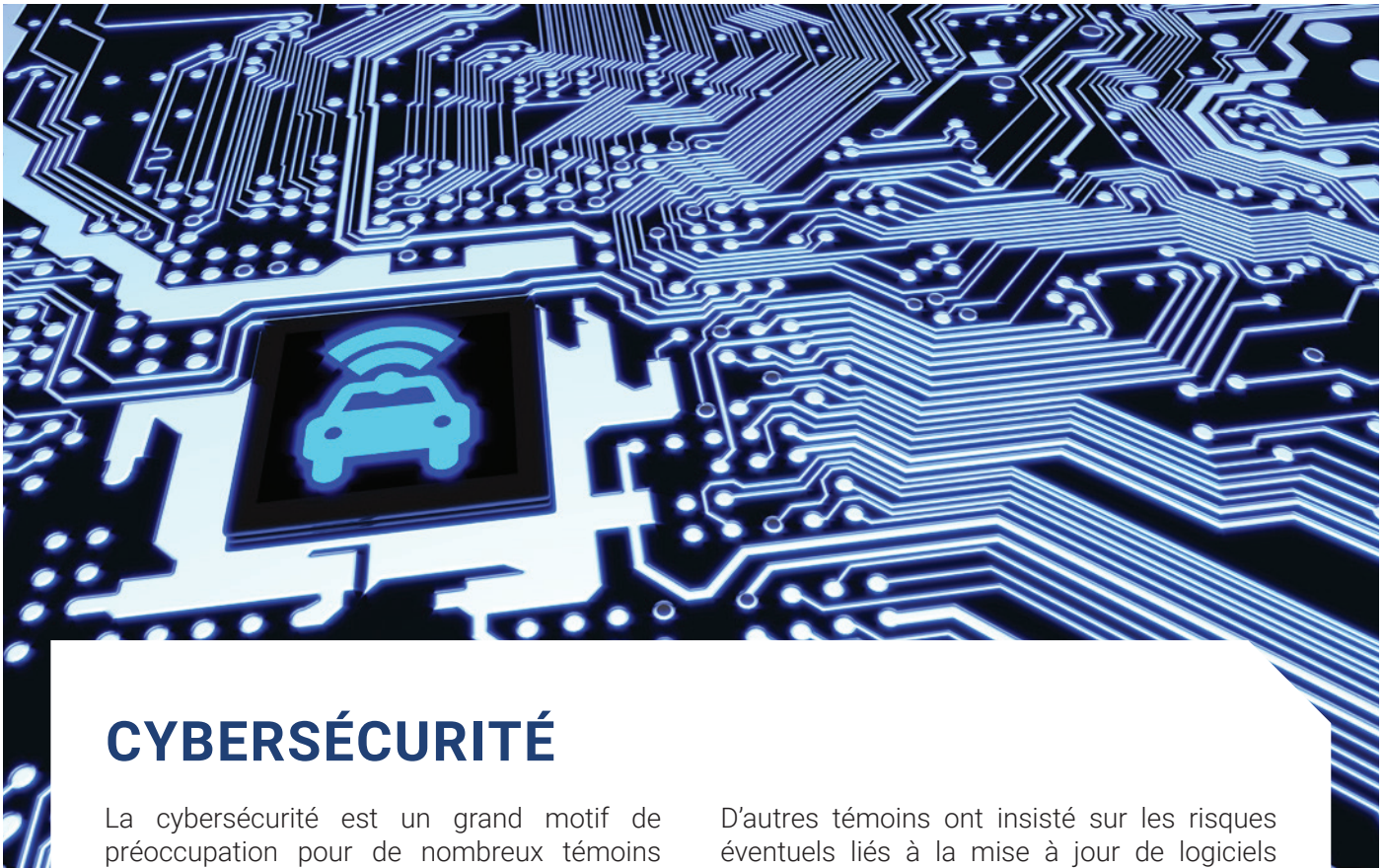
CYBERSÉCURITÉ

La cybersécurité est un grand motif de préoccupation pour de nombreux témoins qui ont comparu devant le comité. Patrick Patterson, président de Carillon Information Security Inc., a expliqué au comité que l'intégrité des données est d'une importance capitale lorsque des véhicules envoient et reçoivent de l'information numérique, comme c'est le cas des VA et VB. En effet, les véhicules doivent savoir si le message qui leur est envoyé est fiable, et les constructeurs doivent avoir l'assurance que le message qui quitte le centre d'émission des signaux se rend au bon véhicule sans être trafiqué en cours de route.

Des témoins ont attiré l'attention du comité sur les conséquences éventuelles des rançongiciels, des logiciels malveillants qui bloquent l'accès à un ordinateur (ou aux données contenues dans un ordinateur) et exigent le paiement d'une somme d'argent pour en rétablir l'accès. Mᵐᵉ Polsky, par exemple, prévoit que cela pourrait avoir un effet « percutant » sur l'économie canadienne.

D'autres témoins ont insisté sur les risques éventuels liés à la mise à jour de logiciels par réseau hertzien. Ce type de mise à jour permet par exemple de corriger des vulnérabilités sur le plan de la sécurité ou de mettre à jour des systèmes d'infodivertissement. Des constructeurs de véhicules utilisent déjà la mise à jour de logiciels par réseau hertzien, pratique qui devrait s'accentuer à mesure que les VA et les VB gagneront en popularité. Cependant, M. Jones a fait remarquer que, à l'heure actuelle, les consommateurs ne peuvent pas avoir la certitude que les mises à jour proviennent du constructeur du véhicule. C'est une situation problématique car, comme l'a expliqué M. Patterson, « c'est la sécurité des environnements informatiques de ces véhicules » qui importe d'abord et avant tout.

M. Patterson a déclaré au comité que, pour atténuer cette incertitude, il faut prendre des mesures pour qu'un véhicule n'exécute pas un programme informatique qui n'est pas approuvé par un constructeur d'automobiles ou un fabricant de logiciels. M. Jones et Patterson ont tous les deux suggéré que le

secteur de l'automobile suive l'approche adoptée par l'industrie aéronautique pour garantir la sécurité des mises à jour.

Certains témoins ont souligné que les problèmes associés à la cybersécurité ne sont pas l'apanage de l'industrie automobile, mais qu'ils se posent également pour l'automatisation des trains, des avions et des navires. M. Patterson a donc proposé que Transports Canada énonce un ensemble commun de normes ou de principes de cybersécurité pour tous les modes de transport. Des témoins ont aussi insisté sur l'importance de la coopération transfrontalière pour l'élaboration de normes et de principes, de manière à garantir l'interopérabilité dans le monde. M. Patterson a aussi fait observer que, pour être efficaces, les lignes directrices fédérales devraient renvoyer à des normes de sécurité précises au lieu de simplement encourager l'industrie à tenir compte de la cybersécurité. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 6

Que Transports Canada, en collaboration avec le Centre de la sécurité des télécommunications et Sécurité publique Canada, mette au point des lignes directrices sur la cybersécurité pour le secteur des transports inspirées des pratiques exemplaires et des principes reconnus en matière de cybersécurité. Les lignes directrices devraient comporter des conseils sur l'équipement d'origine, sur l'équipement de remplacement et sur les mises à jour logicielles.

Plusieurs témoins ont mentionné l'importance de la coopération au sein de l'industrie de même qu'entre l'industrie et le gouvernement afin de renforcer la cybersécurité, mais la portée actuelle de cette coopération n'est pas claire. Par exemple, M. Jones a expliqué que l'importance des partenariats avec l'industrie vient du fait que le CST et d'autres organismes de cybersécurité ne disposent pas forcément d'une expertise propre à ce secteur. Il a aussi déclaré au comité que le CST ne dispose pas actuellement des ressources nécessaires pour travailler avec les constructeurs d'automobiles, bien qu'il ait collaboré avec des experts du secteur de l'aviation.

Dans le même ordre d'idées, Colleen Merchant, directrice générale de la Direction de la cybersécurité nationale à Sécurité publique Canada, a informé le comité que le Centre canadien de réponse aux incidents cybernétiques (CCRIC) est un point de contact unique permettant aux propriétaires et aux exploitants d'infrastructure essentielle au Canada de signaler les cyberincidents au gouvernement fédéral. Cependant, elle a expliqué qu'il existe une étroite collaboration entre le CCRIC et Transports Canada, mais le Centre « n'a pas de lien comme tel » avec l'industrie. Mme Merchant a recommandé d'« accroître l'échange de renseignements entre le gouvernement et l'industrie sur les menaces et les vulnérabilités en matière de cybersécurité » et elle a déclaré qu'il faudrait déployer « des efforts coordonnés dans plusieurs secteurs, dont l'élaboration de règlements et de normes, la recherche ainsi que le signalement des vulnérabilités et des incidents », pour atténuer les préoccupations liées à la cybersécurité des VA et des VB.

Pour ce qui est de la coopération entre les intervenants de l'industrie, selon M. Chennakeshu, il est très important que les constructeurs et les fournisseurs mettent en commun l'information sur les « vulnérabilités et expositions courantes » afin de pouvoir réagir quand un problème est détecté. Bien que M. Chennakeshu reconnaisse le rôle important que joue l'AutoISAC, il a souligné que les intervenants n'en font pas tous partie et que l'information n'est pas partagée en temps réel. C'est pourquoi il a recommandé la création d'un « réseau de connexion en cas de crise » en temps réel pour l'ensemble de l'industrie, qui permettrait aux

adhérents de réagir rapidement aux vulnérabilités en matière de cybersécurité et d'apprendre les uns des autres. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 7

Que Transports Canada travaille avec Sécurité publique Canada, le Centre de la sécurité des télécommunications et les intervenants de l'industrie pour remédier aux problèmes de cybersécurité et pour créer un réseau de connexion en cas de crise en temps réel, et que Transports Canada fasse régulièrement rapport des progrès réalisés à cet égard.

PROTECTION DES RENSEIGNEMENTS PERSONNELS

Le comité a entendu de nombreux témoignages sur l'importance de protéger les renseignements personnels dans le contexte de l'intégration des VA et des VB à grande échelle. Malgré les nombreux enjeux liés à la confidentialité, selon les témoins, la connectivité accrue et le respect de la vie privée ne sont pas incompatibles. Au contraire, le commissaire à la protection de la vie privée a expliqué que la mise en place de garanties adéquates en matière de confidentialité pourrait rassurer les Canadiens et stimuler leur intérêt pour les VA et les VB.

Les observations formulées par les témoins portaient sur quatre grands thèmes : la protection des renseignements personnels dès l'étape de la conception; le consentement éclairé; l'application de la loi; les directives à l'intention de l'industrie.

Protection des renseignements personnels dès l'étape de la conception

La notion de protection des renseignements personnels dès l'étape de la conception, dont les entreprises tiennent compte dès le départ, gagne en popularité dans le secteur de l'automobile. Une responsable d'ISDE a expliqué de quoi il s'agit :

> [Les] entreprises doivent s'assurer de tenir compte dès le départ de la protection des renseignements personnels et de la sécurité informatique. Ce n'est pas quelque chose qu'elles peuvent tout simplement ajouter à la fin. Lorsque la voiture est construite et que les roues sont fixées, ce n'est pas le moment de penser à la protection des renseignements personnels. [...] Par ailleurs, les entreprises doivent veiller à ce que leurs dirigeants y réfléchissent. Il ne s'agit pas seulement d'une question technologique. Les conseils d'administration doivent réfléchir à toute cette question et orienter l'ensemble de leur entreprise pour évaluer ce qu'ils font du point de vue de la protection des renseignements personnels et de la sécurité informatique pour vraiment en comprendre les conséquences.
>
> (Krista Campbell, directrice générale, Spectre, technologies de l'information et télécommunications, Direction générale des politiques numériques, ISDE, 14 février 2017)

Le commissaire à la protection de la vie privée a fait remarquer que la protection des renseignements personnels dès l'étape de la conception est un « bon concept », mais il a insisté sur le fait qu'il faut veiller à mettre ce principe en application de façon concrète. Pour atteindre cet objectif, il a suggéré aux intervenants de travailler ensemble pour établir des normes adéquates qui rassureront l'industrie et les consommateurs.

Consentement éclairé

La *Loi sur la protection des renseignements personnels et les documents électroniques* (LPRPDE) est la loi fédérale canadienne qui régit la protection des renseignements personnels dans le secteur privé. Elle s'applique aux renseignements personnels que les organisations privées, comme les constructeurs d'automobiles et leurs partenaires, recueillent,

utilisent ou communiquent dans le cadre d'activités commerciales au Canada [21]. Les témoins ont admis que cette loi comporte des atouts indéniables, mais ils ont souligné certaines faiblesses en ce qui concerne les VA et les VB.

Par exemple, Philippa Lawson, avocate-procureure représentant l'Association pour l'accès à l'information et le respect de la vie privée de la Colombie-Britannique, a fait remarquer que la LPRPDE « suppose que les gens peuvent donner leur consentement éclairé à la collecte, l'utilisation et la divulgation par un tiers de leurs renseignements personnels ». Or, compte tenu de la multitude d'acteurs présents dans le milieu des voitures branchées et de la tendance de l'industrie à décrire en termes « flous » la manière dont les données seront utilisées, Mme Lawson a fait valoir que cette théorie est inapplicable. En fait, elle prétend que souvent le consentement accordé par les consommateurs n'est guère plus qu'une « fiction ».

> "
> *[L]es entreprises doivent penser à la vie privée et à la cybersécurité dès le début. Ce ne sont pas des choses que l'on peut simplement concevoir en fin de compte.*
>
> – Krista Campbell
> "

Le Commissariat à la protection de la vie privée s'est penché sur des moyens qui permettraient de rendre les processus de consentement plus explicites. En effet, il a entrepris, en mai 2016, des consultations publiques sur le consentement aux termes de la LPRPDE et a récemment publié un rapport sur ses constatations. Le commissaire à la vie privée a expliqué que les consultations ont démontré l'insatisfaction des consommateurs à l'égard du manque de clarté et d'accessibilité de nombreuses politiques de confidentialité de l'industrie. Il a insisté sur la lisibilité de ces politiques afin de renseigner les consommateurs sur les types de renseignements

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21 Il convient de signaler que les organisations dont les activités se déroulent entièrement dans une province qui possède une loi « essentiellement similaire » à la LPRPDE sont exemptées de la loi fédérale.

qui sont recueillis à leur sujet, sur ce qu'en font les entreprises, sur les entités auxquelles elles les communiquent et sur les risques de dommages matériels ou d'atteinte à la réputation pouvant résulter de la divulgation des données les concernant [22]. Le commissaire a aussi affirmé qu'il fallait éviter que les entreprises submergent les consommateurs d'une quantité d'information telle que ceux-ci soient incapables de faire des choix éclairés et d'exercer un véritable contrôle sur leurs renseignements personnels.

L'Association pour l'accès à l'information et le respect de la vie privée de la Colombie-Britannique partage le point de vue exprimé par le Commissariat à la protection de la vie privée quant à l'importance de la transparence dans l'obtention du consentement. Mme Lawson a recommandé une approche semblable à celle adoptée par la Commission des valeurs mobilières de l'Ontario pour les déclarations de fonds communs de placement. Elle a expliqué que la normalisation des termes et du format des déclarations permet aux consommateurs de comparer plus facilement les différentes options qui s'offrent à eux.

Cela dit, bien qu'elle reconnaisse la valeur du consentement valable, Mme Lawson a soutenu, à l'instar d'autres témoins, qu'il peut être impossible, voire inapproprié, d'obtenir le consentement dans certains cas :

> [I]l y a aussi des domaines pour lesquels vous n'aurez jamais le consentement et où cela pourrait s'avérer inapproprié, pour lesquels nous pouvons peut-être décider en tant que société que certaines informations n'ont tout simplement pas besoin d'être collectées et ne devraient pas l'être et que les risques pour la vie privée et la sécurité sont trop importants et surpassent les avantages qu'il pourrait y avoir. Par exemple, en reliant la télématique au système d'info-divertissement, on peut avoir des voitures dans lesquelles le volume du système d'info-divertissement se règle automatiquement en fonction du bruit du moteur.

> Est-ce que cela vaut le coup de prendre le risque de piratage ou d'atteinte à la sécurité que ce type de connexion ou de partage d'information rend possible?

> (Philippa Lawson, avocate-procureure, Association pour l'accès à l'information et le respect de la vie privée de la Colombie-Britannique, 2 mai 2017)

Plusieurs témoins sont d'avis que des règles de partage des données différentes devraient s'appliquer selon le contexte. Par exemple, M. Jack a fait remarquer que les consommateurs ne devraient probablement pas avoir le choix de partager des données anonymisées sur la sécurité, mais qu'ils devraient pouvoir choisir quelles autres données ils sont prêts à partager. M. Iny a fait la distinction entre les renseignements recueillis dans l'intérêt de la sécurité publique et ceux recueillis à des fins purement économiques. Il a aussi préconisé l'élaboration de lignes directrices sur l'échange d'information.

Application de la loi

Selon ce que le comité a appris, bien que la loi actuelle comporte de nombreuses dispositions visant à protéger les renseignements personnels, l'industrie ne s'y conforme pas toujours. Par exemple, Mme Lawson a informé le comité que les fournisseurs de services ne respectent pas toujours la loi canadienne, qui leur interdit d'exiger que les consommateurs consentent à quelque chose qui n'est pas nécessaire au service acheté :

> Ce que nous avons constaté avec ces systèmes, c'est qu'il s'agit d'une proposition de type tout ou rien, si vous n'acceptez pas toutes les conditions – qui sont en général très larges – vous ne pouvez pas utiliser le service, vous ne pouvez pas utiliser le système de navigation automatique.

> (Philippa Lawson, avocate-procureure, Association pour l'accès à l'information et le respect de la vie privée de la Colombie-Britannique, 2 mai 2017)

Le commissaire à la protection de la vie privée a exprimé des préoccupations semblables lorsqu'il a qualifié d'insuffisants les mécanismes de conformité prévus dans la LPRPDE. Il a expliqué que, pour l'instant, le commissariat ne peut entreprendre une enquête que s'il reçoit une plainte, mais que s'il pouvait agir de manière préventive, plutôt qu'en réaction aux

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22 Ces quatre éléments principaux doivent être mis en évidence à l'intention des consommateurs selon la version préliminaire la plus récente des lignes directrices du Commissariat à la protection de la vie privée visant l'obtention du consentement en ligne.

événements, l'observation de la loi s'en trouverait améliorée. C'est pourquoi il estime qu'il faut un cadre souple qui permet à un organisme de réglementation de réagir rapidement et de remédier au nombre « illimité » de problèmes qui pourraient survenir dans le cas des VA et des VB, de l'intelligence artificielle et des mégadonnées.

Mme Polsky, qui a abondé dans le même sens, a aussi indiqué que permettre aux entreprises de faire fi de la loi sur la protection de la vie privée nuit à tous les Canadiens. Elle a proposé plusieurs moyens de renforcer les pouvoirs du commissaire à la protection de la vie privée :

> [J]'ai mentionné très clairement que les lois canadiennes sur la protection des renseignements personnels sont inefficaces. [...] Le commissaire n'a pas le pouvoir nécessaire pour la faire respecter. La législation proprement dite n'est pas [a]déquate. [...] [Les commissaires à la protection de la vie privée] doivent avoir le pouvoir de rendre des ordonnances. Ils doivent être en mesure de mener des enquêtes non seulement après le fait ou après le dépôt d'une plainte, mais aussi de leur propre chef. Quand ils voient un problème, ils doivent être en mesure d'agir. À mon avis, le commissaire doit également avoir un budget et un mandat en matière d'éducation.
>
> (Sharon Polsky, présidente, Conseil du Canada de l'accès et la vie privée, 31 octobre 2017)

Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 8

Que le gouvernement du Canada présente un projet de loi visant à donner au Commissariat à la protection de la vie privée le pouvoir d'enquêter de façon proactive sur le respect de la *Loi sur la protection des renseignements personnels et les documents électroniques* par l'industrie et de faire observer la *Loi.*

Directives et réglementation à l'intention de l'industrie

En plus de préconiser le renforcement des pouvoirs du commissaire à la protection de la vie privée dans la LPRPDE, des témoins ont dit au comité qu'une orientation fédérale à l'intention de l'industrie pourrait améliorer la protection des renseignements personnels. En effet, plusieurs témoins, dont Mme Lawson, ont insisté sur le rôle important que pourrait jouer le gouvernement fédéral afin de rassembler les intervenants pour mettre au point des lignes directrices claires. Le commissaire à la protection de la vie privée a quant à lui fait ressortir le rôle important que peut jouer l'industrie et a vivement conseillé aux entreprises de mettre sur pied des programmes internes robustes de gestion des renseignements personnels pour gerer les données qu'elles recueillent et utilisent dans le cadre de leurs activités commerciales.

Les témoins ont soupesé les avantages de l'adoption volontaire de lignes directrices par l'industrie par rapport à ceux d'une approche réglementaire. De son côté, Mme Lawson a fait valoir qu'une réglementation gouvernementale serait nécessaire, bien qu'elle soutienne l'élaboration d'un code de pratique technologiquement neutre en consultation avec les principaux intervenants à titre de première étape vers la réglementation. Mme Polsky, quant à elle, a semblé être d'accord avec la réglementation et a insisté sur la nécessité que des limites soient « imposées » aux constructeurs d'automobiles. Lorsqu'il a expliqué pourquoi il préférait commencer par des lignes directrices volontaires, le commissaire à la protection de la vie privée a indiqué que la LPRPDE énonce des principes fondamentaux qui peuvent s'appliquer à toutes les industries, mais qu'un code de pratique pourrait fournir des normes améliorées conçues spécifiquement pour les véhicules branchés. C'est pourquoi le commissaire à la protection de la vie privée a informé le comité de l'intention du commissariat de financer un projet indépendant sur l'élaboration d'un code de pratique en matière de protection des renseignements personnels pour les voitures branchées.

Dans un mémoire complémentaire présenté au comité en novembre 2017, le commissaire à la protection de la vie privée a donné des précisions à ce sujet. Bien qu'il y réaffirme l'utilité d'un code de pratique pour les véhicules connectés, il signale qu'il faudrait élargir la portée des efforts déployés pour « tirer parti

des nombreuses possibilités et relever les nombreux défis » que présente l'évolution du véhicule branché. À cette fin, il encourage vivement le gouvernement à « réunir les intervenants visés – les organismes de réglementation, les législateurs, les constructeurs automobiles et les consommateurs – afin d'élaborer un cadre pour les véhicules connectés, qui traiterait entre autres de la protection de la vie privée ». Le commissaire souligne que le Commissariat « a l'intention de jouer un rôle de premier plan dans tout projet de ce genre ».

Le comité estime que l'industrie des VA et des VB est encore trop jeune pour qu'on puisse déterminer si des lignes directrices volontaires seront suffisantes ou s'il faudra prendre des règlements pour protéger les renseignements personnels des Canadiens à l'ère des VA et des VB. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 9

Que le gouvernement du Canada continue d'évaluer la nécessité de prendre des règlements sur la protection des renseignements personnels propres aux véhicules branchés ;

RECOMMANDATION 10

Que Transports Canada rassemble les intervenants concernés – les gouvernements, les constructeurs d'automobiles et les consommateurs – afin d'élaborer un cadre de travail sur les véhicules branchés, dont l'un des principaux éléments sera la protection des renseignements personnels.

ACCÈS AUX DONNÉES ET CONCURRENCE

Selon l'Association pour l'accès à l'information et le respect de la vie privée de la Colombie-Britannique, « l'étendue des données personnelles qui peuvent être recueillies par les VA et les VB va bien au-delà de ce qui peut déjà être tiré des appareils mobiles, tant du point de vue de la qualité que de la quantité » [TRADUCTION]. Les données disponibles, par exemple sur le comportement, la santé, les contacts personnels et l'horaire du conducteur, peuvent avoir une grande valeur, et de nombreux acteurs souhaitent y avoir accès. Les témoins représentant le marché secondaire et le secteur de la location d'automobiles, notamment, ont dit au comité que leurs secteurs devraient avoir accès à ces données pour des motifs légitimes.

Dans le marché secondaire, la Norme canadienne visant les renseignements sur l'entretien des véhicules automobiles (CASIS), une entente volontaire sur le droit de réparer, veille à ce que les équipementiers communiquent aux techniciens du marché secondaire les renseignements sur l'entretien et la réparation dont ils ont besoin pour effectuer des réparations. Jean-François Champagne, président de l'Association des industries de l'automobile du Canada (AIA Canada), a toutefois signalé au comité que la norme CASIS est muette au sujet de la télématique, la technologie des VB qui permet de recueillir et d'envoyer des données en temps réel depuis le véhicule. M. Champagne a expliqué que les équipementiers pourraient utiliser cette technologie pour limiter la concurrence :

[La télématique] procure aux équipementiers et à leurs concessionnaires un accès sans précédent aux communications avec un véhicule et son propriétaire. Cette situation engendre un monopole sur les clients en raison de la nature fermée du circuit de communication. Cette boucle fermée du circuit de communication renforcera de plus en plus la capacité des équipementiers, entre autres, d'indiquer au propriétaire d'un véhicule de le conduire chez un concessionnaire donné pour qu'une vérification de routine et des opérations de diagnostic, des réparations et des mises à jour logicielles soient effectuées. Les applications des services télématiques que j'ai mentionnées pourraient procurer aux équipementiers un énorme avantage concurrentiel dans la réparation, car elles éloigneront la clientèle des ateliers indépendants d'entretien et de réparation.

(Jean-François Champagne, président, AIA Canada, 17 mai 2017)

Malgré ces inquiétudes, M. Champagne a déclaré au comité qu'AIA Canada entend poursuivre son travail dans le cadre de la norme CASIS, l'entente volontaire sur le droit de réparer entre les équipementiers et le marché secondaire de l'automobile. Il a toutefois ajouté qu'« il n'est pas impossible qu'un jour nous soyons de retour ici pour vous présenter une demande, en vous disant qu'au-delà de nos efforts, il serait peut-être temps que le gouvernement s'implique dans le dossier et établisse une structure réglementaire ».

Des témoins ont aussi fait observer que les préoccupations relatives à l'accès aux données pourraient être plus vives dans les régions rurales, où les exploitations familiales sont parfois les seuls ateliers où les gens peuvent faire réparer leur voiture. M. Nantais a déclaré ce qui suit au comité : « Les exploitations familiales ont de la difficulté depuis un certain temps à suivre le rythme des progrès technologiques dans l'industrie, et cela se poursuivra. »

Les témoins du secteur de la location d'automobiles craignent eux aussi que les équipementiers restreignent l'accès aux données recueillies par les VA et les VB. En effet, Mme Gerber a signalé au comité que de nombreux constructeurs de véhicules ont l'intention de fabriquer des VA et de s'en servir pour offrir des services de transport aux consommateurs. Ainsi, a-t-elle expliqué, ces équipementiers pourraient être portés à restreindre l'accès aux données et à limiter les choix offerts aux consommateurs :

Advenant le cas où un constructeur posséderait et gérerait sa propre flotte de véhicules autonomes et offrirait des services de transport aux consommateurs en même temps qu'il vendrait des autos à d'autres exploitants de flotte offrant les mêmes services aux consommateurs, le constructeur aurait alors la capacité de restreindre l'accès aux données permettant de faire fonctionner la flotte de façon efficace et efficiente, et il pourrait dicter aux fournisseurs le prix qu'ils doivent payer pour exploiter leur flotte. Vous êtes à même de voir les distorsions que cela créerait à court terme sur le marché de la concurrence.

(Tomi Gerber, vice-présidente adjointe, Affaires gouvernementales et publiques, Enterprise Holdings, 4 octobre 2017)

Les enjeux entourant l'accès aux donnés et la concurrence auront des effets sur le marché secondaire et sur le secteur de la location d'automobiles et, comme l'a fait remarquer Mme Gerber, auront probablement une incidence sur les compagnies d'assurance et les entreprises de gestion de parcs de véhicules.

Dans son mémoire, Geotab Inc., une entreprise ontarienne d'Oakville qui œuvre dans le domaine de la technologie des VB, a également exprimé ses préoccupations au sujet de l'accès aux données recueillies par les véhicules. En effet, l'entreprise craint

que les constructeurs n'imposent des restrictions à l'usage de ces données au moyen de licences d'utilisation, de manière telle que les propriétaires de véhicules et de parcs de véhicules (comme les entreprises de location de voitures) devraient payer pour y accéder.

M. Ticoll a quant à lui expliqué au comité que si les Canadiens ont recours aux transports sur demande au lieu d'avoir une automobile, « une poignée d'entreprises internationales » pourrait contrôler la plupart des voitures se trouvant dans nos rues ainsi que les données qu'elles génèrent.

Le comité estime que l'industrie des VA et des VB est encore trop jeune pour qu'on puisse déterminer avec certitude si la technologie en cours de développement aura la moindre répercussion sur le comportement concurrentiel des équipementiers. Cependant, compte tenu du risque noté par les représentants du marché secondaire et du secteur de la location d'automobiles, le comité estime que le gouvernement devrait surveiller la situation. Les enjeux liés à la concurrence relèvent du mandat d'ISDE. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 11

Qu'Innovation, Sciences et Développement économique Canada surveille les répercussions de la technologie des véhicules automatisés et branchés sur la concurrence entre les divers secteurs des industries liées à l'automobile et aux transports, afin de veiller à ce que les secteurs comme le marché secondaire et la location de voitures conservent l'accès aux données dont ils ont besoin pour offrir leurs services.

RECHERCHE-DÉVELOPPEMENT

Le gouvernement fédéral a déjà commencé à investir dans la recherche-développement sur les VA et les VB par l'intermédiaire de programmes existants, et des témoins ont informé le comité que le Canada a une expertise de renommée internationale dans les domaines de l'automobile, de la technologie de l'information et de l'intelligence artificielle (IA). C'est au Canada (dans le corridor Windsor-Montréal) que se trouve la plus grande grappe de technologies de l'information en Amérique du Nord en dehors de la Silicon Valley. Par exemple, M. Kintz a déclaré au comité que son entreprise a choisi d'installer les bureaux d'un de ses groupes de technologie de pointe à Toronto parce que cette ville est un centre d'expertise dans le domaine de l'IA.

D'autres témoins sont d'avis que le gouvernement fédéral devrait encourager davantage la mise à l'essai de ces véhicules au Canada. Selon eux, le Canada a du retard sur d'autres pays en ce qui a trait à la recherche-développement sur les VA et les VB.

Des témoins ont parlé au comité du CTRVM de Blainville, au Québec, qui est une installation de renommée internationale. Or, M. Bonny fait remarquer dans son mémoire qu'en l'absence de nouveaux investissements, le CTRVM « sera perdu faute d'infrastructures pour évaluer les véhicules du futur ». Sachant que le Canada ne dispose d'aucun site d'essais permettant d'évaluer tous les systèmes d'un VA ou d'un VB, M. Bonny indique dans son mémoire que l'infrastructure actuelle du CTRVM serait le lieu idéal pour établir un nouveau Centre d'essais et de recherche pour la mobilité intelligente et l'innovation.

Le comité estime qu'il faut mettre les VA et les VB à l'essai tant dans des milieux urbains que ruraux, car l'intégration de la technologie comporte des considérations très différentes dans chacun de ces milieux. Dans son mémoire, le gouvernement des Territoires du Nord-Ouest a lui aussi suggéré au gouvernement fédéral de faire des études et des analyses sur les problèmes liés à l'utilisation des VA et des VB dans différentes régions canadiennes, surtout dans celles où le climat est très froid.

Étant donné l'importance de la cybersécurité et de la confidentialité en ce qui a trait aux véhicules, le comité estime également que ces sujets pourraient faire l'objet de recherches

plus poussées. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 12

Que le gouvernement du Canada investisse davantage dans la recherche-développement sur les véhicules automatisés et branchés par la création d'un nouveau Centre d'essais et de recherche pour la mobilité intelligente et l'innovation, qui serait situé sur les lieux de l'actuel Centre de test et de recherche pour les véhicules motorisés. Il faudrait accorder une attention particulière aux projets portant sur la cybersécurité et la protection des renseignements personnels, en plus de veiller à ce que ces véhicules soient mis à l'essai dans une combinaison de milieux urbains et ruraux et dans des climats froids.

M. Gingras a parlé au comité d'AUTO21, un réseau de recherche qui a reçu des fonds des Réseaux de centres d'excellence du Canada (RCE). Créés en 1989 par ISDE et les trois organismes subventionnaires fédéraux, les RCE « finance[nt] des partenariats entre les universités, l'industrie, le gouvernement et les organismes sans but lucratif afin de mettre sur pied des réseaux de recherche d'envergure ».

AUTO21, plus particulièrement, a été le plus important réseau de recherche consacré à la recherche-développement automobile de pointe au Canada. Mme Vrkljan a mentionné qu'AUTO21 avait permis de rapprocher l'industrie et le milieu de la recherche.

Comme l'a signalé M. Gingras, le réseau AUTO21 a mis fin à ses activités en 2016 en raison d'une règle établie dans le Guide du programme des RCE, qui précise que les réseaux doivent avoir un plan pour assurer la cessation graduelle de leurs activités à la fin de la période de financement du programme (dont la durée maximale est de 15 ans). M. Gingras a recommandé de modifier cette règle afin que des réseaux qui restent utiles comme AUTO21 ne soient pas tenus de mettre un terme à leurs activités. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 13

Qu'Innovation, Sciences et Développement économique Canada collabore avec les Réseaux de centres d'excellence (RCE) pour réexaminer la règle qui exige la cessation des activités de ces réseaux à l'échéance du financement du programme.

INFRASTRUCTURE ET TRANSPORTS EN COMMUN

Les gouvernements provinciaux et territoriaux et les municipalités sont responsables de la construction, de l'exploitation et de l'entretien de la plupart des infrastructures publiques [23]. Néanmoins, depuis 2000, le gouvernement fédéral joue un rôle grandissant pour leur procurer un soutien à cet égard en finançant des projets partout au Canada [24].

Des témoins ont longuement parlé de l'ampleur de l'aménagement en infrastructure nécessaire pour que l'intégration des VA et des VB soit réussie. Certains témoins ont indiqué que les VA sont conçus pour emprunter les routes existantes sans qu'il soit nécessaire de modifier les infrastructures actuelles et sont persuadés que la technologie pourra surmonter les difficultés liées au guidage des VA sur des routes enneigées ou verglacées en hiver. D'autres témoins, par contre, y compris un responsable d'ISDE, sont plus prudents :

> Il ne fait aucun doute qu'il faudra investir considérablement dans les infrastructures, et pas seulement à un endroit particulier, mais dans l'ensemble du pays. Si vous regardez les bancs d'essai pour certaines de ces technologies précoces –

qu'il s'agisse de capteurs intégrés aux routes ou d'autres technologies fusionnées aux infrastructures –, il est évident qu'il faudra prévoir un investissement considérable dans les infrastructures pour en arriver là.

(Charles Vincent, directeur général, Direction générale des industries de l'automobile et des transports, ISDE, 14 février 2017)

Il n'en demeure pas moins que les témoins s'entendaient généralement pour dire que des investissements dans les infrastructures seront nécessaires pour tirer le maximum des VA et des VB. Comme l'a expliqué M. McKenzie, il ne sera pas nécessaire de modifier les infrastructures routières d'ici les cinq prochaines années, mais il faudra le faire peu de temps après de manière à permettre la communication V2I et V2V. M. Khan a indiqué que l'automatisation ne peut pas vraiment se révéler utile si on ne change pas l'intelligence de l'infrastructure au moyen de la connectivité.

Les témoins ont également convenu de la nécessité d'évaluer les répercussions

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23 Gill, Vijay et coll., *Les véhicules automatisés : L'avènement de la prochaine technologie perturbatrice*, Le Conference Board du Canada, janvier 2015, p. 39 [EN ANGLAIS SEULEMENT].

24 Transports Canada, Examen de la *Loi sur les transports au Canada, Parcours : Brancher le système de transport du Canada au reste du monde* (4,8 Mo, 286 pages), tome 1, 2015, p. 20.

des VA et des VB sur les projets d'infrastructure. M. Ticoll a [fait remarquer] que certains projets d'infrastructure envisagés aujourd'hui, qui sont fondés sur des hypothèses antérieures à l'intégration des VA et des VB, pourraient sembler trop chers ou dépassés d'ici leur réalisation. Devant ce constat, certains témoins, dont M. Kirk, ont proposé de rendre obligatoire la tenue d'une vérification permettant d'évaluer les répercussions des VA sur les projets pour les nouveaux investissements dans les infrastructures routières et de transports en commun. M. Kirk a toutefois [souligné] que les outils de modélisation mathématique nécessaires pour effectuer ce genre de vérification des VA n'existent pas encore.

Le transport en commun est un autre secteur de compétence provinciale, même si le gouvernement fédéral offre du financement pour l'infrastructure qui y est rattachée. On prévoit que l'arrivée des technologies des VA et des VB aura d'importantes répercussions sur ce secteur. Des témoins estiment toujours que les transports en commun joueront un rôle dans ce dossier. M. Ticoll, par exemple, a [fait ressortir] les « excellentes » occasions que présentent les nouvelles technologies du côté de l'automatisation des voies ferrées et des voies réservées aux autobus. Cela dit, au-delà de la simple automatisation de moyens de transport en commun existants, des témoins ont affirmé que de nouveaux moyens de transport seraient intégrés au réseau de transport en commun. Ils ont surtout parlé du fait que l'intégration généralisée des VA pourrait aboutir à l'utilisation de petits taxis automatisés pour le transport individuel de porte à porte et de navettes automatisées pour faire le trajet de la maison à la station de métro ou l'arrêt de bus le plus près, et de la station de métro ou l'arrêt de bus final à la destination finale.

Plusieurs témoins ont indiqué que les VA pourraient fort bien améliorer le transport dans les secteurs qui sont actuellement mal desservis par les transports en commun classiques. Voici ce qu'a [expliqué] M. Leclerc :

> Nous croyons que l'avènement des véhicules autonomes représente une belle occasion de compléter et d'améliorer l'offre de services en matière de transport collectif, notamment là où le transport en commun à grande échelle n'est pas optimal, c'est-à-dire dans les zones à faible densité ou à faible demande. Dans ces cas,

> les petits véhicules autonomes pourront transporter les résidents, selon un horaire fixe ou à la demande, et les conduire à un axe principal de transport en commun rapide et efficace. Une telle approche permettra d'améliorer l'efficience du système et une utilisation optimale des ressources.

> (Patrick Leclerc, président-directeur général, Association canadienne du transport urbain, 19 septembre 2017)

Malgré les possibilités offertes par les VA et les VB, des témoins ont prévenu le comité que ces véhicules ne résoudront pas tous les problèmes liés au transport en commun. En effet, M. Litman a [déclaré] que le transport en commun demeurera sans doute coûteux pour les familles des régions rurales :

> Je soupçonne fort que les taxis sans conducteur n'offriront jamais un tarif inférieur à environ 40 cents le kilomètre; il variera probablement entre 40 et 50 cents le kilomètre. Pour ceux qui habitent dans un secteur rural, où le magasin le plus proche est à plus de 50 kilomètres, les déplacements ne seront jamais à bas prix. Il n'existe pas de technologie qui permettra d'offrir un transport à prix vraiment abordable à ceux qui font la navette pour se rendre au travail ou aller magasiner tous les jours.

> (Todd Litman, directeur général, Victoria Transport Policy Institute, 2 mai 2017)

M. Leclerc a [déclaré] que de nombreux problèmes liés au transport en commun en milieu urbain ne seront pas résolus par les VA si des politiques et des réflexions adéquates ne sont pas mises de l'avant :

> Cela signifie que la transformation de nos véhicules personnels en véhicules autonomes ne réglera pas l'un des problèmes principaux auxquels nous faisons face dans les villes, c'est-à-dire le manque d'espace urbain. En effet, un véhicule autonome dans lequel se trouve seulement une personne ne prend pas moins d'espace urbain qu'un véhicule traditionnel dans lequel se trouve un conducteur. Les problèmes liés à la congestion routière, à la capacité de la route et aux embouteillages demeureront les mêmes.

> (Patrick Leclerc, président-directeur général, Association canadienne du transport urbain, 19 septembre 2017)

ASSURANCES

D'après les témoignages entendus, l'arrivée des VA et des VB devrait entraîner des changements en ce qui concerne les contrats, les tarifs, la distribution des ventes et le traitement des réclamations dans le secteur de l'assurance automobile. Ryan Stein, directeur des politiques au Bureau d'assurance du Canada, fait partie des témoins qui ont expliqué au comité que toutes sortes de facteurs contribueront à ces changements. Par exemple, M. Stein a souligné que l'intégration des VA et des VB pourrait entraîner une baisse du nombre de collisions, mais que les coûts associés à ces dernières augmenteront. M. Stein a plus précisément cité des données du cabinet d'experts-conseils KPMG, qui prévoit une chute de 35 à 40 % du taux de collision et une augmentation de 25 à 30 % du coût des réparations au cours de la prochaine décennie.

Plusieurs témoins ont aussi dit que des changements pourraient survenir quant à la responsabilité en cas d'accident. L'Institut d'assurance du Canada a expliqué que l'erreur humaine est la principale cause de collisions depuis l'avènement des véhicules motorisés. En conséquence, les lois et les procédures d'assurance « se fondent sur l'hypothèse d'une erreur du conducteur [25] ». Cependant, en raison de l'automatisation accrue, les assureurs et le régime juridique devront tenir compte du rôle des erreurs informatiques et de la défaillance de l'équipement dans les collisions. À long terme, cela remet en question la responsabilité du conducteur, qui pourrait être entièrement transférée au constructeur lorsque les véhicules automatisés deviendront le moyen de transport prédominant [26].

L'Institut d'assurance du Canada a toutefois signalé que « le défi le plus important » entourant la responsabilité ne surviendra pas quand tous les véhicules seront automatisés, mais plutôt au cours de la prochaine décennie, lorsque les voitures traditionnelles, les voitures semi-automatisées et les premières voitures entièrement automatisées se côtoieront sur les routes. Le défi sera en partie attribuable à l'absence « de règles claires permettant de déterminer la responsabilité [et] de techniques approuvées pour l'obtention des éléments de preuve de la responsabilité » dans ce nouveau contexte.

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25   Institut d'assurance du Canada, *Les véhicules automatisés : conséquences pour l'industrie de l'assurance au Canada*, p. 43.

26   *Ibid*.

De plus, des témoins ont attiré l'attention du comité sur le fait qu'il est important que les constructeurs de véhicules transmettent des données aux assureurs pour que l'on puisse déterminer la cause d'une collision. M. Stein a d'ailleurs informé le comité que le Bureau d'assurance du Canada a créé un groupe de travail pour étudier les enjeux entourant l'arrivée des VA, comme l'accès aux données et les modifications possibles à la réglementation. Mario Fiorino, directeur, conseiller juridique et avocat principal du Bureau d'assurance du Canada, est persuadé que l'industrie de l'assurance appuiera toute directive formulée par le commissaire à la protection de la vie privée au sujet de l'utilisation des données.

L'assurance automobile, les infrastructures et les transports en commun sont des secteurs qui relèvent principalement de la compétence des provinces. De plus, bien qu'on sache que l'incidence des technologies des VA et des VB sur ces secteurs sera importante, on ignore quelle sera sa portée exacte. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 14

Que Transports Canada surveille l'incidence des technologies des VA et des VB sur l'assurance automobile, les infrastructures et les transports en commun au Canada.

EMPLOI ET ÉDUCATION

Nombreux sont ceux qui s'attendent à ce que les technologies des VA et des VB entraînent des pertes d'emplois dans certains secteurs de l'économie canadienne. Des responsables d'EDSC ont expliqué au comité que le gouvernement fédéral travaille en étroite collaboration avec les gouvernements des provinces et des territoires pour concevoir des programmes suffisamment souples pour s'adapter aux fluctuations de l'économie. Ils ont informé le comité que le gouvernement fédéral investit annuellement près de 3 milliards de dollars dans les ententes de transfert avec les provinces et les territoires aux fins de la formation et des programmes d'aide à l'emploi. Ces ententes permettent aux provinces de créer des programmes et des services

pour offrir aux chômeurs et aux personnes sous-employées de l'aide en matière de développement des compétences, de formation et de recherche d'emploi. Le comité se réjouit des efforts déployés par le ministère, mais demeure inquiet à la suite des témoignages sur les répercussions possibles des VA et des VB sur le marché du travail. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 15

Qu'Emploi et Développement social Canada continue de travailler en étroite collaboration avec les provinces et les territoires afin de renforcer le recyclage professionnel, la mise à niveau des compétences et le soutien à l'emploi pour les Canadiens touchés par des perturbations du marché du travail.

De nombreux témoins ont fait remarquer que le secteur des technologies des VA et des VB était susceptible de créer des emplois dans des domaines comme la technologie, les logiciels, la visualisation et la simulation. Ils ont notamment souligné que le Canada jouit d'une bonne réputation sur la scène mondiale en ce qui concerne le développement de logiciels et l'intelligence artificielle et qu'il attire un nombre important d'entreprises de haute technologie.

Malgré cette bonne réputation, des témoins comme M. Khan ont insisté sur le fait que le Canada doit chercher activement à profiter des perspectives économiques qu'offrent les VA et les VB. M. Khan a ajouté qu'il faut chercher à générer sans tarder ces retombées car, d'ici 10 ans, le Canada pourrait perdre sa chance de devenir un chef de file mondial dans le domaine.

Des témoins ont aussi parlé de la pénurie de main-d'œuvre qualifiée, actuelle et future,

sur le marché du travail canadien. Par exemple, Mme Merchant a déclaré qu'il faut augmenter le nombre de professionnels de la sécurité des technologies de l'information disponibles, et John Wall, premier vice-président et chef de BlackBerry QNX, a parlé de la pénurie d'expertise dans le domaine des logiciels intégrés. M. Wall a aussi affirmé que l'industrie doit aider les universités à déterminer les compétences qui sont nécessaires pour que le Canada puisse être concurrentiel sur le marché mondial.

Des représentants d'EDSC ont expliqué que le ministère est en train de mettre en œuvre un « Programme d'apprentissage intégré au travail » afin d'offrir aux étudiants davantage de possibilités d'acquérir une expérience en milieu de travail pendant leurs études postsecondaires. Le programme met particulièrement l'accent sur les domaines des STGM (sciences, technologies, génie et mathématiques). Le comité se réjouit de l'existence de tels programmes, mais il a aussi appris que les occasions d'apprentissage doivent être fournies plus tôt dans l'éducation des enfants. Par exemple, M. Wall a déclaré que les efforts déployés au secondaire sont insuffisants, particulièrement pour inciter les filles à faire carrière dans l'industrie des technologies.

Il faut également donner aux gens la formation et l'éducation nécessaires pour qu'ils puissent utiliser les technologies des VA et des VB de façon sécuritaire au quotidien. Sachant que l'octroi des permis de conduire relève de la compétence des provinces, Mme Vrkljan a proposé d'intégrer des séances de formation sur les nouvelles technologies au processus de renouvellement du permis. Dans le même ordre d'idées, Paul Kovaks, chercheur et auteur auprès de l'Institut d'assurance du Canada, a insisté sur l'importance de la formation, pour que tous les conducteurs apprennent à se servir le mieux possible des technologies des VA et des VB afin d'en tirer le meilleur parti possible.

Des témoins ont aussi mentionné le rôle de la formation et de l'éducation pour promouvoir les connaissances sur la cybersécurité dans la société. En ce qui concerne les initiatives en cours, M. Jones a indiqué que le CST a pris des mesures pour mieux informer le public en créant un compte Twitter, en publiant de nouveaux renseignements sur son site Web et en produisant des vidéos publiques sur son

travail en matière de cyberdéfense. Les témoins se sont toutefois entendus pour dire qu'il y a encore beaucoup à faire et ils ont insisté sur l'importance d'intervenir rapidement :

> [J]e reconnais que l'éducation est une compétence provinciale, mais pour des raisons liées à l'intérêt public, aux politiques économiques nationales et aux stratégies en matière de cybersécurité, nous sommes d'avis que l'éducation doit exiger l'enseignement de ces notions dès la maternelle. Je suis sérieuse. [...] Nous devons enseigner ces notions aux enfants, afin qu'ils puissent devenir des législateurs, des concepteurs d'automobiles et des technologues qui conçoivent des choses – des lois, des produits, des technologies – qui tiennent compte de la protection de la vie privée dès le départ. C'est une stratégie à long terme, mais nous devons commencer. Nous avons déjà du retard.
>
> (Sharon Polsky, présidente, Conseil du Canada de l'accès et la vie privée, 31 octobre 2017)

Le comité partage les inquiétudes exprimées par les témoins qui sont intervenus dans le cadre de la présente étude. Par conséquent, dans le cadre d'une stratégie nationale sur les VA et les VB, le comité recommande :

RECOMMANDATION 16

Que Sécurité publique Canada et le Centre de la sécurité des télécommunications travaillent en étroite collaboration avec les provinces et les territoires pour créer des documents et des programmes de formation sur la cybersécurité afin que le public comprenne mieux les enjeux liés à la cybersécurité.

De gauche à droite, les sénateurs Michael L. MacDonald, Betty Unger et Terry Mercer à bord d'un autobus automatisé pendant une mission d'étude au Centre pour le transport intelligent de l'Université de l'Alberta, à Edmonton, en septembre 2016.

CONCLUSION

Lorsque le Comité sénatorial permanent des transports et des communications a entrepris cette étude sur les véhicules automatisés et branchés, il cherchait à comprendre quels seraient les effets de cette technologie sur le Canada et à cerner les enjeux réglementaires et techniques entourant son intégration. Si les consommateurs canadiens ont déjà accès à un faible degré d'automatisation et de connectivité, l'étude menée par le comité démontre que l'arrivée d'une automatisation et d'une connectivité plus généralisées sur les routes canadiennes n'est plus qu'une question de temps.

Les VA et les VB plus perfectionnés pourraient avoir plusieurs avantages, notamment en ce qui concerne la réduction du nombre d'accidents d'automobile, la réduction de la pollution provenant des véhicules, l'accroissement des options de transport mises à la disposition des Canadiens et divers avantages économiques. Cette technologie soulève toutefois plusieurs préoccupations au chapitre des pertes d'emploi, de la protection des renseignements personnels, de la cybersécurité et de l'étalement urbain. Le comité estime donc qu'il ne sera pas possible de profiter pleinement des avantages de cette technologie en l'absence d'une stratégie nationale coordonnée.

Afin de mettre à profit les initiatives déjà mises en œuvre par les gouvernements au Canada, le comité a recommandé à Transports Canada et à ISDE de créer une entité conjointe chargée des politiques, qui serait responsable de coordonner les efforts à l'échelon fédéral et de mettre en œuvre une stratégie nationale sur les VA et les VB. Dans le cadre de ses recommandations, le comité a aussi cerné les éléments principaux de cette stratégie, qui porte entre autres sur les questions relatives à la sécurité des véhicules, à la cybersécurité et à la protection des renseignements personnels.

Le comité estime que cette stratégie aidera le Canada à planifier l'intégration des véhicules automatisés et branchés pour que le pays soit prêt à faire face à cette période d'évolution rapide de la technologie.

ANNEXE A :
TÉMOINS

Le mercredi 8 février 2017	
Transports Canada	Kim Benjamin, directrice générale, Sécurité routière et réglementation automobile, Groupe sécurité et sûreté Catherine Higgens, sous ministre adjointe, Programmes, Groupe des programmes Craig Hutton, directeur général, Politiques stratégiques, Groupe des politiques Ryan Klomp, directeur principal par intérim, Programmes environnementaux et de transport, Groupe des programmes
Le mardi 14 février 2017	
Innovation, Sciences et Développement économique Canada	Krista Campbell, directrice générale, Spectre, technologies de l'information et télécommunications, Direction générale des politiques numériques Martin Proulx, directeur général, Spectre, technologies de l'information et télécommunications, Direction générale du génie, de la planification et des normes Charles Vincent, directeur général, Direction générale des industries de l'automobile et des transports
Le mercredi 8 mars 2017	
Ressources naturelles Canada	Aaron Hoskin, chef par intérim, ecoENERGY pour les biocarburants, conseiller technique principal, Office de l'efficacité énergétique Dean Haslip, directeur général, CanmetÉNERGIE Paula Vieira, directrice, Division des transports et carburants de remplacement, Office de l'efficacité énergétique Marc Wickham, directeur, Programmes en science et technologie énergétiques, Bureau de recherche et développement énergétiques
Le mardi 28 mars 2017	
Commissariat à la protection de la vie privée du Canada	Daniel Therrien, commissaire à la protection de la vie privée du Canada Patricia Kosseim, avocate générale principale et directrice principale, Direction des services juridiques, des politiques, de la recherche et de l'analyse des technologies

Le mercredi 29 mars 2017	
Emploi et Développement social Canada	Amy Mifflin-Sills, directrice, Politiques des programmes, Direction générale des compétences et de l'emploi
	Atiq Rahman, directeur général par intérim, Programme canadien des prêts étudiants, Direction générale de l'apprentissage
	Jonathan Will, directeur général, Direction de la politique économique, Direction générale des politiques stratégiques et de service
Le mardi 4 avril 2017	
Gendarmerie royale du Canada	Surintendant principal Eric Stubbs, directeur général, Service national des enquêtes criminelles, Services de police contractuels et autochtones
Centre de la sécurité des télécommunications	Scott Jones, chef adjoint de la Sécurité des TI
	Richard Pierson, directeur général, Cyberdéfense, Sécurité des TI
Sécurité publique Canada	Colleen Merchant, directrice générale, Direction de la cybersécurité nationale
Le mercredi 5 avril 2017	
Conseil canadien des administrateurs en transport motorisé	Allison Fradette, directrice générale
Ministère des Transports de l'Alberta	Wendy Doyle, coprésidente, Groupe de travail sur les véhicules automatisés, Conseil canadien des administrateurs en transport motorisé
Le mardi 11 avril 2017	
À titre personnel	David Ticoll, agrégé supérieur de recherche, Laboratoire des politiques d'innovation, Munk School of Global Affairs, Université de Toronto
Borden Ladner Gervais S.E.N.C.R.L., S.R.L.	Kevin LaRoche, avocat et associé
	Robert Love, avocat et associé
Le mardi 2 mai 2017	
Association pour l'accès à l'information et le respect de la vie privée de la Colombie-Britannique	Vincent Gogolek, directeur général
	Philippa Lawson, avocate-procureure
Victoria Transport Policy Institute	Todd Litman, directeur général

Le mercredi 3 mai 2017	
PMG Technologies	Franck N'Diaye Bonny, directeur général, Centre de test et de recherche pour les véhicules motorisés
Centre d'excellence des véhicules automatisés du Canada	Barrie Kirk, directeur général
Le mardi 9 mai 2017	
Association canadienne des automobilistes	Ian Jack, directeur général, Communications et relations gouvernementales, Affaires publiques Jason Kerr, directeur, Relations gouvernementales, Affaires publiques
Association pour la protection des automobilistes	George Iny, directeur, siège social
Le mercredi 10 mai 2017	
Institut du véhicule innovant	François Adam, directeur général Frederick Prigge, directeur, Recherche et développement
À titre personnel	Ata Khan, professeur, membre du conseil d'administration de l'organisme ONE ITS, Département de génie civil et environnemental, Université Carleton
Le mardi 16 mai 2017	
À titre personnel	Denis Gingras, professeur, Laboratoire en intelligence véhiculaire, Université de Sherbrooke Tony Zhijun Qiu, professeur, Faculté de génie, Université de l'Alberta
Le mercredi 17 mai 2017	
Automotive Parts Manufacturers' Association	Warren Ali, directeur, Initiatives en technologies émergentes
Association des industries de l'automobile du Canada	Jean-François Champagne, président France Daviault, directrice principale, Relations avec les parties intéressées
Le mardi 30 mai 2017	
Centre de recherche automobile de Waterloo (WatCAR), Université de Waterloo	Ross McKenzie, directeur général
Le mercredi 31 mai 2017	
Constructeurs mondiaux d'automobiles du Canada	David Adams, président
Toyota Canada Inc.	Stephen Beatty, vice-président, Entreprise Dave Nichols, directeur national, Affaires extérieures

Le mardi 6 juin 2017	
BlackBerry	Sandeep Chennakeshu, président, BlackBerry Technology Solutions John Wall, premier vice-président et chef de BlackBerry QNX
Le mercredi 7 juin 2017	
Compagnie General Motors du Canada	Harry Lightsey, directeur administratif, Politique sur les nouvelles technologies David Paterson, vice-président, Affaires corporatives et environnementales
Association canadienne des constructeurs de véhicules	Mark A. Nantais, président
Le mardi 13 juin 2017	
CoinDesk	Nolan Bauerle, directeur de la recherche
Carillon Information Security Inc.	Patrick Patterson, président
Ford du Canada Limitée	Blake Smith, directeur en chef, Durabilité, Environnement et Ingénierie de la Sécurité
Le mercredi 14 juin 2017	
À titre personnel	David Michelson, coprésident, Société des systèmes de transport intelligents du Canada, et professeur, Université de la Colombie-Britannique
Le mardi 19 septembre 2017	
Association canadienne du transport urbain	Patrick Leclerc, président-directeur général
Transdev Canada	Dominique Lemay, chef de la direction
Le mercredi 20 septembre 2017	
Alliance canadienne du camionnage	Marco Beghetto, vice-président, Communications et Nouveaux médias
Association du camionnage des provinces de l'Atlantique	Jean-Marc Picard, directeur exécutif

Le mardi 26 septembre 2017	
CARP (anciennement appelée Canadian Association for Retired Persons)	Rick Baker, président, chapitre d'Ottawa de CARP, Défense des intérêts des personnes âgées
Conseil des Canadiens avec déficiences	Bob Brown, président du Comité des transports
Candrive	Brenda Vrkljan, professeure agrégée, Ergothérapie, École des sciences de la réadaptation, Université McMaster
Le mercredi 27 septembre 2017	
Bureau du gouverneur de l'Arizona, États-Unis	Matthew Clark, conseiller en politiques
Le mercredi 4 octobre 2017	
Bureau d'assurance du Canada	Mario Fiorino, directeur, conseiller juridique et avocat principal Ryan Stein, directeur des politiques
Enterprise Holdings	Tomi Gerber, vice-présidente adjointe, Affaires gouvernementales et publiques
Associated Canadian Car Rental Operators	Craig Hirota, vice-président, Relations gouvernementales et services aux membres
L'Institut d'assurance du Canada	Peter Hohman, président et directeur général Paul Kovacs, chercheur et auteur
Le mardi 17 octobre 2017	
Département américain des Transports	Nathaniel Beuse, administrateur associé pour la recherche sur la sécurité des véhicules, Administration nationale de la sécurité du trafic routier Finch Fulton, sous-secrétaire adjoint à la politique de transport
Département des Transports du Michigan	Kirk Steudle, directeur
Le mercredi 18 octobre 2017	
Uber	Justin Kintz, directeur principal, Politiques et communications (Amériques)
Le mardi 24 octobre 2017	
Central North American Trade Corridor Association	Paul Godsmark, chef des services technologiques au Centre d'excellence des véhicules automatisés du Canada Roy Ludwig, maire, Ville d'Estevan, Saskatchewan

Le mercredi 25 octobre 2017	
Département des véhicules à moteur de Californie, États-Unis	Bernard Soriano, directeur adjoint
Le mardi 31 octobre 2017	
Motor Coach Industries	John-Paul Pelletier, vice-président, Ingénierie
Conseil du Canada de l'accès et la vie privée	Sharon Polsky, présidente
New Flyer Industries Canada	Thomas Small, directeur, Développement de nouveaux produits

TAB 8

POLICIES FOR STRONGER AND MORE INCLUSIVE GROWTH IN CANADA

Better Policies Series

OECD

BETTER POLICIES FOR BETTER LIVES

Foreword

Canada has experienced solid improvements in living standards in the last two decades and enjoys a higher quality of life than many other OECD countries. GDP per capita is above the OECD average, and Canadians enjoy better environmental quality and better health outcomes than the average in OECD countries. Canada's employment rate is well above the OECD average, and Canada is also one of the strongest OECD countries in terms of students' skills.

However, not all population groups enjoy equally high levels of well-being. Although Canada is one of the few OECD countries where inequality did not rise during the 2000s, inequalities in income and other dimensions of well-being remain higher than in the OECD countries with the lowest inequalities. This suggests that Canada can do even better. Incomes for the top 10% of the income distribution are, on average, nine times higher than for the bottom 10%, compared to five and six times higher in the best-performing OECD countries. Moreover, even though the share of middle-income households has barely changed over the last 15 years, fewer and fewer Canadian households perceive themselves as belonging to the middle class.

The government under Prime Minister Justin Trudeau is determined to tackle these issues, to strengthen equality of opportunity and ensure that every Canadian has the chance to succeed in life. This brochure has been prepared to help the Canadian government identify key policy reforms that would help the country achieve more inclusive growth. Specifically, it suggests that action is required on three main fronts.

First, the Canadian government needs to help Indigenous people, women, older workers, migrants and people with mental health problems to better integrate into the labour market. Currently, all these groups fare worse than the average Canadian in terms of labour market outcomes. To this end, the government needs to strengthen the skills of Indigenous people, put in place better family-friendly supports, strengthen training for older workers, advance the recognition of foreign qualifications and better leverage education institutions and employers to foster good mental health.

Second, since efforts to ensure that all individuals have the opportunity to lead meaningful and productive lives rely on a flourishing business sector, the government also needs to address the slowdown in productivity growth. As in other countries, this slowdown is linked to a growing divide between high-productivity frontier firms that make use of cutting-edge technology (including digital technologies) and other firms. Repairing the technology diffusion machine requires creating a competitive playing field for firms, including through regulatory reform and more targeted support for small business, and helping small firms grasp the opportunities of the digital revolution.

Third, the government needs to continue its efforts to modernise the public sector and strengthen public governance. The multidimensional nature of inclusive growth calls for solutions that are well co-ordinated within and across levels of government. This is particularly challenging in such a highly decentralised country as Canada. A number of important steps have already been taken, including the Canada Free Trade Agreement and the Pan-Canadian Framework on Clean Growth and Climate Change.

Only through complementary reforms in all these areas will Canada be able to succeed in further enhancing the well-being of all its citizens. The OECD looks forward to supporting the Government of Canada in this endeavour as it designs, promotes and implements better policies for better lives.

Angel Gurría
OECD Secretary-General

Editorial

Globalisation and technological change are transforming the way the Canadian economy functions, creating tremendous opportunities for growth but also risking higher inequalities. The Canadian economy increasingly operates on a global scale, in a world economy where capital and high-skilled labour are internationally mobile, partly as a result of intensive technological change, and particularly digitalisation, which reduce mobility costs and enhance access to new business opportunities. Canada scores highly in many well-being dimensions but challenges remain as certain inequalities of outcomes and opportunities persist.

The OECD's Inclusive Growth initiative provides an ideal framework for better understanding the challenges that Canada's increasingly globalised economy implies for inclusiveness and for identifying the mechanisms through which policies can ensure that everyone has the opportunity to succeed in life. The framework underscores the vicious circle by which inequalities of outcomes, in particular income, lead to inequalities of opportunities, which in turn reinforce inequalities of outcomes. It builds on the OECD's longstanding expertise on inequalities, growth and productivity dynamics, as well as on well-being, and underpins the OECD's New Approaches to Economic Challenges efforts to develop a new paradigm of economic growth that generates improved well-being for all. The framework also builds on the OECD's analysis of the nexus between productivity and inclusiveness, which suggests that promoting inclusiveness is key to stronger and more sustainable productivity growth and conversely, that a dynamic environment for business and innovation is a pre-condition for reducing inequality and opportunity gaps.

This report applies the Inclusive Growth framework to the analysis of two aspects of Canadian performance, (a) well-being inequalities and (b) productivity growth. It finds that the Canadian economy has grown robustly since the turn of the century and recovered more strongly from the global financial crisis than most other OECD countries. But stagnating productivity and weak business dynamism are a concern. Aggregate firm entry and exit rates and the entrepreneurship rate have been falling since the 1980s. Labour productivity, whilst high, is rising more slowly than in the United States and Australia. The shortfall in labour productivity performance compared to relevant peers is largely due to a deterioration in multi-factor productivity growth, as capital intensity actually rose more quickly in the recent period than in the 1990s. This trend is likely to continue for some time, as GDP growth potential slows and Canada's population ages because of low fertility rates and rising life expectancy.

In terms of inequalities, Canada's performance is similar to the OECD average. Differences in health outcomes as well as education and skills between people with high and low socio-economic backgrounds are even smaller in Canada than the OECD average. Moreover, overall labour market outcomes of immigrants are above those observed in other OECD countries. Canada also does relatively well in terms of gender equality, even though it has not progressed in this area recently. Still, a number of challenges remain as certain inequalities of outcomes and opportunities persist, particularly for Indigenous people, who suffer from various social problems, including living in sub-standard housing, and a higher likelihood to drop out of school, to take up smoking and heavy drinking and to have health problems. They are also 20% less likely to be employed than their non-Indigenous peers.

Canada has already begun responding to these challenges. The federal government is seeking to engage more women and Indigenous people in the labour market, and find ways of boosting productivity growth through increased competition, innovation and skills. To overcome barriers to equitable access to tertiary education, the federal government is increasing targeted needs-based financial assistance, improving the transparency of the aid application process, and expanding information about returns to education. The federal government has also made improving outcomes for Indigenous people a top priority. Moreover, Canada has attempted to boost business dynamism in recent times through measures such as the

Paperwork Burden Reduction Initiative, the Red Tape Reduction Action Plan and the Venture Capital Action Plan.

However, more progress can be made. Fostering growth that is *both* stronger and more inclusive requires countries to create equality of opportunities *ex ante* so that everybody has a chance to thrive and contribute to economic activity, rather than focusing on fixing an unequal distribution of well-being *ex post* through redistribution. This means that the whole range of policy levers available to governments needs to be reassessed to make sure they explicitly take equity considerations into account. To this end, an integrated fiscal policy agenda should be adopted to reduce inequality not just through tax-and-transfer redistribution but by making the pre-tax distribution of income more equal as well, for instance by supporting private investment in human capital. Targeted early childhood care and education support for disadvantaged families and Indigenous people should be expanded. This includes removing barriers to early childhood education and care services for those in need, helping poor parents connect to the resources they need to educate their children and investing in lifelong-learning programmes. Canada also needs to enhance its business dynamism. This can be achieved through regulatory reforms that make it easier for young firms to enter markets and provide them with easier access to finance and stronger contract enforcement, providing direct support and tax incentives for all firms to carry out R&D regardless of size, and reducing compliance costs through the use of digital technologies.

The OECD stands ready to use its inclusive growth framework to help Canada create a more equal society in which all people and firms can thrive.

Gabriela Ramos
OECD Chief of Staff and Sherpa

Key recommendations

Canada needs to reinforce policy efforts to build a prosperous and inclusive society. To this end, policy action is needed to enable all Canadian people to be well integrated into the labour market and contribute to economic prosperity, to give all Canadian firms a chance to create jobs, enhance their productivity and disseminate innovative ideas, and to put in place strong governance structures that support inclusive growth objectives. Specific reforms that could help Canada achieve these goals include the following:

- Support growth-oriented entrepreneurship by women, including by removing unwarranted restrictions on the eligibility of part-time entrepreneurs to public enterprise support programmes and scaling up supplier-diversity initiatives

- Continue building the governance capacities of First Nations, Inuit and Métis communities, and facilitate the exchange of information about successful approaches to employment and job creation.

- Expand the access of older displaced workers to more intensive job-search assistance, case management and training, particularly for those who are affected by small-scale or individual displacements or ineligible for Employment Insurance due to severance payments.

- Establish an institutional mechanism, such as the OECD's Competition Assessment Toolkit, to review existing and proposed public policies, identify those that unduly restrict competition and revise them by adopting more pro-competitive alternatives, where feasible without jeopardising other policy objectives such as inclusiveness.

- Strengthen Canadian small businesses' skills for the digital economy, including through coaching programmes to extend digital literacy.

- Review small business taxation to identify clear market failures and the policy instruments best suited to addressing them.

- Consider strengthening the measurement of public sector productivity, including by measuring outputs beyond the education and health sectors and strengthening intra-governmental co-ordination on productivity measurement.

- Better target policy co-ordination and dialogue between the three levels of government to productivity and competitiveness priorities.

- Ensure effective and timely implementation of the Pan-Canadian Framework on Clean Growth and Climate Change, establish a mechanism for policy evaluation and adjustment, and promote co -ordination of sub-national climate policies.

Table of Contents

1 Introduction

After two decades of solid growth of household disposable income and living standards more generally, Canadians enjoy a high level of well-being. GDP per capita is above the OECD average, and the country is one of the strongest OECD countries in terms of students' skills. Canadians enjoy better environmental outcomes than the OECD average and also live healthier lives. However, disparities persist: not all population groups have benefitted equally strongly from past improvements in living standards. Income inequality is close to the OECD average and has remained broadly stable over the last 15 years, but the tax and benefit system is less redistributive than those in most OECD countries. At the same time, productivity growth has slowed down, limiting the potential for further improvements in living standards. The cross-cutting challenge presented by the persistence of multidimensional inequalities and weak productivity growth underlines the need to reappraise Canada's policy-making process with the aim of fostering stronger and more inclusive growth. The government's commitment to strengthening the middle class and providing all those who work hard the opportunity to join it is very welcome in this regard.

On average, well-being is high in Canada

Canada performs strongly in terms of the well-being of its citizens (Figure 1.1). In many areas of the OECD's Better Life Index, the country scores among the top-performing OECD countries. Canadians are more satisfied with their lives than the OECD average. When asked to rate their general satisfaction with life on a scale from 0 to 10, Canadians gave it a 7.4 grade in 2015, well above the OECD average of 6.5. GDP per capita is relatively high (USD 44 963 in 2016, compared with the OECD average of USD 42 096), as is the employment rate (72.6% in 2016, compared to the OECD average of 67%). Canadians enjoy better air quality than the OECD average (the level of tiny air pollutant particles was 12.1 micrograms per cubic meter in 2013, compared to the OECD average of 14.05 micrograms per cubic meter), better water quality (90% of people said in 2015 that they were satisfied with the quality of their water,

FIGURE 1.1. **HOW'S LIFE IN CANADA?**
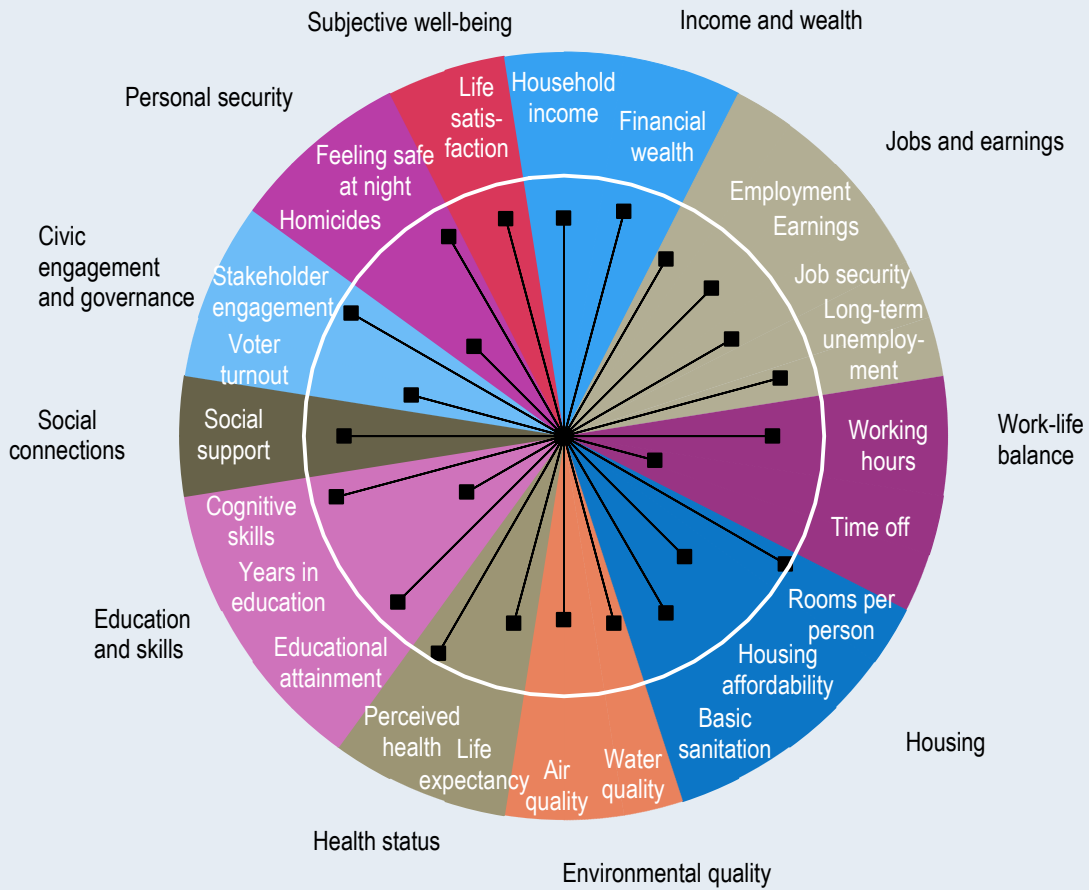
Note: The centre of the circle depicts the worst-performing OECD country and the white circle depicts the best-performing OECD country. The black dots at the end of the black lines depict the performance of Canada. Longer lines show areas of relative strength, while shorter lines show areas of relative weakness.

Source: OECD Better Life Index, 2016.

compared to the OECD average of 81%) and better health outcomes (89% of Canadians rated their health as good in 2013, one of the highest shares among OECD countries). And there is a strong sense of community among Canadian citizens. In 2015, 94% of Canadians said that they know someone they could rely on in time of need (higher than the OECD average of 88%). Canada is also one of the strongest OECD countries in terms of students' skills. In the OECD's Programme for International Student Assessment (PISA), the average Canadian student scored 523 on average in reading literacy, maths and science in 2015 (well above the OECD average of 486).

But there are also a number of areas in which Canada performs less well. For example, while overall living conditions are very good (Canada has the highest number of rooms per person in the OECD), housing expenditure is high, with 43% of low-income renters spending more than 40% of their disposable income on rent in Canada (5 percentage points more than the OECD average). Moreover, full-time employees on average report having less time off (i.e. time spent on leisure and personal care) than full-time employees in most other OECD countries. While the unemployment, rate has fallen over the last year, at 6.7% it was still above the OECD average

FIGURE 1.2. **LIVING STANDARDS HAVE BEEN RISING RAPIDLY IN CANADA**

Growth of multidimensional living standards, median households, in % 1995-2015
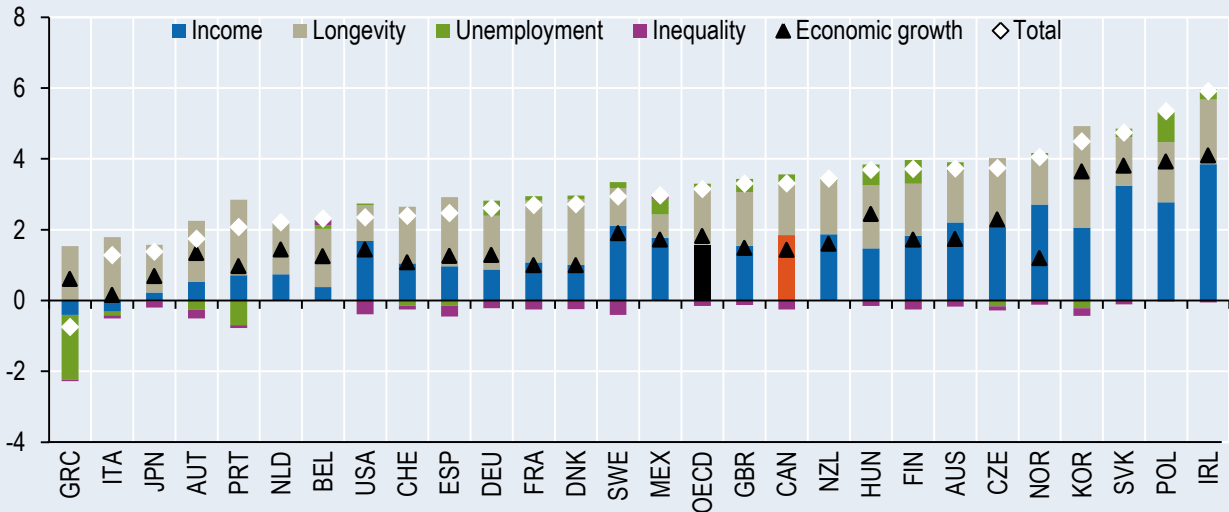
Note: Calculations on income inequality are based on an inequality aversion parameter equal to 1.5 and are based on the difference between the income growth of the average income and that of the median income.

Source: OECD calculations based on OECD Annual National Accounts; OECD Income Distribution Database, http://www.oecd.org/social/income-distribution-database.htm; and OECD Health Database, https://data.oecd.org/health.htm.

of 6.3% in the first quarter of 2017. Canada also scores less well in terms of personal security. While Canadians generally feel safe when walking alone at night, the homicide rate is higher than in most other OECD countries.

Canada's good performance on the OECD's Better Life Index is also reflected in two decades of rapid improvement on the OECD's index of Multidimensional Living Standards (MDLS), which combines household average disposable income, life expectancy at birth, the unemployment rate and income inequality. Focusing on households with median disposable income, Canada had the fastest growth rate of MDLS among G7 countries over the last two decades (Figure 1.2). The substantial margin by which MDLS growth (3.3%) exceeded income growth (1.9%) reflects a large increase in longevity and a decline in the unemployment rate over the period.

Inequality is not particularly high in Canada, but the gap with the most equal OECD countries is sizable

Income inequality in Canada is close to the OECD average. As measured by the Gini coefficient, income inequality in Canada is close to the OECD average, lower than in the United States, but

higher than in some European countries (Figure 1.3). In Canada, taxes and benefits reduce income inequality among the working-age population by 21% (i.e. the Gini coefficient for household disposable incomes is 21% lower than for market incomes, which are before taxes and transfers). This is below the OECD average of 25% and well below the redistributive effects of the tax and benefit systems of some European countries (e.g. 28% in Germany, 34% in France and 41% in Ireland), but above that of the United States (18%).

Although inequality increased considerably in Canada in the 1990s, reflecting both widening disparities in market wages and weaker redistribution through taxes and transfers, Canada is one of the few OECD countries where inequality did not rise during the 2000s and throughout the economic crisis. This is partly explained by stagnating incomes at the top end of the income distribution and a slight increase in the middle, although low incomes also stagnated between 2008 and 2011. Income inequality has also remained stable during the recovery. Households at the top and the middle experienced higher income growth between 2011 and 2013, while

lower-income households caught up in 2014. Canada's poverty rate declined slightly in recent years, to 12.6% in 2014 (about 1 percentage point above the OECD average of 11.5%).

High inequality hinders social mobility because low-income parents are not able to invest as much in their children's education and development as high-income parents, and they do not have access to such strong social connections to help their children get ahead. In terms of social mobility, Canada performs quite well over a number of different dimensions, including health, earnings, social class and education, compared with other countries. For instance, on average across the OECD, children with lower-educated parents have just a 13% chance of attaining tertiary education, while about 42% remain with lower education attainment. By contrast, in Canada, similar individuals will actually be more likely to attain tertiary education (a 33% chance) than to stay at the same level as their parents (20%). Similarly, the degree of persistence between parents' and children's social class and earnings is below the OECD average. Indeed, the elasticity between father's and son's earnings is 0.32 in Canada, but close to 0.4 on average in OECD countries.
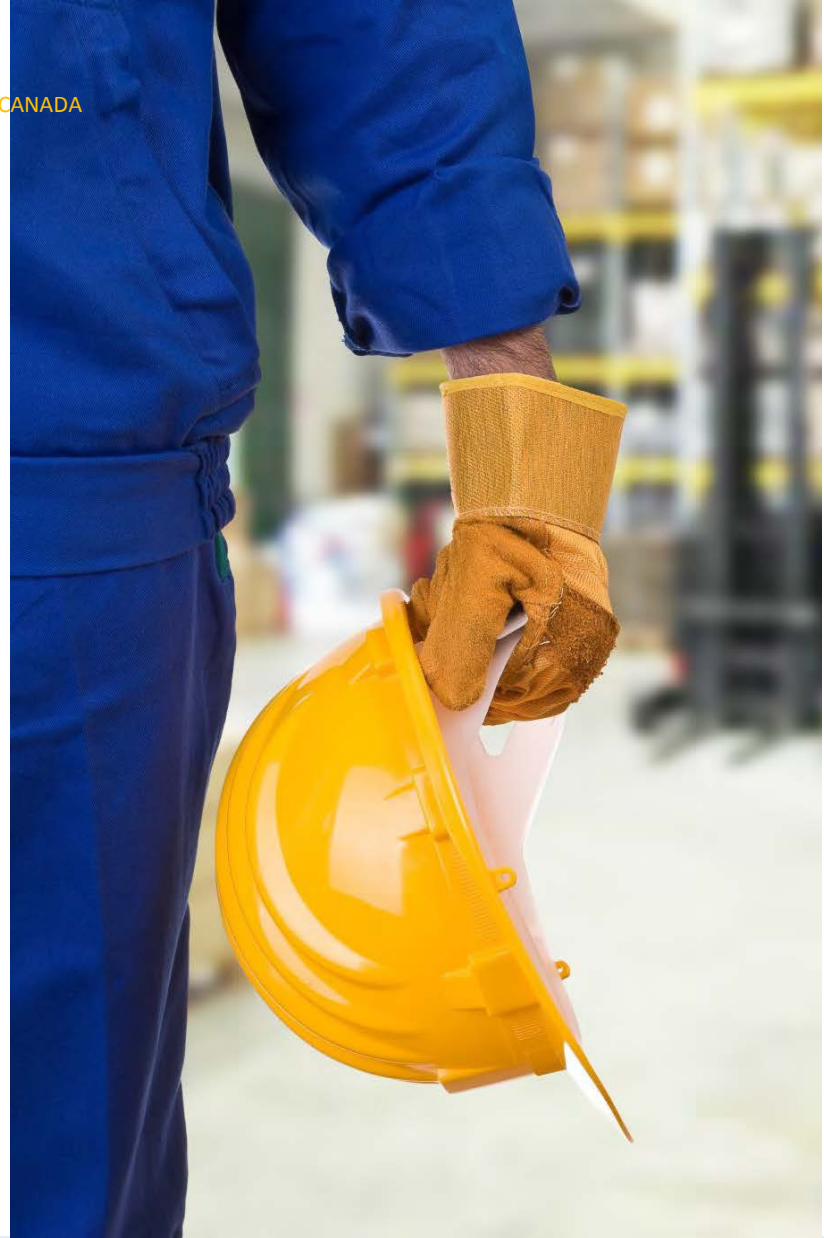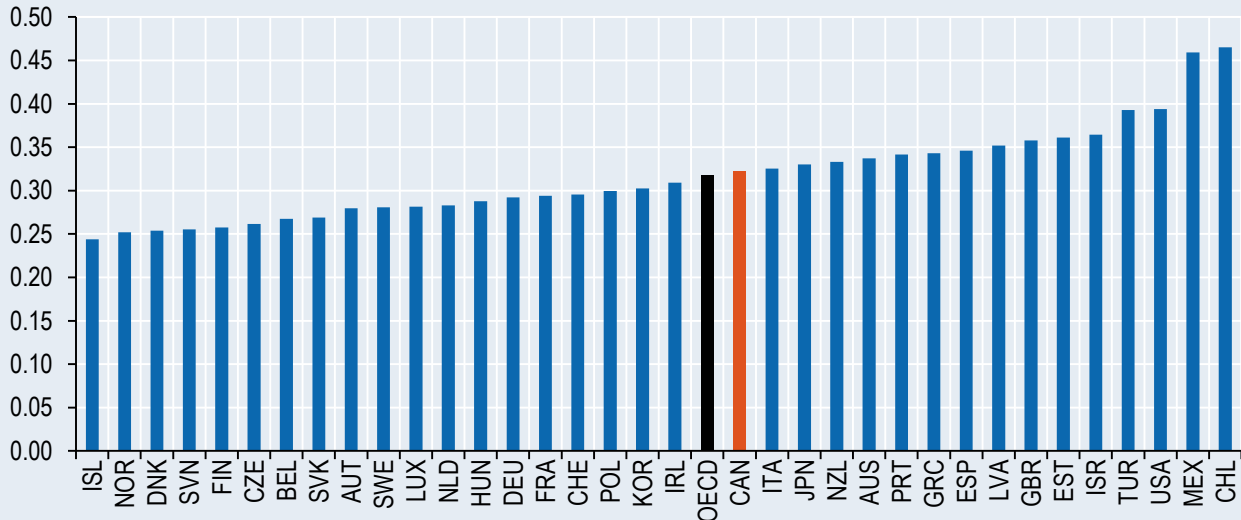
FIGURE 1.3. **INCOME INEQUALITY IN CANADA IS CLOSE TO THE OECD AVERAGE**

Gini coefficient of disposable income inequality, from 0 (most equal) to 1 (most unequal), 2014 or latest available year, total population

Source: OECD Income Distribution Database, http://www.oecd.org/social/income-distribution-database.htm.

FIGURE 1.4. **DISPARITIES IN WELL-BEING BY GENDER ARE SOMEWHAT LARGER THAN THE OECD AVERAGE**

Normalised scores on a scale from 0 (worst condition) to 10 (best condition)
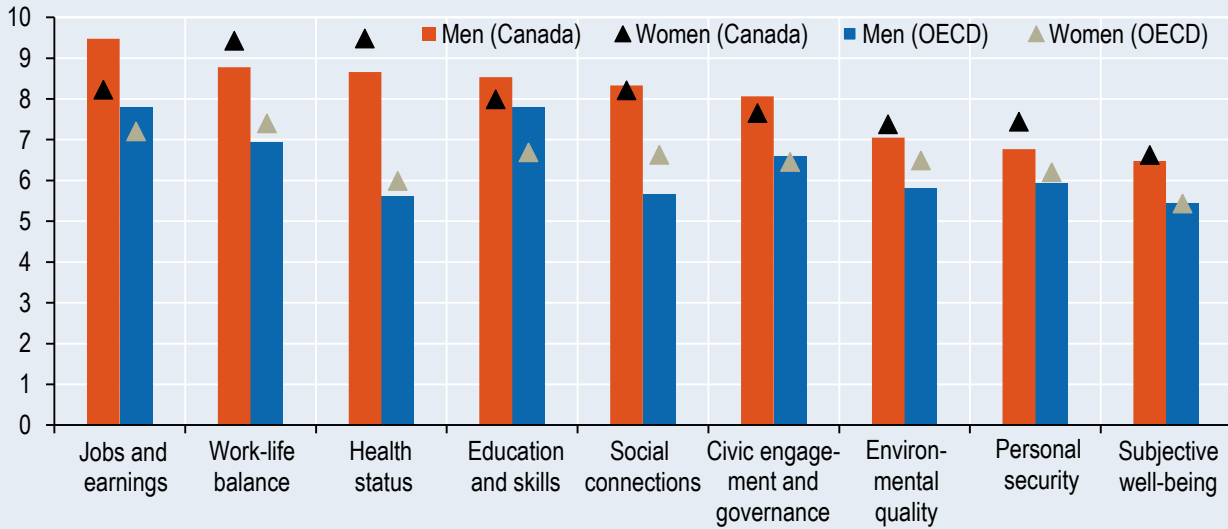
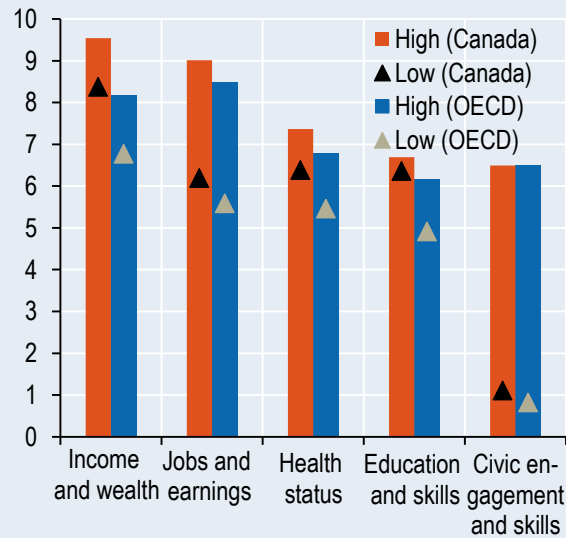

Source: OECD Better Life Index, 2016.

As in most other OECD countries, women score less well than men in the OECD's Better Life Index on the dimensions of jobs and earnings, environmental quality and personal security (Figure 1.4). With the exception of personal security, the gender differences are smaller in Canada than the OECD average. Women outperform men in terms of education and skills, health status, work-life balance and subjective well-being, with a larger gap than the OECD average in all areas with the exception of work-life balance. Canadian women are less likely to be employed than men and have lower average earnings than men. However, the proportion working 50 hours or more per week is five times lower for women than for men, and women are more likely to have attained at least an upper secondary qualification. With respect to women in public life, Canada is below the OECD average when it comes to representation in the lower house parliament (26.3% in 2017 compared to the OECD average of 28.8%), though in the executive, it has established gender parity in its Cabinet at the federal level. In terms of social connections and civic engagement, gender differences in Canada are very small.

There are large differences in well-being between people with high and low socio-economic background (Figure 1.5), albeit smaller than the OECD average. Incomes for the top 20% of the

income distribution are, on average, five times higher than for the bottom 20%, compared with the OECD average of six times. Canadians with a tertiary

FIGURE 1.5. **WELL-BEING DISPARITIES BY SOCIO-ECONOMIC BACKGROUND IN CANADA ARE AROUND THE OECD AVERAGE**

Normalised scores on a scale from 0 (worst condition) to 10 (best condition)
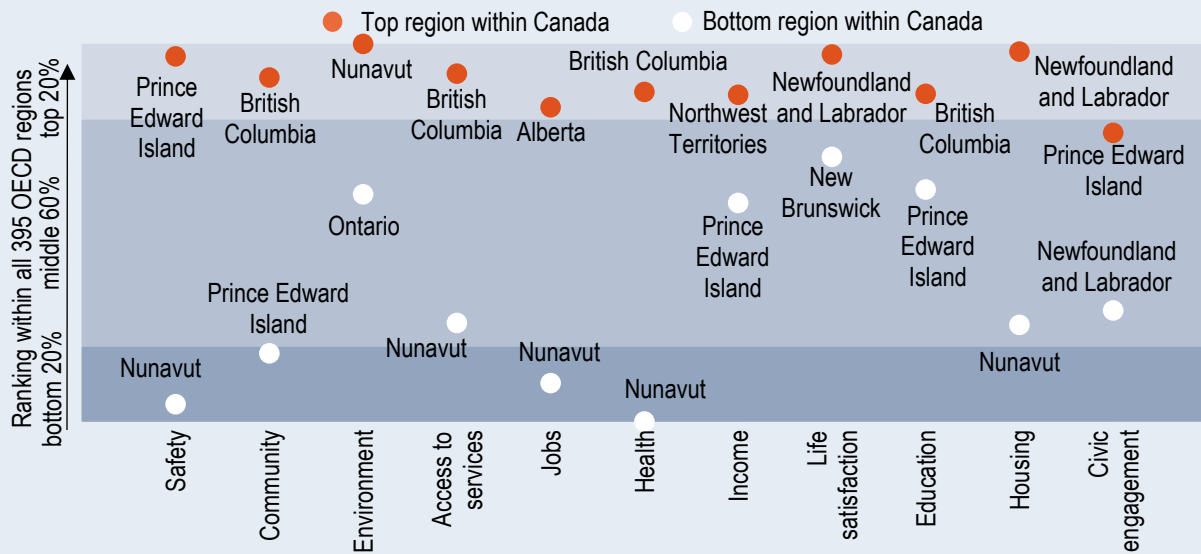

Note: High/low socio-economic background (denoted "High"/"Low") is defined as having a disposable income among the top/bottom 20% or having attained tertiary/only primary education.

Source: OECD Better Life Index, 2016.

FIGURE 1.6. **REGIONAL DISPARITIES ARE RELATIVELY HIGH IN CANADA**

Relative performance of Canadian regions by well-being dimensions

Source: OECD Regional Well-Being Database, https://www.oecdregionalwellbeing.org.

education are more likely to be employed, less likely to be in long-term unemployment and earn almost two-and-a-half times more than Canadians with less than upper secondary education. Conversely, there are relatively smaller differences in health status, education and skills and civic engagement and governance. However, people with a disposable income among the top 20% tend to report better health and are more likely to vote, and students with higher socio-economic background perform better in school.

There are also large regional disparities in Canada (Figure 1.6), particularly in the areas of safety, health and jobs. However, these disparities are largely due to the particular challenges faced by the sparsely populated territory of Nunavut. Moreover, regional disparities are smaller than in some other OECD countries, such as the United States or Australia. It should also be noted that the high-performing Canadian regions fare better than the OECD average in all dimensions of the OECD's Better Life Index, and even the low-performing regions perform better than the OECD average in relation to education and access to services.
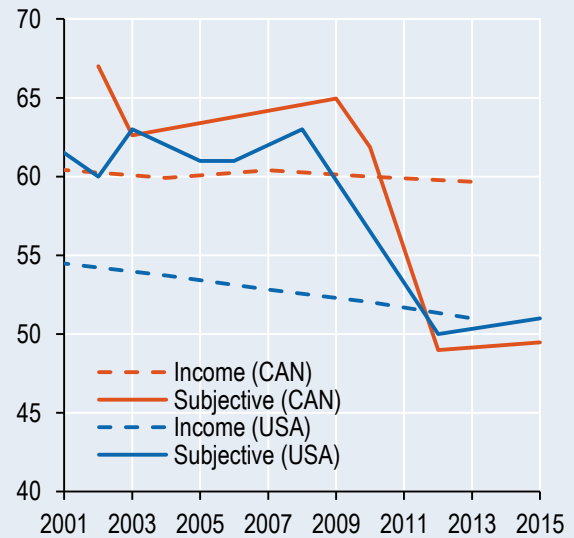
Middle class self-identification has fallen significantly in recent years

The share of the population that considers itself as belonging to the middle class in Canada fell from two-thirds to one-half in the last ten years. This decline is almost entirely due to a rise in the share of population perceiving itself as belonging to the lower class, which is now almost as large as the middle class. Trends in household income do not reflect such pessimism: the share of middle-income households has barely changed in the last 15 years (Figure 1.7). Currently, 60% of Canadians live in middle-income households, close to the OECD average of 62%. Possible explanations for the change in perceptions include rapid increases in house prices and associated rising household debt, together with the elimination of many well-paying jobs for moderately educated people during the crisis. Labour market changes driven by technological change and rising non-standard forms of work stir growing financial and employment insecurity.

FIGURE 1.7. **FEWER AND FEWER CANADIAN HOUSEHOLDS PERCEIVE THEMSELVES AS MIDDLE CLASS**

Share of middle-class households, subjective and income definition

Note: Subjective definition based on self-identification (upper middle and middle class in the United States, and middle class in Canada. Income definition based on household disposable income (75-200% median).

Source: OECD Secretariat calculations based on data from LIS Cross-National Data Center, Gallup (USA) and EKOS (Canada).
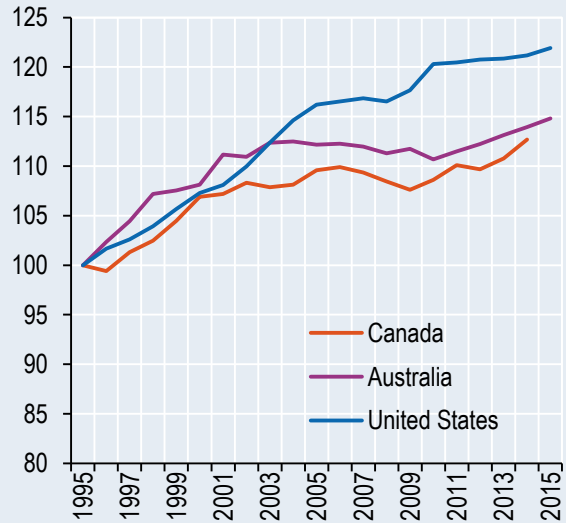
FIGURE 1.8. **IMPROVEMENTS IN GDP PER CAPITA ARE HELD BACK BY LOW PRODUCTIVITY GROWTH**

A. GDP per capita in thousand USD, 2010 PPP
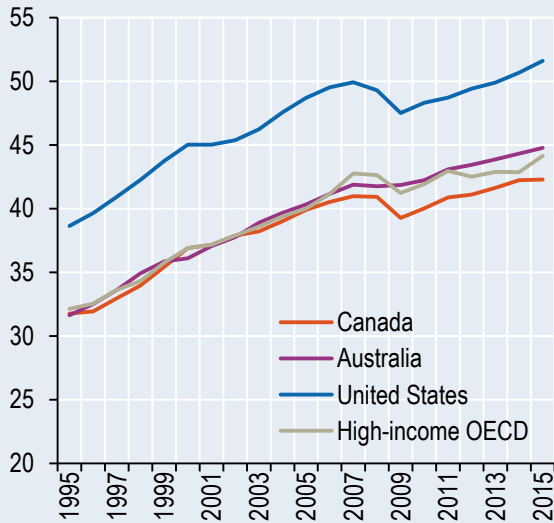
B. Multifactor productivity, index 1995 = 100

Note: High-income OECD is the median of the 17 OECD countries with the highest GDP per capita. Multifactor productivity in the business sector is based on quality-adjusted hours worked.

Sources: OECD (2017a), Economic Policy Reforms: Going for Growth 2017, OECD Publishing, Paris, http://dx.doi.org/10.1787/growth-2017-en; OECD Productivity Database.

Productivity growth is low, and the gap between high-productivity firms and others has grown

GDP per capita was similar to the median of the most affluent OECD countries until 2005, but fell slightly behind over the last decade (Figure 1.8, Panel A). Labour productivity growth in the business sector has been weak, due to poor multifactor productivity growth (productivity growth after accounting for increases in employment and capital) (Figure 1.8, Panel B). Canada has only stayed so close to leading OECD countries in terms of GDP per capita due to a rising employment rate, which increased from 67.5% in 1995 to 72.5% in 2015, well above the OECD average of 66.3%. Improvements in the employment rate cannot be sustained indefinitely and will be more difficult with an ageing population. This underscores the importance of improving productivity growth.

Labour productivity growth in the 10% of firms with the highest productivity levels (i.e., firms at the national productivity frontier) has been robust since the turn of the century, averaging 5.1 % in manufacturing and 6.1% in non-financial services over 2000-12 (Figure 1.9). Most other firms have

recorded much lower productivity growth, resulting in a growing gap in productivity levels between the productivity leaders and others. As in other countries, the productivity diffusion machine appears to be broken. This may reflect a diminished capacity of non-productivity-frontier firms to learn from frontier firms. This is consistent with longer-run evidence on the penetration rates of new technologies (e.g. Comin and Mestieri, 2013), possible winner-takes-all dynamics (Gabaix and Landier, 2008; Autor et al., 2017) and the growing importance of tacit knowledge.

Small business dynamism appears to have weakened, weighing on productivity growth. Firm entry and exit rates have declined (Figure 1.10, Panel A), as has happened in most other countries (Criscuolo, Gal and Menon, 2014). The start-up rate in Canada appears to be relatively low by international comparison (Figure 1.10, Panel B), and there seems to be a relatively large share of small old firms that contribute less to productivity growth than other firms (Figure 1.11). However, these international comparisons are subject to uncertainty, as Canadian data exclude spurious start-ups and exits resulting from reorganisations or mergers and acquisitions, thereby reducing

start-up and exit rates and increasing the share of small old firms. The slowdown in business start-ups is problematic for productivity growth, as start-ups are a key source of innovations and put pressure on incumbents to innovate. The survival of many small old firms with low productivity can be a drag on productivity growth, by hogging resources that could otherwise flow to innovative firms with high growth potential (especially start-ups).

Canada needs to foster more inclusive growth

The twin challenges presented by the persistence of multidimensional inequalities and slow productivity growth underscore the need to reappraise Canada's policy-making process. Such an exercise should span an array of domains essential for promoting growth and helping all individuals and firms to fulfil their potential.

In line with this approach, the federal government has adopted a plan to deliver CAD 181 billion of infrastructure spending over 12 years, three times the amount in the baseline when it took office. The plan covers physical, social and green infrastructure (including investments in clean

FIGURE 1.9. **THERE IS AN INCREASING DIVERGENCE IN LABOUR PRODUCTIVITY PERFORMANCE ACROSS FIRMS**

A. Labour productivity in manufacturing, index 2000 = 100

B. Labour productivity in non-financial services, index 2000 = 100
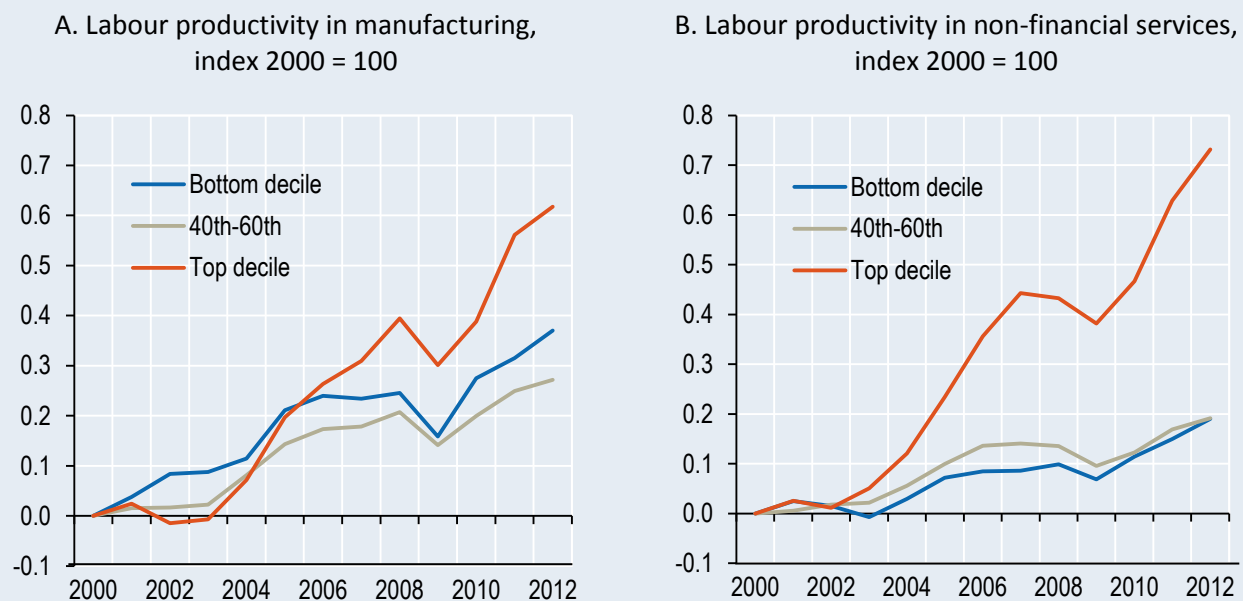
Note: The graph reports the unweighted average of real labour productivity (defined as real value added per employee) expressed in 2005 USD. Estimates are based on micro-aggregated data and might differ from official national statistics.

Sources: Data from the OECD Multiprod project, preliminary results, April 2016, http://www.oecd.org/sti/ind/multiprod.htm and see Berlingieri, G., P. Blanchenay and C. Criscuolo (2017), "The great divergence(s)", OECD Science, Technology and Industry Policy Papers, No. 39, OECD Publishing, Paris, http://dx.doi.org/10.1787/953f3853-en, for more details.

FIGURE 1.10. **SMALL BUSINESS DYNAMISM HAS DECLINED**

A. Aggregate firm entry and exit rates and new entrepreneurship rate, in %
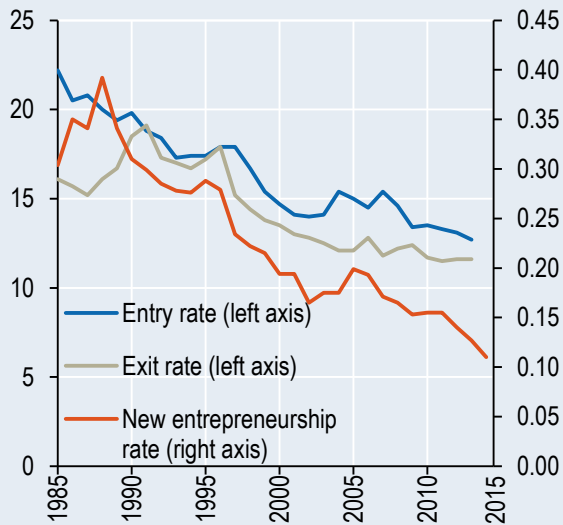
B. Percentage of 0 to 2 year old employer enterprises in % of all employer enterprises, 2014
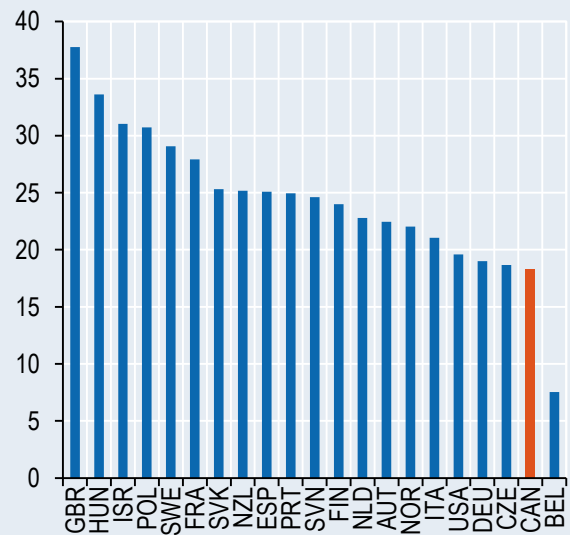
Note: Panel A: The start-up rate is the number of start-up employer enterprises (0-2 year old) as a percentage of the number of active employer enterprises. Panel B: 2013 data for FIN, FRA and PRT, 2012 data for USA and BEL.

Sources: Cao, S. et al. (2015), "Trends in Firm Entry and New Entrepreneurship in Canada", Bank of Canada Discussion Paper, No. 2015-11, October, Charts 1 and 3, Bank of Canada, Ottawa, http://www.bankofcanada.ca/2015/10/discussion-paper-2015-11/; OECD Structural and Demographic Business Statistics Database, http://www.oecd.org/std/business-stats/structuralanddemographicbusinessstatisticssdbsoecd.htm.

energy, climate change adaptation and local water and wastewater facilities). It should promote longer-term growth and enhance environmental performance and inclusiveness.

The infrastructure plan includes a substantial increase in funding to improve the substandard socio-economic conditions facing Indigenous people. This amounts to a 22% increase in end-of-period levels and represents a big effort to make growth more inclusive and opportunities more equal. Most of this expenditure (about half of the total) will be on education and training, including upgrading of school buildings, and social and green infrastructure (housing, water and wastewater treatment, and health care). Funding is also being provided for improving governance by their representative organisations and for strengthening the capital base of the First Nations Finance Authority, which raises private long-term capital for economic development in their communities.

Building a fair and open government is a key priority of the federal government. It has set in motion plans to make government information

FIGURE 1.11. **MANY SMALL CANADIAN FIRMS ARE OLD**

Young enterprises in % of all enterprises with less than 10 employees, 2008-14 average
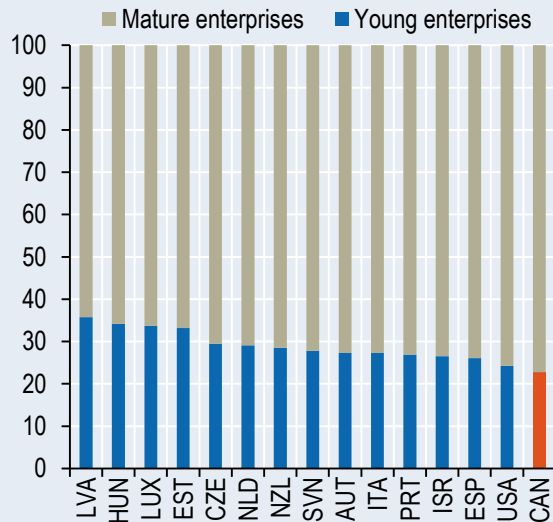
Note: Young enterprises are a sum of nascent enterprises as well as those surviving 1 and 2 years. EST, USA: 2006-12, ISR: 2007-14, NLD: 2006-14 excluding 2008, NZL: 2006-15.

Source: OECD Structural and Demographic Business Statistics Database, http://www.oecd.org/std/business-stats/structural anddemographicbusinessstatisticssdbsoecd.htm.

more accessible and to expand and accelerate open data initiatives. It also plans to close political financing loopholes and strengthen public sector integrity. Enabling Parliament to better represent communities and hold the government to account also feature prominently in the government's agenda.

Fighting climate change and protecting the environment are also high priorities. The federal, provincial and territorial governments (with the exception of Manitoba and Saskatchewan) agreed on the Pan-Canadian Framework on Clean Growth and Climate Change in December 2016. It sets a national benchmark for carbon prices that will rise progressively to facilitate the achievement of Canada's greenhouse gas emissions abatement goals at least cost.

This brochure looks at the key policy reforms that would help Canada advance its inclusive growth agenda. Chapter 2 focuses on how the Canadian government can help all people to create prosperity and thrive. Indigenous people, women, older workers, migrants and people with mental health issues currently fare worse than average Canadians in terms of labour market outcomes. Promoting greater inclusion in the labour market requires strengthening the skills of Indigenous people, putting in place better family-friendly supports to make it easier for mothers and fathers to combine work and family life, strengthening training for older workers, advancing recognition of foreign qualifications and better leveraging education institutions and employers to foster good mental health.

Efforts to ensure that all individuals have the opportunity to live meaningful and productive lives rely on a flourishing business sector. Against this background, Chapter 3 investigates how the Canadian government can ensure a level and competitive playing field for firms, enable them to access the finance they need at fair cost, provide regulatory clarity and consistency, and put in place framework conditions that are conducive to innovation. Small business dynamism and productivity would also benefit from focusing small business support more clearly on reducing market failures.

Strong public governance is crucial to implement an inclusive growth agenda. Chapter 4 therefore looks into how Canada can build on recent progress in fostering public sector innovation, ensuring stakeholder engagement and developing good regulatory practices to further enhance the quality of public goods and services. Addressing multilevel governance challenges is also crucial, as policies for inclusive growth need to be designed, implemented and reviewed in a highly co-ordinated manner. With Canada being a very decentralised country, where provincial or local governments are responsible for many of the policies that are essential for inclusive growth, governance co-ordination is particularly crucial at the vertical level.

2 Enabling all Canadians to create prosperity and thrive

Labour force participation in Canada is strong and well above the OECD average. However, there are considerable variations across the country and between socio-economic groups. Indigenous people, women, older workers, migrants, and people with mental health issues are less likely than average Canadians to be employed and more likely to have jobs of lower quality. By furthering policy action to promote inclusion in the labour market, Canada can enable its citizens to create stronger and more inclusive growth.

Strengthening the skills of Indigenous people is key to better integrating them into the labour market

Indigenous people are an important part of Canadian society, with 1.4 million people who reported an Indigenous identity in 2011, representing 4.3% of the population (Statistics Canada, 2011). It is estimated that the Indigenous population will continue to grow at a faster rate than the non-Indigenous population, possibly increasing to between 2.0 million to 2.6 million by 2036 (Statistics Canada, 2015). But many of them continue to face barriers to successful labour market integration. The unemployment rate for Indigenous Peoples aged 25-54 was 11% in 2015 – nearly double the rate for the non- indigenous group of the same age at 5.7% (Statistics Canada, 2017). To a large extent, poor labour market integration reflects lower educational outcomes: in 2015, only 51% of Indigenous Peoples had completed post-secondary education, compared with 70% of the non-Indigenous population. At the national level, Indigenous people aged 16-64 scored lower in numeracy (244) and literacy (260) than the non-Indigenous population (266 in numeracy and 274 in literacy) in the 2012 OECD Survey of Adult Skills, although these differences varied considerably across provinces and territories. Educational attainment gaps, however, do not fully account for poor labour market integration, as employment rates are lower even for Indigenous people with a post-secondary education (78% versus 86% for non-Indigenous individuals).

The government has undertaken several initiatives to strengthen higher education and labour market outcomes for Canada's Indigenous people. For example, the Aboriginal Skills and Employment Training Strategy is a broad-based labour market programme, and the Aboriginal Bursaries Search Tool helps Indigenous students to search for bursaries, scholarships and other incentives offered by governments, universities and other organisations. Apprenticeship programmes can be a key tool for helping Indigenous people to develop skills that are well linked to a job. In the Yukon, the Tr'ondëk Hwëch'in First Nation acts as an intermediary between employers and the vocational education system, minimising the administrative burden for employers and recognising that Indigenous apprentices will move between employers to obtain their necessary training.

Entrepreneurship could also be a route to better integrate Indigenous people into the labour market. Only 2% of small and medium-sized enterprises (SMEs) are operated by Indigenous entrepreneurs, about half of their share in the total population (Gulati, 2012). There are organisations dedicated to strengthening networks of entrepreneurs, mentoring and entrepreneurial skills, and helping to develop successful role models, but these efforts need to be reinforced. To promote Indigenous entrepreneurship, the top priority is to invest in education and capacity building (Gulati and Burleton, 2015), both in indigenous Economic Development Corporations that account for most Indigenous SME income (how to set up and run one and create effective corporate governance arrangements) and in the Indigenous community at large (job and skills training). Indigenous firms also need better access to IT infrastructure – 20% of those in Ontario did not have an Internet connection in 2013, rising to 37% for those on reserves (Canadian Council for Aboriginal Business, 2015). The government's commitment to invest up

to CAD 500 million over five years, starting in 2016-17, to extend and enhance broadband service in rural and remote communities is therefore welcome.

Strengthening the labour force participation of women requires better family-friendly supports

Labour force participation among women in Canada (74%) is 7.6 percentage points lower than among men, but above the OECD average for women (67%). Young Canadian women are more likely to obtain tertiary education than men, but Canada has room to improve their participation in manufacturing and construction and other science, technology, engineering and mathematics (STEM) fields in tertiary education. The gender pay gap remains stubbornly high (Figure 2.1). The monthly median wage of women is 18.6% lower than that of men, compared to the OECD average of 14.7%.

Family-friendly supports (including parental leave, childcare and flexible work options) are needed to maintain and strengthen labour force participation among women. The Canada Child Benefit, which was introduced in 2017, provides a maximum annual benefit of CAD 6 400 per child under the age of 6 and up to CAD 5 400 per child aged 6 to 17. This benefit will help reduce child poverty, but

should be combined with incentives to work. Issues around the availability of affordable quality childcare are widely acknowledged in Canada, with only the province of Quebec having a comprehensive childcare support system. The available evidence suggests that participation in preschools is low in international comparison. Only 56.7% of 3-to-5 year-olds participate, compared with the OECD average of 83.8%. To address this challenge, the government plans to invest CAD 47 billion over 10 years, starting in 2018-19, to support and create more high-quality, affordable child care places across the country.

Encouraging a broadly equal use of parental leave and flexible workplace measures by men and women can also help promote gender equality in the workplace. With the introduction of the Quebec Parental Insurance Plan, which includes five weeks of paternity leave in addition to sharable parental leave, the number of fathers claiming some leave increased from 22% in 2004 to 79% in 2013, and fathers often took leave for more than eight weeks. Changing attitudes may take time, but it can help reduce the burden of unpaid work on women and facilitate greater economic participation of women on an equal footing (OECD, 2017b).

FIGURE 2.1. **THE MEDIAN MONTHLY GENDER PAY GAP FOR FULL-TIME EMPLOYEES IS ABOVE THE OECD AVERAGE**

Gender gap in median monthly earnings, full-time employees
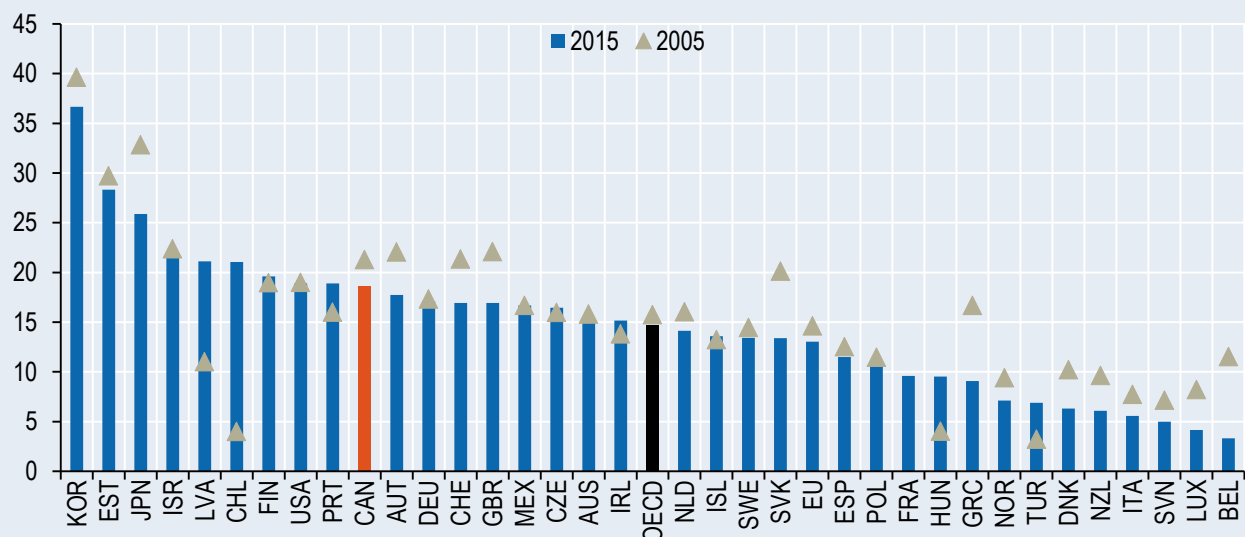
Note: The gender pay gap is defined as the difference between male and female median monthly earnings divided by male median monthly earnings for full-time employees. Full-time employees are defined as those individuals working more than 30 paid hours per week. 2015 refers to 2015 or the latest year available.

Source: OECD (2017c), OECD Employment Outlook 2017, OECD Publishing, Paris, http://dx.doi.org/10.1787/empl_outlook-2017-en.

Canadian women are actively engaged in entrepreneurship, more than in most other OECD countries. However, they are less likely than their male counterparts to run growth-oriented enterprises. SMEs owned by women tend to be smaller and report lower revenue growth than those owned by men (ISED, 2015). They are less likely to seek external finance and more likely to have loans rejected because of insufficient collateral, and they are also less likely to export. Women entrepreneurs are also under-represented in high-technology manufacturing and knowledge-intensive sectors (Institute for Competitiveness and Prosperity, 2012), and far fewer self-employed women (31.3%) than men (50%) incorporate their businesses (Canada Works, 2014; OECD, forthcoming). The federal government has given priority to reducing gender inequalities in growth-oriented entrepreneurship through new programmes in areas such as networking, mentorship, access to international markets (e.g. the Business Women in International Trade programme) and finance (e.g. Business Development Bank of Canada's investment of CAD 50 million to support women entrepreneurs in the technology sector, as announced in November 2016). Moving forward, stronger support by the Business Development Bank of Canada, including through a new dedicated programme for women entrepreneurs, removal of restrictions on the eligibility of part-time entrepreneurs to public enterprise finance programmes and further expansion of supplier diversity initiatives would have disproportionate benefits for women business owners.

Older workers would benefit from stronger participation in training

While population ageing has been somewhat slower in Canada than in many other OECD countries until now, it is set to accelerate sharply in the next decades. In 2015, there were 26 persons aged 65 and over for every 100 people of working-age (20-64 years) in Canada, compared to the OECD average of 28 persons. By 2050, the number for Canada is projected to rise to 45

persons according to Statistics Canada. This makes it very important for Canada to put in place the right policies to ensure that growth is also inclusive for the elderly.

Currently, Canada performs well in terms of labour market inclusion for the elderly. According to OECD data, the poverty rate for Canadians aged over 65 (6%) is in the bottom third of OECD countries, while the employment rate for Canadians aged 55-64 (60.9%) exceeds the OECD average by around 3 percentage points. However, there is a clear education-related employment gap in Canada, and older workers tend to participate less in training than younger workers. The ratio of participation in training for older workers relative to workers aged 25-54 is 0.78. Moreover, adult education tends to reinforce inequalities inherited from the school system, in particular for workers in their mid to late careers. While only 26% of older employees with no upper secondary education participate in training, the rate is 59% for older workers with higher education qualifications (OECD, 2014a).

A multipronged approach is necessary to foster inclusion of people with mental health issues

In Canada, one in five people are estimated to experience mental illness every year, and mental illness is one of the top three drivers of both short-term and long-term disability, accounting for some 30% of claims. Adults with severe mental health problems and illnesses in Canada die up to 25 years earlier than adults in the general population, often from co-morbid physical illness such as cardiovascular disease. The economic costs of mental illness are significant. The OECD estimates that the total indirect and direct costs of mental illness exceed 4% of GDP worldwide (OECD, 2014b; OECD, 2015b). Canada's high-level political recognition of the importance of good mental health is most commendable. Both Prime Minister Trudeau and Minister of Health Jane Philpott have clearly stated their belief in the importance of high-quality, accessible mental health services for all. Addressing the high burden of mental health issues and responding to significant unmet needs still pose a significant challenge, but Canada has a good range of treatments, interventions, and policy solutions in place.
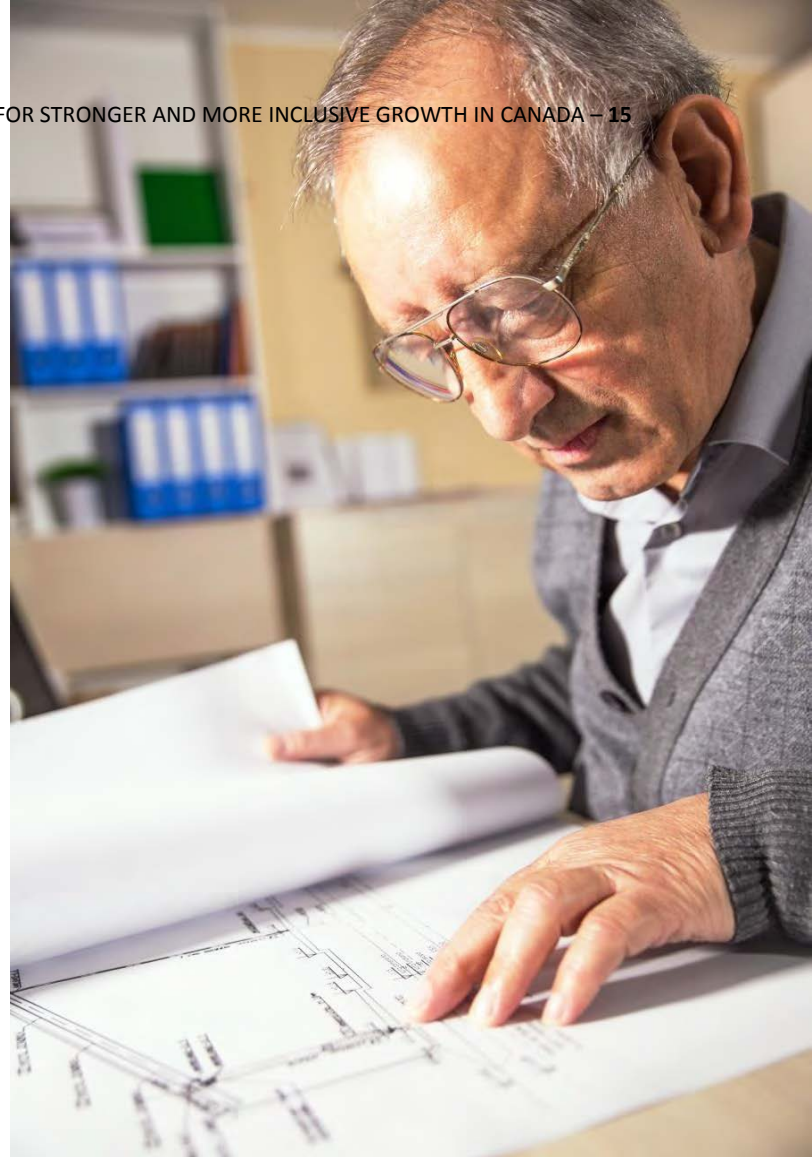
To make further progress in this area, Canada, like other OECD countries, should focus on three priorities. First, developing indicators of performance and progress in mental health care would allow a deeper understanding of the burden of mental illness, the state of the mental health system and outcomes for people using mental health services. Second, access to evidence-based treatment for mental illnesses needs to be improved, as unmet need for mental health care is a major concern. Only one in three people in Canada who report that they experienced a mental health problem also report that they sought and received treatment. Third, improving the engagement of education institutions and workplaces can help foster good mental health by providing a supportive environment and thoughtfully facilitating return to work after sick leave for depression.

Canada could further improve the integration of its immigrant population by advancing the recognition of foreign qualifications

Relative to its population, Canada has one of the largest foreign-born populations among OECD countries: more than one person in five is an immigrant. Canada has a large managed labour migration programme, and the bulk of annual inflows are labour migrants and their families. Canada's immigrant population is among the most highly educated in the OECD. Contrary to what happens in most OECD countries, foreign-born students and the children of foreign-born parents in Canada perform on a par with their native peers. This has contributed to overall labour market outcomes of immigrants that are above those observed in other OECD countries.

However, Canada could make even better use of immigrants' skills, particularly those who have foreign qualifications, as immigrants are at high risk of working in jobs below their formal qualification level. The process of foreign credential recognition is a key element in enhancing transparency for employers and facilitating access to certain higher-skilled occupations. Canada has taken several actions in this respect, and it is important to continue this initiative.

Special efforts are needed for refugees who face particular challenges in integrating into the labour market. In response to the Syrian refugee crisis, Canada resettled more than 40 000 Syrian refugees between November 2015 and January 2017. Early access to employment is crucial for refugees to integrate into the labour market and society more generally.

Key recommendations

- Consider introducing a country-wide non-transferable individual paid leave period for fathers of one or two months.

- Swiftly implement the plan to increase the supply of affordability childcare places.

- Continue efforts to raise the education and employment outcomes of Indigenous youth by providing access and incentives to higher education and training programmes.

- Ensure that national and regional policies related to labour market, skills and economic development promote flexibility and co-ordination at the local level.

- Continue building the governance capacities of First Nations, Inuit and Métis communities, and facilitate the exchange of information about successful approaches to employment and job creation.

- Support growth-oriented entrepreneurship by women, including by removing unwarranted restrictions on the eligibility of part-time

- entrepreneurs to public enterprise support programmes and scaling up supplier-diversity initiatives.

- Provide better access to training adjusted to the experience and learning needs of older workers.

- Collect robust and internationally comparable indicators of performance and progress in mental health care.

- Ensure access to high-quality evidence-based mental health services, such as psychological therapies, early intervention approaches or pharmacological therapies, to address unmet need.

- Better engage education and workplaces in fostering good mental health, using the Recommendation of the OECD Council on Integrated Mental Health, Skills and Work Policy as a guiding framework.

- Continue efforts to improve the recognition of foreign credentials.

3 Giving all Canadian firms a chance to flourish

In the long run, a thriving business sector is the most important source of greater living standards and well-being. Businesses provide employment opportunities, foster individual well-being in the work place, contribute to the development of skills, and promote the creation and dissemination of knowledge and technology. Reversing the decline in productivity growth and business dynamism is therefore crucial for Canada. The country's framework policies, such as product and labour market regulation, are generally supportive of a thriving business sector. Labour market regulation poses few barriers to the reallocation of labour, and the country performs very well with respect to the cost and time to set up a new company, the administrative burden of running a corporation and the ease of the insolvency regime. However, barriers to foreign direct investment and the regulatory protection of incumbents are higher than in many other countries, the latter primarily due to an above-average use of antitrust exemptions. Small business dynamism and productivity would also benefit from focusing small business support more clearly on reducing market failures and better harmonising provincial legislation.

Greater product market competition can help boost productivity growth

As noted above, productivity growth has been weak in recent decades relative to rates in comparable high-income countries. It is not clear what the major causes of this weakness are, but encouraging product market competition and

strengthening the internal market (Chapter 4) could help to improve performance.

Productivity growth in utilities has been weak over the last decade, constraining firm growth in other sectors through higher input costs. In the electricity sector, the poor productivity performance is likely to be linked to the

FIGURE 3.1. **CANADA HAS ROOM TO FURTHER EASE TRADE RESTRICTIONS IN A NUMBER OF SERVICES SECTORS**

Services Trade Restrictiveness Index (STRI), from 0 (least restrictive) to 1 (most restrictive), 2016
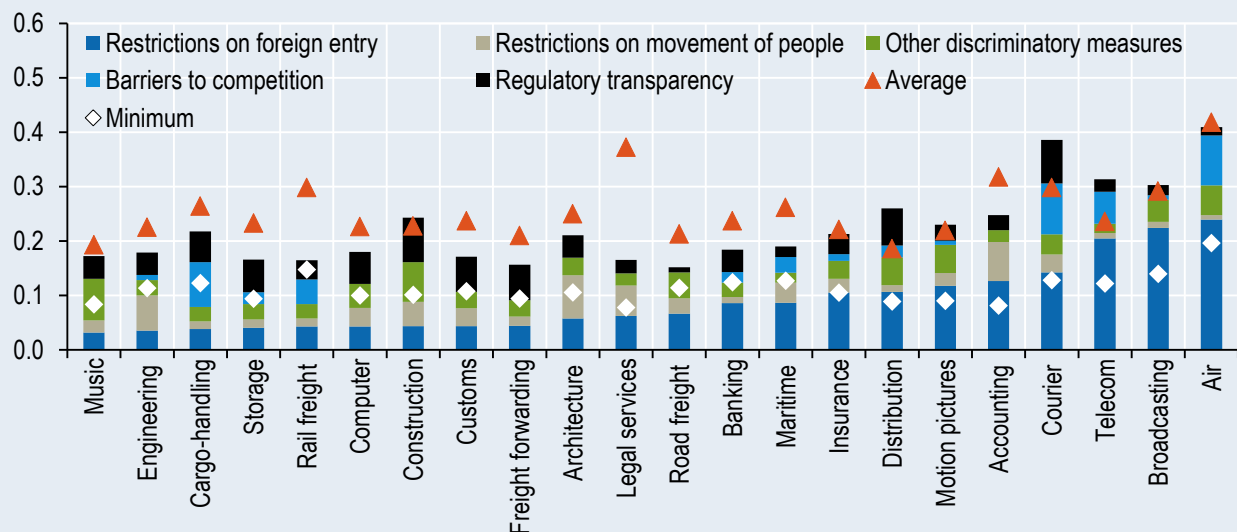
Note: The STRI records measures on a most-favoured-nation basis; preferential trade agreements are not taken into account. Air transport and road freight cover only commercial establishment (with accompanying movement of people). The data have been verified and peer-reviewed by OECD member countries.

Source: OECD, STRI database, http://www.oecd.org/tad/services-trade/services-trade-restrictiveness-index.htm

FIGURE 3.2. **SMEs SUFFER PARTICULARLY STRONGLY FROM SERVICES TRADE RESTRICTIONS**

Estimated additional *ad valorem* tariff in %, equivalent of an STRI of 0.2 on top of what is paid by firms of CAD 400 million and more in turnover
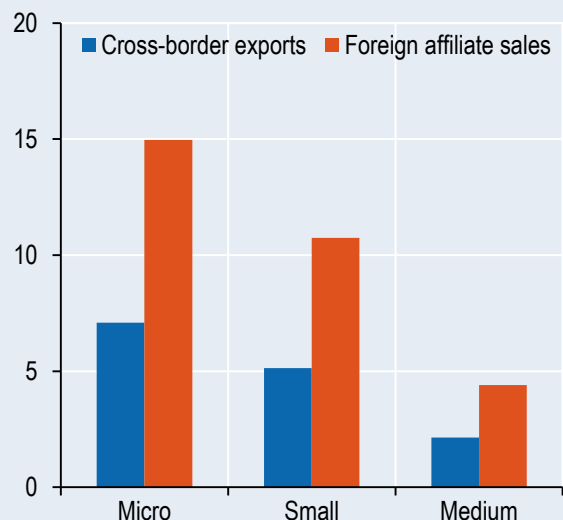
Note: Average turnover used for calculations is CAD 1 million for micro enterprises, CAD 5 million for small enterprises and CAD 25 million for medium-sized enterprises. Import demand elasticity is -2.5.

Source: OECD calculations based on estimates from OECD (2017d), Services Trade Policies and the Global Economy, OECD Publishing, Paris, http://dx.doi.org/10.1787/ 9789264275232-en.

predominance of vertically integrated public providers. OECD estimates suggest that the level of economy-wide multifactor productivity would rise by 0.5% within a decade if generation of electricity were fully separated from its transmission and distribution, with non-discriminatory access to network infrastructure (OECD, 2016a). In addition, improving transmission interconnection between provinces could facilitate market deregulation and further investment in renewables, by increasing resilience to electricity shortages, as well as raise efficiency. The lack of east-west interconnection between provinces is largely a result of geography and the uneven distribution of the population, but it also reflects regulatory fragmentation. Expanding efforts such as the Atlantic Energy Gateway, a collaborative effort of federal-provincial utilities, and working towards greater harmonisation through the energy chapter in the Canada Free Trade Agreement (Chapter 4) would enhance efficiency.

Canada could also do more to encourage competition in a number of services sectors, including by further opening up the country's markets to foreign services providers. The OECD's Services Trade Restrictiveness Index (STRI) shows the scope for reform in Canada to be greatest in air transport, courier services, telecommunications and broadcasting and distribution services (Figure 3.1). Recent OECD analysis (OECD, 2017d) found that the costs of dealing and complying with diverging regulations in every new market fall particularly heavily on small and medium-sized enterprises, imposing the equivalent of an additional 5% to 15% import tariff compared to larger firms (Figure 3.2).

In air transportation, the high STRI score is attributable to restrictive foreign ownership limits. These limits result in financing restrictions that may deter entry, raise finding costs for incumbents and lead to slower adoption of new technology and know-how. Competition could be increased and downstream cost competitiveness enhanced by lessening these restrictions, for instance by increasing the foreign voting equity limit from the current 25% to 49% for carriers operating international air services (allowing more could invalidate international Air Service Agreements) and eliminating them completely in the domestic market on a reciprocal basis, including granting rights of establishment, as in Australia and New Zealand.

Of the sectors with high STRI scores, telecommunications and distribution services take on particular importance given their potential role in helping businesses access a wider set of opportunities at home and abroad, including through digital means (e.g. e-commerce and other Internet-enabled business). The relatively high score for telecommunications is largely related to Canada maintaining a 20% cap on foreign equity in large telecoms operators. Rouzet and Spinelli (2016) estimate that eliminating the ownership restrictions in telecoms could reduce price-cost margins by 2 percentage points from Canada's average for exchange-listed companies, yielding tangible gains for consumers and downstream firms. In distribution services, the high STRI score reflects discriminatory access to certain settlement methods, which can act as an impediment to e-commerce and multichannel retailers in Canada (OECD, 2017d).

To remove as many barriers to competition as possible, Canada should also consider implementing the 2009 OECD Council Recommendation that calls for governments to identify existing or proposed public policies that unduly restrict competition and to revise them by adopting more pro-competitive alternatives. The Recommendation also invites governments to establish institutional mechanisms for undertaking such reviews. One option could be to apply the OECD's Competition Assessment Toolkit, which provides a structured guide for policy makers to identify regulations that have anti-competitive effects and to design pro-competitive alternatives.

There are ways to help firms catch up with the productivity leaders

The rising productivity gap between high productivity firms and the rest raises questions about the obstacles that prevent all firms from successfully adopting well-known and replicable innovations. OECD analysis has identified five key factors that shape the productivity diffusion process: 1) global connections and knowledge exchange via trade, FDI, participation in Global Value Chains (GVCs) and the international mobility of skilled labour; 2) connections and knowledge exchange within the national economy; 3) scope for experimentation by firms (especially new entrants) with new technologies and business models; 4) synergistic investments in R&D, skills and managerial capabilities and other forms of knowledge-based capital; and 5) efficient reallocation of scarce resources.

Structural factors that shape the diffusion process from the global productivity frontier are generally favourable in Canada (Figure 3.3). In particular, Canada trades intensively with the frontier economy (the United States) and allocates skills efficiently (it has low skills mismatch). The factor where there is the largest potential to increase productivity spillovers from the productivity frontier is managerial quality, followed by increasing participation in GVCs and increasing business R&D intensity.

Enhancing managerial quality is also critical to support adoption of digital technology by small firms, identified as a key focus area in the Innovation and Skills Plan recently launched by the federal government. Canada does well in terms of

FIGURE 3.3. **POLICIES MATTER FOR THE EFFICIENCY OF TECHNOLOGY DIFFUSION FROM THE GLOBAL FRONTIER**

Percentage point difference in annual productivity growth linked to differences in policy settings
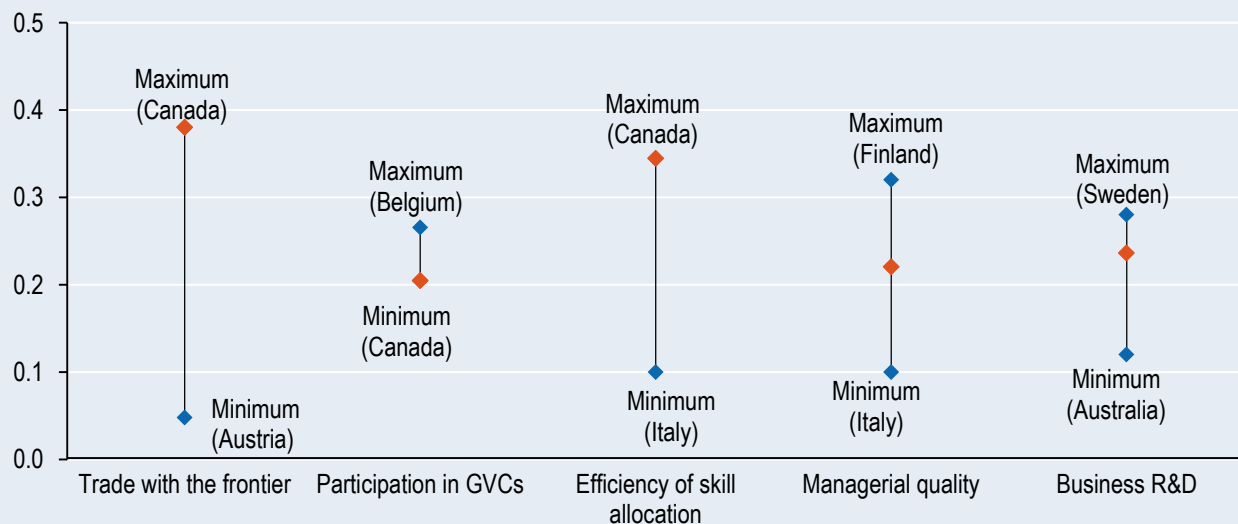
Note: The chart shows how the sensitivity of multifactor productivity (MFP) growth to changes in the frontier leader growth varies with different levels of each structural variable. The diamond refers to the estimated frontier spillover effect associated with a 2% MFP growth at the frontier around the average level of the structural variable.

Source: Saia, A. D. Andrews and S. Albrizio (2015) "Productivity spillovers from the Global Frontier and Public Policy: Industry-Level Evidence", OECD Economics Department Working Paper No. 1238, OECD Publishing, Paris. http://dx.doi.org/10.1787/5js03hkvxhmr-en.

broadband penetration (it tops the OECD league in terms of cable connections per 100 inhabitants, followed closely by Belgium and the United States), but Canadian small businesses experience poor ICT adoption rates. In 2015 only 13.4% of small Canadian firms used enterprise resource planning software, well behind their large Canadian counterparts (63.5%) and much lower than small firms in Germany (50.1%) and Belgium (44.5%) (OECD, 2017e). Coaching programmes to extend digital literacy are an effective way to tackle this problem, that Canada could consider expanding in the future. Another is to reduce impediments to competition to allow firms to grow, as larger firms tend to be better managed (Adalet, McGowan and Andrews, 2015).

Public R&D expenditure (R&D expenditure by higher education institutions and the government) is above the OECD average (0.8% of GDP in Canada, compared to the OECD average of 0.7%), but business expenditure on R&D, at 0.8% of GDP, is below it (Figure 3.4), despite R&D tax credits that are among the highest in the OECD (OECD, 2017f). This reflects numerous factors, not all of which are amenable to policy. Besides industry structure,

possible factors include subpar investments in tangible capital, small market size, high corporate taxes, business complacency, the low educational attainment of Canadian managers, the dearth of management experience and business acumen, and the aversion to risk in Canadian businesses.

Following a recent review of support for business R&D, there has been a slight shift away from Canada's strong reliance on tax incentives, which represented approximately 80% of federal government innovation spending in 2014 (OECD, 2017g), towards direct funding instruments (e.g., competitive grants, equity funding). However, more could be done to shift the balance from general tax credits to targeted programmes that also reward innovation outcomes, such as research commercialisation, and not just innovation inputs, such as R&D spending (OECD, forthcoming). It is also important to acknowledge the importance of non-R&D-based forms of innovation, and better identify projects with the highest potential spillovers to the broader economy. The government plans to create a new CAD 1.26 billion five-year Strategic Innovation Fund to consolidate and simplify existing business innovation programmes.

It appears that over-reliance on aggregate input and output performance indicators by analysts and policy makers means that little attention has been paid to factors inside firms, including innovation management capabilities, internal structural/ organisational competencies such as work organisation and talent management, or the culture of innovation in Canadian firms more generally. More focus on schemes that offer assistance with expertise and managerial competence could help to address these shortcomings. Canada's Innovation Agenda, which is attempting to better co-ordinate and align support for Canadian innovators, is a step in the right direction.

Greater small business dynamism can help enhance productivity

A dynamic small business sector can heighten competition and underpin productivity growth. Dynamism can be reflected in high rates of firm creation, exit and scaling up, and in relatively few stagnant, old firms – in other words, a high start-up rate and strong "up-or-out" dynamics. A recent OECD study (OECD, 2015c) found that an increase

FIGURE 3.4. **CANADA HAS LOW R&D BUSINESS INVESTMENT BY INTERNATIONAL COMPARISON**

Business R&D expenditure, % of GDP, 2015 or latest available year
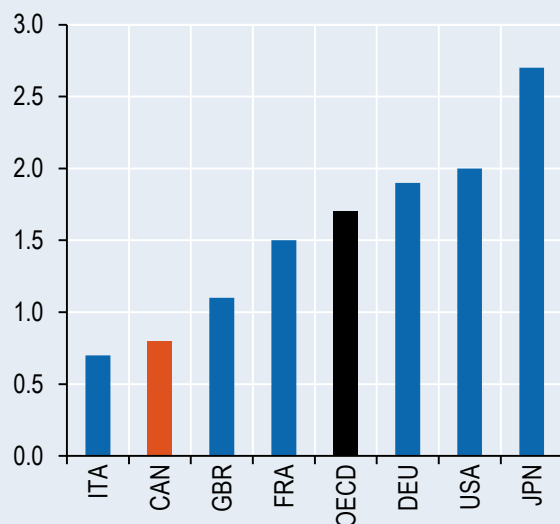
Note: Canada data refer to 2014.

Source: OECD, Main Science and Technology Indicators Database, www.oecd.org/sti/msti.htm.

in the share of firms younger than 6 years old relative to firms aged 12 years and over is associated with higher multifactor productivity growth and that this effect is mainly attributable to start-ups (i.e., firms younger than 3 years old). It also finds that an increase in the share of employment in small old firms, which indicates an absence of "up-or-out" dynamics, is associated with lower productivity growth. As noted above, small business dynamism has declined in Canada, as in other countries, and on most dimensions Canada lags well behind the leaders.

Canada's framework policies, such as product and labour market regulation, are generally supportive of small business dynamism, although less so than in the United States. Labour market regulation, in particular, poses few barriers to the reallocation of labour, which is critical for a vibrant small business sector. There is, however, scope to lower barriers to trade and investment to increase product market competition. As noted above, Canada has relatively high barriers to foreign direct investment, which inhibit allocative efficiency and discriminate against foreign suppliers in public procurement. Regulatory protection of incumbents is high by international standards and arises primarily from an above-average use of anti-trust exemptions.

Small business dynamism and productivity would also benefit from focusing small business programmes more clearly on reducing market failures. The programme with the largest budget cost, the preferential tax rate for companies under a threshold size based on taxable capital (known as the Small Business Deduction), is not so focused. The aim of this arrangement is to leave these firms with more money to invest, effectively making it a financing programme. However, the economic literature on capital market failures does not establish a case for subsidising SMEs based on their size alone. In the Mirrlees Review of taxation in the United Kingdom (Mirrlees et al., 2010), it was concluded that there was no evidence of any general capital market failure affecting small firms. Accordingly, there was no economic case for a reduced small business corporate tax rate. The principal financing gap in the United Kingdom was for new and start-up businesses (Graham, 2004), and this gap could be more effectively addressed through targeted measures. The Canadian federal government should review the Small Business Deduction and, if it reaches the same

conclusions as the Mirrlees Review, eliminate this tax preference, as the United Kingdom did in 2015.

The federal government is also a major player in the venture capital market. A case can be made for subsidising venture capital based on the external benefits from innovation in firms suitable for venture capital. Indeed, such benefits may be much higher than for business R&D (Lerner, 2010). The key to success is finding instruments that increase the quantity of venture capital without diminishing its quality. One promising approach is to establish funds that operate like independent, limited partnership venture capital funds, with private partners selecting investments and mentoring, while the government leverages returns for private investors by not sharing fully in any profits but fully sharing in losses. This approach was adopted by the federal government in the Venture Capital Action Plan (VCAP). The government plans to make available through the Business Development Bank of Canada CAD 400 million on a cash basis over three years, starting in 2017-18, for a new Venture Capital Catalyst Initiative that will increase late-stage venture capital available to Canadian entrepreneurs.

A new OECD report on SME and entrepreneurship policy in Canada documents the country's extensive package of federal government interventions that are effective in overcoming market failures and institutional problems affecting the emergence and growth of new and small firms. Good initiatives include the National Research Council's Industrial Research Assistance Program (IRAP), supporting innovative SMEs through financing and tailored business/technical advice, and the Community Futures Program, fostering entrepreneurship and SME development in the rural regions of Canada. Today's challenge is to fill gaps in this policy offer where there is insufficient scale of interventions or gaps in responses to market and institutional failures (OECD, forthcoming).

To this end, some of Canada's support programmes could be adjusted. The government's plan to review all federal innovation and clean technology programmes across all departments with the aim to simplify them and improve their effectiveness is therefore welcome. One adjustment that seems warranted relates to the Build in Canada Innovation Program, which encourages the procurement of innovative products and services from Canadian

businesses and other organizations. The programme could move from a responsive approach in which the government waits for proposals to emerge from the market, to a proactive approach in which it identifies the innovative public procurement needs within the government and invites proposals from companies to meet such needs (OECD, forthcoming). The government proposes in its 2017 budget to provide up to CAD 50 million to launch a new procurement program, Innovative Solutions Canada, which will follow the model of the Small Business Innovation Research programme of the United States, which applies a more proactive approach.

Other programmes with potentially high external benefits to the economy should be maintained and possibly expanded, subject to evaluation. This is the case of VCAP. The latest figures show that CAD 340 million of government investment has generated CAD 886 million of total investments, and that VCAP has been able to attract some categories of private investors back to the venture capital asset class, including some large Canadian banks, insurers and corporations. With the first VCAP programme to be fully committed by late 2017, further government action will help keep momentum and make its impact more sustainable. In addition, fostering the role of the TSX Venture small cap stock exchange in providing initial public offering exit routes for later stage ventures should also benefit the innovation finance ecosystem as a whole.

Entrepreneurship education could also be strengthened to enhance the quality of entrepreneurs. Such education is well established at Canadian tertiary education institutions and supported by both provincial and federal governments. In its 2017 budget, the government proposes to set up a new Digital Literacy Exchange Programme to teach basic digital skills and to provide Futurpreneur Canada with CAD 14 million to offer young entrepreneurs mentorship, learning resources and start-up financing.

To get the most out of the support programmes, greater dialogue and collaboration between the federal government and bodies such as the Council of Ministers of Education could be encouraged, while existing good practices at provincial and local level could be better shared to foster mutual learning in this new field of education. Educational institutions could also be encouraged to employ experienced entrepreneurs to teach as adjunct professors and include more practice-based learning formats in entrepreneurship training (e.g. by meeting real entrepreneurs, starting virtual companies or the use of informal educational processes such as gaming technologies) (OECD, forthcoming; OECD, 2016b).

Key recommendations

- Develop more east-west interconnections in electricity networks through provincial co-operation where there is an economic case to do so and liberalise the generation and distribution segments to encourage wholesale and retail competition in jurisdictions that have not yet done so.

- Reduce foreign ownership restrictions in air transportation.

- Establish an institutional mechanism, such as the OECD's Competition Assessment Toolkit, to review existing and proposed public policies, identify those that unduly restrict competition and revise them by adopting more pro-competitive alternatives, where feasible without jeopardising other policy objectives such as inclusiveness.

- Strengthen Canadian small businesses' skills for the digital economy, including through coaching programmes to extend digital literacy.

- Shift the balance of support for business innovation further from Canada's high reliance on tax incentives towards direct funding instruments, including those that reward innovation outputs or offer assistance with expertise and managerial competence.

- Review small business taxation to identify clear market failures and the policy instruments best suited to addressing them.

- Maintain and possibly expand good-practice programmes, including IRAP.

- Strengthen the design and delivery of entrepreneurship education through better co-ordination between the federal government and education stakeholders at all levels, the sharing of provincial and local good practices, and the adoption by educational institutions of practice-based learning methodologies.

4 Supporting inclusive growth through strong governance

Public governance plays an important role in delivering on inclusive growth objectives. The multidimensional nature of inclusive growth calls for the need to deal with complex problems and ensure strong levels of policy coherence both within and across levels of government. Recognising the need to foster inclusive growth, Canada has taken important steps to support the innovation capabilities of the Canadian Public Service, ensuring stakeholder engagement in the development of good regulatory practices, and investing in Open Government Data. Multilevel governance challenges must also be addressed to enable inclusive growth. With Canada being the most decentralised country in the OECD in terms of public spending, co-ordination among and across levels of government and across different spheres of stakeholders is critical to align priorities and funding.

Canada needs to better mobilise the public sector for inclusive growth through innovation and good regulatory practices

Public sector governance is an essential lever for inclusive growth, in particular given its important share in Canada's economy. In Canada, the gross value added of government represented 16.1% of GDP in 2015, above the OECD average of 12.3%.
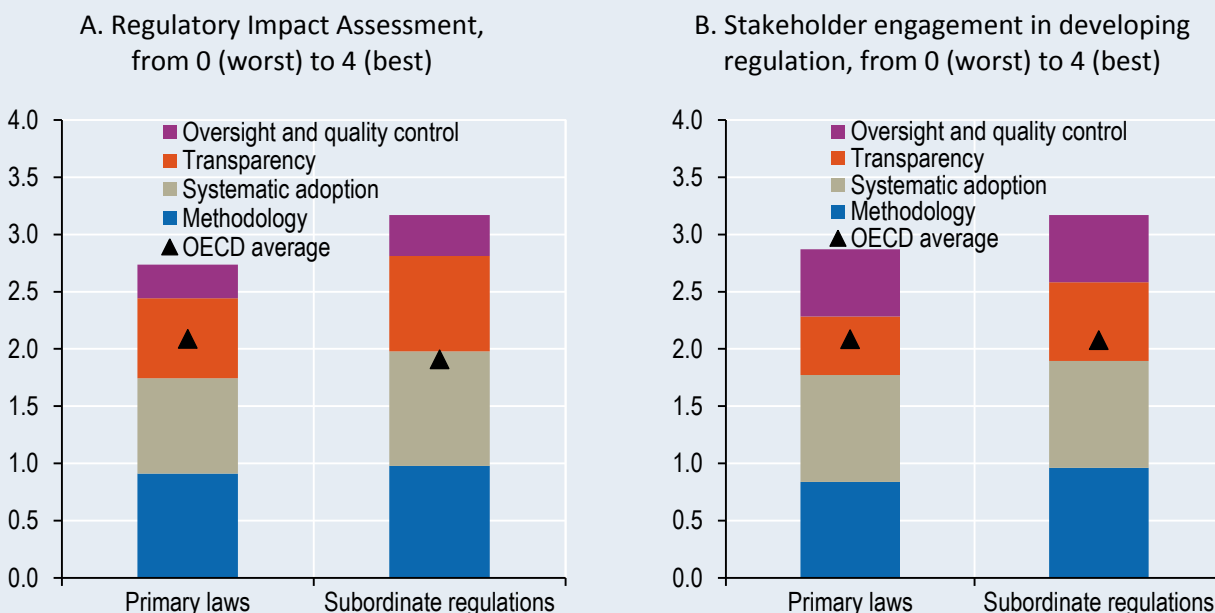
Boosting the ability of the public sector to deliver on inclusive growth outcomes requires investment in innovation. As in many countries, there is a long history of innovation by the public sector in Canada. However, also as in many other countries, the need for more consistent and sophisticated innovation by the public sector is growing, as citizen expectations evolve and complex challenges require more effective responses. Over the past few years, a number of initiatives have been undertaken to further strengthen the innovation capabilities of the Canadian public sector. One of the most recent has been a government commitment to devote a fixed percentage of programme funds to experimenting with new approaches and measuring impact to instil a culture of measurement, evaluation and innovation in programme and policy design and delivery. This emphasis on experimentation is welcome, but balancing the exploration of new ideas with the need to deliver on existing core business is a major challenge. Despite the growing number of examples within the Canadian public administration of new approaches being applied, there remain questions as to whether this balancing challenge has really been met. Further time and evidence will be needed to assess whether these promising practices are truly part of a consistent and sustained shift to integrating innovation into core business.

Good regulatory policies are also an important lever to enable inclusive growth. Canada has made strong regulatory governance a critical pillar of its development. In particular, the processes for developing subordinate regulations are generally detailed and transparent. Open consultation is conducted for all subordinate regulations, and regulators must indicate how comments from the public have been addressed. All subordinate regulations are subject to regulatory impact assessment and evaluation requirements. Canada could improve the transparency of developing primary laws by systematically consulting on draft legislation and supporting impact analysis before legislation is put before Parliament (Figure 4.1).

The strategic use of digital technologies can help the public sector to better deliver services to citizens, for example by drawing on the smart use of data as an input to predict the needs of citizens. The Canadian government has invested technical, human and financial resources to foster the publication of Open Government Data and, as a result, it is among the top five OECD countries in regard to the definition and implementation of open government data policies. Still, like many other OECD countries, Canada faces the challenge of fully reaping the value of open data (produced either by the public sector or external actors)

FIGURE 4.1. **CANADA WOULD BENEFIT FROM APPLYING THE GOOD PRACTICES IT HAS FOR SUBORDINATE REGULATION ALSO TO PRIMARY LAWS**

A. Regulatory Impact Assessment, from 0 (worst) to 4 (best)

B. Stakeholder engagement in developing regulation, from 0 (worst) to 4 (best)

Note: The results for stakeholder engagement and Regulatory Impact Assessment (RIA) apply exclusively to processes for developing primary laws initiated by the executive. As in Canada approximately 77% of primary laws are initiated by the executive, the indicators on RIA and stakeholder engagement cover 77% of primary laws. The composite indicators are based on regulatory policy practices as described in the 2012 OECD Recommendation on Regulatory Policy and Governance. The more of these practices a country has adopted, the higher its indicator score.

Source: OECD Indicators of Regulatory Policy and Governance 2015, http://www.oecd.org/gov/regulatory-policy/indicators-regulatory-policy-and-governance.htm.

as a key building block of the overall transformation of the public sector. Results from the 2017 edition of the OECD's OURdata Index show that Canada could further strengthen the capacities of public sector institutions to reuse open data. The index shows that developing skills among public officials to leverage open government data in policy development processes would be crucial to utilise these data as a valuable input for more data-driven and evidenced-based policies, and more efficient public services and organisational processes. Further developing these capacities would also build a knowledge base among public officials to better capitalise on data produced by external actors.

Multilevel governance can be further improved

Canada is the most decentralised country in the OECD in terms of public spending (Figure 4.2). Subnational governments (10 provinces, 3 territories and 3 945 local governments) manage almost 80% of total public spending, notably in

policy areas that are key for inclusive growth, such as education, health, social protection, economic affairs and environmental protection. They also collect almost 60% of tax revenues and finance more than 90% of public investment.

However, not all subnational governments enjoy equal levels of fiscal autonomy, which can affect territorial disparities and inclusive growth. For example, urbanisation is putting pressure on the capacity of many municipalities to fund increasing needs for infrastructure, thus creating a financing gap. The establishment of the Canada Infrastructure Bank in late 2017 will contribute towards diversifying financing sources for public investment, notably by attracting private sector capital.

Metropolitan areas in Canada are spatially segregated by income groups, with a higher concentration of rich households in specific neighbourhoods (whereas metropolitan areas in Denmark and the Netherlands, for example, tend

to have pockets of poor households) (OECD 2016c). There are growing concerns that rising house prices in Canada's largest cities may be pushing people further away from the city centre, thus aggravating social spatial inequalities, increasing commuting time and generating negative environmental effects.

Co-ordination among and across levels of government and across different spheres of stakeholders is critical to align priorities and funding. This requires a clear allocation of responsibilities and a policy-making process that cuts across sectors and integrates inputs from a wide range of stakeholders. For instance, while Canada has no elected layer of metropolitan government to address core-periphery disparities in metropolitan areas, there have been several waves of municipal amalgamations to harmonise public service delivery (e.g. Halifax in 1996, Toronto in 1998, Ottawa in 2001), sometimes combined with the creation of a metropolitan co-ordination body (e.g. Montreal Metropolitan Community in 2001). Regional authorities have also been set up to co-ordinate a specific policy across member municipalities (e.g. transport in

FIGURE 4.2. **CANADA IS THE MOST DECENTRALISED COUNTRY IN THE OECD**

Share of subnational governments in general government indicators, 2014
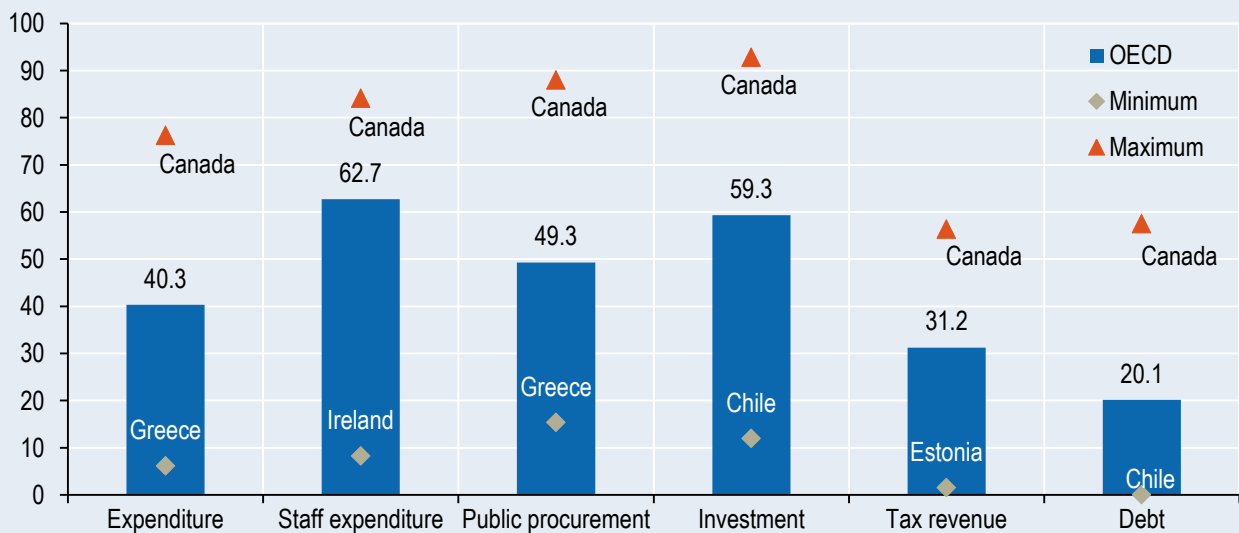
Note: Debt includes insurance reserves and other accounts payable, in addition to financial debt.

Source: OECD elaboration based on OECD (2016d) Subnational Governments in OECD Countries: Key Data, 2016 edition, OECD Publishing, Paris, https://www.oecd.org/cfe/regional-policy/Subnational-governments-in-OECD-Countries-Key-Data-2016.pdf.

Vancouver and Toronto). Moreover, civil society engagement can help drive policy change. For example, in Toronto, a non-profit organisation convenes all three levels of government with business, labour, academic and non-profit sectors every four years to foster collective action on pressing issues such as transport, energy and socio-economic inclusion.

The Canadian Free Trade Agreement will enhance opportunities and living standards

Interprovincial barriers to trade are a major hurdle for better economic performance and living standards in Canada. The Bank of Canada estimates that removing interprovincial barriers to trade could increase Canada's potential growth rate by 0.2 percentage point. Federal, provincial and territorial governments engaged in negotiations from late 2014 until early 2017 to strengthen and modernise the Agreement on Internal Trade (AIT). They agreed on the new Canadian Free Trade Agreement (CFTA) that will take effect on 1 July, 2017. This represents a major step forward in intergovernmental co-ordination.

The CFTA will reduce barriers to trade, investment and worker mobility. In contrast to the AIT, it adopts a negative-list approach to exclusions, meaning that almost all areas of economic activity in Canada are covered unless explicitly excluded. This change is particularly important for innovation, as new goods and services that come to market will automatically be covered by rules designed to promote economic development. The CFTA will cover most of the service economy, accounting for 70% of GDP and, for the first time, the energy sector, accounting for a further 9% of GDP. While the inclusion of the energy sector is promising, increases in interprovincial trade will depend on making provincial regulatory regimes compatible, in particular by having competitive electricity generation and distribution markets (Chapter 3). Agriculture is not covered by the agreement, which is unfortunate, as supply management contributes to a misallocation of resources, notably in dairy production. The resulting higher prices are particularly burdensome for low-income households.

FIGURE 4.3. **CANADA'S GHG EMISSIONS SHOW NO SIGN OF FALLING YET**

Panel A: GHG emission and targets in million tonnes of CO_2 equivalents
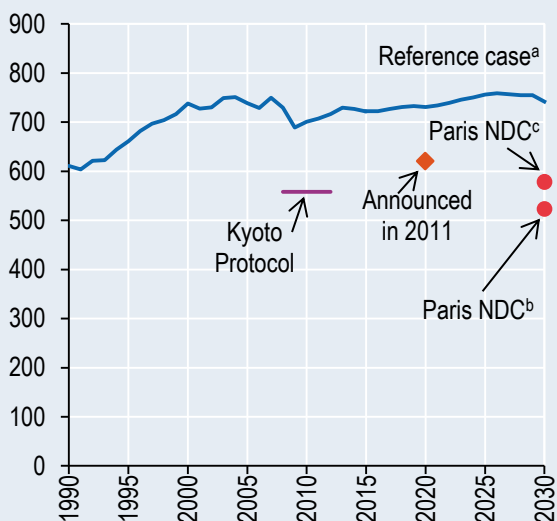
Panel B: GHG emissions by sector in million tonnes of CO_2 equivalents
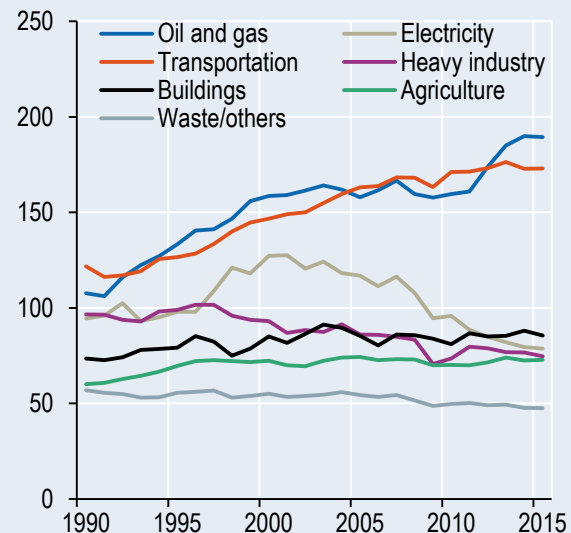
Notes: Panel A: a) Government of Canada emissions projections with policies and measures in place as of 1 November 2016; b) Canada's Nationally Determined Contribution (NDC) under the Paris Agreement, including purchases of international credits; c) Canada's Nationally Determined Contribution (NDC) under the Paris Agreement, domestic reduction only. Panel B: Waste/other includes coal production, light manufacturing, construction and forest resources.

Sources: ECCC (2017), National Inventory Report 1990-2015, ECCC, Ottawa,; country submission.

To reduce regulatory differences across jurisdictions that act as a barrier to trade, governments have agreed to establish a regulatory reconciliation process. A new Regulatory Reconciliation and Co-operation Table is to be established. It will be mandated to eliminate existing trade barriers and prevent new regulatory differences from emerging. This will be particularly helpful for small businesses, many of which have identified regulatory differences between jurisdictions as a significant barrier to internal trade. The performance of this Table will be vital for the success of the agreement. The CFTA also contains improved dispute resolution provisions (e.g. higher maximum monetary penalties for governments that act in a manner inconsistent with the Agreement, higher administrative efficiency of person-to-government disputes, and a new summary dismissal process). Government procurement is to be more open, which will help to create a level playing field and improve value for money. For the first time, the energy sector and many utilities will be covered by open procurement rules, opening up more than CAD 4.7 billion per year in procurement to broader competition. The CFTA also creates processes to help strengthen Canada's economic union in the future, committing the parties to assess options for further liberalising

trade in alcohol, triggering future negotiations on financial services and committing them to enhance economic development in the food sector in the territories.

The CFTA is better aligned with Canada's commitments under international trade agreements than the AIT was. For Canadian firms, this will reduce compliance costs for those doing business both at home and abroad and secure the same access to Canada's market as that enjoyed by foreign firms covered by an international trade agreement, such as Canada-European Union Comprehensive Economic and Trade Agreement.

Better co-ordination is particularly crucial for climate policy

Canadian greenhouse gas (GHG) emissions are among the highest in the OECD on a per capita basis. Emissions are almost 20% above the 1990 level and have fallen back only slightly since 2000. While emissions in electricity generation have been cut quite significantly, they have grown substantially in domestic transport and in the oil and gas extraction industry – the two largest emitting sectors in absolute terms (Figure 4.3, Panel A). Canada's Nationally Determined Contribution for the Paris Agreement specifies an emissions reduction of 30% from the 2005 level by 2030.

While this target leaves Canada's emissions not much below previous commitments (Figure 4.3, Panel B), it remains ambitious given the country's current and foreseeable emissions profile. Without a change in its current policy set, Canada will not meet its targets.

Until recently, federal policy action on climate change has operated primarily through a sector-based regulatory approach, including stringent regulations for coal-fired electricity generation, as well as progressively tightening vehicle standards (aligned with tighter standards introduced in the United States). In the meantime, several provinces moved ahead with ambitious cross-sectoral climate policies, including various schemes of carbon pricing. British Columbia has a carbon tax. Quebec has a joint cap-and-trade system with California that Ontario is planning to join in 2018. Alberta has a hybrid system that involves emission-intensity targets for major emitters, with offset trading between under-performers and over-performers, or payment of a set price per tonne for under-performers, combined with a carbon levy elsewhere in the economy.

In December 2016, Canadian First Ministers announced the Pan-Canadian Framework on Clean Growth and Climate Change (PCF), the country's first-ever overarching plan to meet the mitigation target in a co-ordinated approach among federal, provincial and territorial levels. A key component is to expand the application of national carbon pricing across Canada in 2018. The PCF sets a national benchmark of CAD 10 per tonne of CO_2 equivalent in 2018 (with an expectation that it will rise to CAD 50 per tonne by 2022). For jurisdictions with cap-and-trade regimes, it requires (i) a reduction in emissions by 30% or more by 2030 and (ii) a decline of annual caps until at least 2022 that corresponds with projected emission reductions from the carbon price in price-based systems (e.g. a carbon tax). For any jurisdiction not having a carbon pricing system that aligns with the benchmark, a federal government carbon pricing backstop system will apply, with revenues returned to the jurisdiction. All jurisdictions have signed on to the PCF except Manitoba and Saskatchewan.

The PCF is a well-thought-out strategy, building on progress that different provinces and territories have already made. Practical implementation will,

however, be a huge challenge. Much work will be needed to understand how to ensure some sort of level playing field from a competitiveness perspective. Indeed, differences in the coverage and price levels across jurisdictions may create pressures for eventual conversion of the different pricing systems to reduce costs, improve efficiency and address business competitiveness concerns. The linkage of the Quebec-Ontario-California cap-and-trade system presents another challenge. To ensure successful implementation of the PCF, Canada should establish a strong accountability mechanism that would allow for tracking and comparing progress across provinces.

Key recommendations

- Consider strengthening the measurement of public sector productivity, including by measuring outputs beyond the education and health sectors and strengthening intragovernmental co-ordination on productivity measurement.

- Improve the transparency of developing primary laws in the executive by making evidence publicly available already before legislation is put before Parliament.

- Connect the open government data policy to overarching public sector modernisation strategies to ensure it contributes to the overall digital transformation of the public sector.

- Better target policy co-ordination and dialogue between the three levels of government to productivity and competitiveness priorities.

- Ensure diversified financing methods for public investment (including co-financing between different levels of government and public-private partnerships).

- Adopt adequate equalisation or other fiscal mechanisms for municipalities that struggle to meet their responsibilities.

- Ensure effective and timely implementation of the Pan-Canadian Framework on Clean Growth and Climate Change, establish a mechanism for policy evaluation and adjustment, and promote co-ordination of sub-national climate policies.

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where governments work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

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TAB 9

AI Now 2017 Report

Authors

Alex Campolo, New York University
Madelyn Sanfilippo, New York University
Meredith Whittaker, Google Open Research, New York University, and AI Now
Kate Crawford, Microsoft Research, New York University, and AI Now

Editors

Andrew Selbst, Yale Information Society Project and Data & Society
Solon Barocas, Cornell University

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Recommendations

These recommendations reflect the views and research of the AI Now Institute at New York University. We thank the experts who contributed to the *AI Now 2017 Symposium and Workshop* for informing these perspectives, and our research team for helping shape the *AI Now 2017 Report.*

1. **Core public agencies, such as those responsible for criminal justice, healthcare, welfare, and education (e.g "high stakes" domains) should no longer use "black box" AI and algorithmic systems.** This includes the unreviewed or unvalidated use of pre-trained models, AI systems licensed from third party vendors, and algorithmic processes created in-house. The use of such systems by public agencies raises serious due process concerns, and at a minimum they should be available for public auditing, testing, and review, and subject to accountability standards.

2. **Before releasing an AI system, companies should run rigorous pre-release trials to ensure that they will not amplify biases and errors due to any issues with the training data, algorithms, or other elements of system design.** As this is a rapidly changing field, the methods and assumptions by which such testing is conducted, along with the results, should be openly documented and publicly available, with clear versioning to accommodate updates and new findings.

3. **After releasing an AI system, companies should continue to monitor its use across different contexts and communities.** The methods and outcomes of monitoring should be defined through open, academically rigorous processes, and should be accountable to the public. Particularly in high stakes decision-making contexts, the views and experiences of traditionally marginalized communities should be prioritized.

4. **More research and policy making is needed on the use of AI systems in workplace management and monitoring, including hiring and HR.** This research will complement the existing focus on worker replacement via automation. Specific attention should be given to the potential impact on labor rights and practices, and should focus especially on the potential for behavioral manipulation and the unintended reinforcement of bias in hiring and promotion.

5. **Develop standards to track the provenance, development, and use of training datasets throughout their life cycle.** This is necessary to better understand and monitor issues of bias and representational skews. In addition to developing better records for how a training dataset was created and maintained, social scientists and measurement researchers within the AI bias research field should continue to examine existing training datasets, and work to understand potential blind spots and biases that may already be at work.

6. **Expand AI bias research and mitigation strategies beyond a narrowly technical approach.** Bias issues are long term and structural, and contending with them necessitates deep interdisciplinary research. Technical approaches that look for a one-time "fix" for fairness risk oversimplifying the complexity of social systems. Within each domain – such as education, healthcare or criminal justice – legacies of bias and movements toward equality have their own histories and practices. Legacies of bias cannot be "solved" without drawing on domain expertise. Addressing fairness meaningfully will require interdisciplinary collaboration and methods of listening across different disciplines.

7. **Strong standards for auditing and understanding the use of AI systems "in the wild" are urgently needed.** Creating such standards will require the perspectives of diverse disciplines and coalitions. The process by which such standards are developed should be publicly accountable, academically rigorous and subject to periodic review and revision.

8. **Companies, universities, conferences and other stakeholders in the AI field should release data on the participation of women, minorities and other marginalized groups within AI research and development.** Many now recognize that the current lack of diversity in AI is a serious issue, yet there is insufficiently granular data on the scope of the problem, which is needed to measure progress. Beyond this, we need a deeper assessment of workplace cultures in the technology industry, which requires going beyond simply hiring more women and minorities, toward building more genuinely inclusive workplaces.

9. **The AI industry should hire experts from disciplines beyond computer science and engineering and ensure they have decision making power.** As AI moves into diverse social and institutional domains, influencing increasingly high stakes decisions, efforts must be made to integrate social scientists, legal scholars, and others with domain expertise that can guide the creation and integration of AI into long-standing systems with established practices and norms.

10. **Ethical codes meant to steer the AI field should be accompanied by strong oversight and accountability mechanisms.** More work is needed on how to substantively connect high level ethical principles and guidelines for best practices to everyday development processes, promotion and product release cycles.

Executive Summary

Artificial intelligence (AI) technologies are in a phase of rapid development, and are being adopted widely. While the concept of artificial intelligence has existed for over sixty years, real-world applications have only accelerated in the last decade due to three concurrent developments: better algorithms, increases in networked computing power and the tech industry's ability to capture and store massive amounts of data.

AI systems are already integrated in everyday technologies like smartphones and personal assistants, making predictions and determinations that help personalize experiences and advertise products. Beyond the familiar, these systems are also being introduced in critical areas like law, finance, policing and the workplace, where they are increasingly used to predict everything from our taste in music to our likelihood of committing a crime to our fitness for a job or an educational opportunity.

AI companies promise that the technologies they create can automate the toil of repetitive work, identify subtle behavioral patterns and much more. However, the analysis and understanding of artificial intelligence should not be limited to its technical capabilities. The design and implementation of this next generation of computational tools presents deep normative and ethical challenges for our existing social, economic and political relationships and institutions, and these changes are already underway. Simply put, AI does not exist in a vacuum. We must also ask how broader phenomena like widening inequality, an intensification of concentrated geopolitical power and populist political movements will shape and be shaped by the development and application of AI technologies.

Building on the inaugural 2016 report, *The AI Now 2017 Report* addresses the most recent scholarly literature in order to raise critical social questions that will shape our present and near future. A year is a long time in AI research, and this report focuses on new developments in four areas: labor and automation, bias and inclusion, rights and liberties, and ethics and governance. We identify emerging challenges in each of these areas and make recommendations to ensure that the benefits of AI will be shared broadly, and that risks can be identified and mitigated.

> **Labor and automation**: Popular media narratives have emphasized the prospect of mass job loss due to automation and the widescale adoption of robots. Such serious scenarios deserve sustained empirical attention, but some of the best recent work on AI and labor has focused instead on specific sectors and tasks. While few jobs will be completely automated in the near term, researchers estimate that about a third of workplace tasks can be automated for the majority of workers. New policies such as the Universal Basic Income (UBI) are being designed to address concerns about job loss, but these need much more study.
>
> An underexplored area that needs urgent attention is how AI and related algorithmic systems are already changing the balance of workplace power. Machine learning techniques are quickly being integrated into management and hiring

decisions, including in the so-called gig economy where technical systems match workers with jobs, but also across more traditional white collar industries. New systems make promises of flexibility and efficiency, but they also intensify the surveillance of workers, who often do not know when and how they are being tracked and evaluated, or why they are hired or fired. Furthermore, AI-assisted forms of management may replace more democratic forms of bargaining between workers and employers, increasing owner power under the guise of technical neutrality.

Bias and inclusion: One of the most active areas of critical AI research in the past year has been the study of bias, both in its more formal statistical sense and in the wider legal and normative senses. At their best, AI systems can be used to augment human judgement and reduce both our conscious and unconscious biases. However, training data, algorithms, and other design choices that shape AI systems may reflect and amplify existing cultural assumptions and inequalities. For example, natural language processing techniques trained on a corpus of internet writing from the 1990s may reflect stereotypical and dated word associations—the word "female" might be associated with "receptionist." If these models are used to make educational or hiring decisions, they may reinforce existing inequalities, regardless of the intentions or even knowledge of system's designers.

Those researching, designing and developing AI systems tend to be male, highly educated and very well paid. Yet their systems are working to predict and understand the behaviors and preferences of diverse populations with very different life experiences. More diversity within the fields building these systems will help ensure that they reflect a broader variety of viewpoints.

Rights and liberties: The application of AI systems in public and civil institutions is challenging existing political arrangements, especially in a global political context shaped by events such as the election of Donald Trump in the United States. A number of governmental agencies are already partnering with private corporations to deploy AI systems in ways that challenge civil rights and liberties. For example, police body camera footage is being used to train machine vision algorithms for law enforcement, raising privacy and accountability concerns. AI technologies are also being deployed in the very legal institutions designed to safeguard our rights and liberties, with proprietary risk assessment algorithms already being used to help judges make sentencing and bail decisions, potentially amplifying and naturalizing longstanding biases, and rendering them more opaque to oversight and scrutiny.

Privacy rights represent a particularly sensitive challenge for current AI applications, especially in domains like healthcare, where AI is being used to help make diagnoses. For AI to deliver on its promises, it requires large amounts of data, which likely means an increase in data collection, both its scale and granularity. Without contextual knowledge, informed consent, and due processes mechanisms, these systems can create risks that threaten and expose already vulnerable populations.

Ethics and governance: The areas of ethics and governance attempt to address many of the challenges and opportunities identified above. We track the growing

interest in ethical codes of conduct and principles, while noting that these need to be tied more closely to everyday AI design and development. The military use of artificial intelligence takes on a special urgency in the case of lethal autonomous weapons systems.

There are multiple signs of progress in the development of professional and legal ethical codes to govern the design and application of AI technologies. However, in the face of rapid, distributed, and often proprietary AI development and implementation, such forms of soft governance face real challenges. Among these are problems of coordination among different ethical codes, as well as questions around enforcement mechanisms that would go beyond voluntary cooperation by individuals working in research and industry. New ethical frameworks for AI need to move beyond individual responsibility to hold powerful industrial, governmental and military interests accountable as they design and employ AI.

The following report develops these themes in detail, and reflects on the latest academic research. AI is already with us, and we are now faced with important choices on how it will be designed and applied. Most promisingly, the approaches described in this report demonstrate that there is growing interest in developing AI that is attuned to underlying issues of fairness and equality.

Introduction

In July of 2016, Kate Crawford and Meredith Whittaker co-chaired the first *AI Now Symposium* in collaboration with the Obama White House's Office of Science and Technology Policy and the National Economic Council. The event brought together experts and members of the public to discuss the near-term social and economic impacts of artificial intelligence (AI).[1] AI systems are already being integrated in social, political and economic domains, and the implications can be complex and unpredictable. The now-annual *AI Now Symposium* focuses on AI's core social implications, bringing together leading experts from across sectors and disciplines with the aim of better understanding how AI systems are already working in the world.

The *AI Now 2016 Symposium* identified instances where AI challenged current thinking about professional responsibilities, decision-making and accountability. Following this, *The AI Now 2016 Report* reflected expert discussion and provided recommendations for future research and policy interventions.[2]

The *AI Now 2017 Symposium* deepened this examination of the near-term social and economic implications of AI, and the accompanying report provides an overview of the key issues that the *2017 Symposium* addressed. These are: 1) *Labor and Automation*, 2) *Bias and Inclusion*, *3) Rights and Liberties* and 4) *Ethics and Governance*. In selecting these four themes, we are building on the 2016 report[3] and introducing new areas of concern, with close attention to developments that have occurred in the last 12 months.

The first section on *Labor and Automation* considers the need for a more granular, skills-based, and sectoral approach to understanding AI and automation's impacts on labor practices. While big questions about what implications automation and AI have for labor overall are still wide open, there are also important questions about the distinct roles that automation and AI will play within specific industries, sectors and tasks - particularly how it will be used as a tool of employee hiring, firing and management. The second section focuses on *Bias and Inclusion*, a growing concern among those looking at the design and social implications of AI decision-making systems. Here, we address the problem of diversity and inclusion within the AI industry itself. We also share new technical advances

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[1]   As AI pioneers Stuart Russell and Peter Norvig point out, the history of artificial intelligence has not produced a clear definition of AI, but can be seen as variously emphasizing four possible goals: "systems that think like humans, systems that act like humans, systems that think rationally, systems that act rationally." In this report we use the term AI to refer to a broad assemblage of technologies, from early rule-based algorithmic systems to deep neural networks, all of which rely on an array of data and computational infrastructures. These technologies span speech recognition, language translation, image recognition, predictions and determinations - tasks that have traditionally relied on human capacities across the four goals Russell and Norvig identify. While AI is not new, recent developments in the ability to collect and store large quantities of data, combined with advances in computational power have led to significant breakthroughs in the field over the last ten years. Stuart J. Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Englewood Cliffs, NJ: Prentice Hall, 1995: 27

[2]   AI Now, "The AI Now Report: The Social and Economic Implications of Artificial Intelligence Technologies in the Near-Term," (2016) https://ainowinstitute.org/AI_Now_2016_Report.pdf.

[3]   Ibid.

that help to better understand and mitigate biases that AI systems may perpetuate and even amplify due to biased training data, faulty algorithms or other factors. The third section, on *Rights and Liberties*, begins by recognizing the recent rise of political authoritarianism, and asks about the role of AI systems in either supporting or eroding citizens' rights and liberties in areas like criminal justice, law enforcement, housing, hiring, lending and other domains. The last section, on *Ethics and Governance*, connects AI as we see it today with the history of AI research and development. It also looks at *whose* concerns are ultimately reflected in the ethics of AI, and how ethical codes and other strategies could be developed in a time of political volatility.

We are in the early stages of a long-term discussion, and accordingly, there are as many new questions as there are answers to the old ones. We hope this report provides a productive grounding in the extraordinary challenges and opportunities of the current moment, and helps spur research and inquiry into the social and economic implications of the turn to AI. .

Labor and Automation

The editors of *Nature* have argued that we need to match technical AI research funding with "solid, well-funded research to anticipate the scenarios [AI] could bring about, and to study possible political and economic reforms that will allow those usurped by machinery to contribute to society."[4] The *AI Now Labor Primer* described how forms of automation based on machine learning and robotics have the potential to both increase the productivity of labor and to exacerbate existing inequalities in the distribution of wealth.[5] In an economic context characterized by both low productivity growth and historically high levels of inequality, it will be important to find ways to use AI to promote equality and shared prosperity.[6]

While there is still considerable attention focused on large, structural changes in labor markets and on the economy as a whole, new research has been focusing on specific industries and the impact of AI systems on particular tasks within a profession. This section describes new developments in AI's application within various labor sectors, and suggests directions that research could productively explore in the future.

Research by Sector and Task

At the beginning of 2017, the McKinsey Global Institute (MGI) released a report looking at specific workplace *tasks* and whether they were more or less susceptible to automation, specifically those involving "predictable physical" activities and those involving data collection or processing. While relatively few current jobs can be totally automated with

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[4]   "Anticipating Artificial Intelligence," *Nature* 532, no. 7600 (April 28, 2016): 413, doi:10.1038/532413a.
[5]   "Labor and AI" (New York, NY: *AI Now*, July 7, 2016), https://ainowinstitute.org/AI_Now_2016_Primers.pdf.
[6]   Jason Furman, "Is This Time Different? The Opportunities and Challenges of Artificial Intelligence," expanded remarks from the *AI Now* expert workshop, July 7, 2016, New York University, https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160707_cea_ai_furman.pdf.

today's technology, MGI estimates that 60 percent of all occupations have the potential for about a third of their activities to be automated.[7] In a similar vein, analysts in Deloitte's Human Capital division predict a future where human skills will be "augmented" through "collaboration" with machines capable of performing routine tasks.[8]

To prepare for these changes, it will be essential that policymakers have access to robust data on how advances in machine learning, robotics and the automation of perceptual tasks are changing the nature and organization of work, and how these changes manifest across different roles and different sectors. This data will be necessary for any robust policy proposal. However, a recent report from the National Academies of Sciences, Engineering, and Medicine identifies a lack of such data, finding existing federal statistical data limited in its capacity to answer these questions. The report recommends new multidisciplinary and qualitative research methods to capture present and future transformations in work.[9]

A series of economic studies have begun to investigate the effects of robots on labor markets from an empirical perspective. A 2015 paper by George Graetz and Guy Michaels used new data from the International Federation of Robots to estimate changes in productivity and employment due to robot adoption, finding increases in productivity and slightly lowered working hours for low and middle-skilled workers.[10] Using the same data, Daron Acemoglu and Pascual Restrepo analyzed developments in labor markets across the United States from 1990 to 2007. They estimated that the number of jobs lost due to robots during this period ranged from 360,000 to 670,000, and that this trend could accelerate with a more intensive adoption of automation across sectors.[11] Model assumptions play an important role in these empirical analyses[12] and will need to be continually tested against employment data. To this end, Management Professor and former Senior Economist at the White House Council of Economic Advisers Robert Seamans argues that even more fine-grained, company-level data will be necessary to understand whether AI and automation systems are replacing or complementing human workers.[13]

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[7]   Ibid., 5-6.
[8]   Jeff Schwartz, Laurence Collins, Heather Stockton, Darryl Wagner and Brett Walsh, "The Future of Work: The Augmented Workforce," (Deloitte Human Capital, February 28, 2017), https://dupress.deloitte.com/dup-us-en/focus/human-capital-trends/2017/future-workforce-changing-nature-of-work.html
[9]   National Academies of Sciences, Engineering and Medicine, "Information Technology and the U.S. Workforce: Where Are We and Where Do We Go from Here?," (Washington, DC: The National Academies Press, 2017), https://www.nap.edu/read/24649/.
[10] Georg Graetz and Guy Michaels, "Robots at Work," IZA Discussion Paper (Institute for the Study of Labor (IZA), March 2015), http://econpapers.repec.org/paper/izaizadps/dp8938.htm.
[11] Daron Acemoglu and Pascual Restrepo, "Robots and Jobs: Evidence from US Labor Markets," Working Paper (Cambridge MA: National Bureau of Economic Research, March 2017), doi:10.3386/w23285.
[12] For instance, economists at the Economic Policy Institute argue that Restrepo and Acemoglu's estimates of unemployment were localized and that the media distorted their conclusions regarding job loss while also ignoring productivity increases. See: Lawrence Mishel and Bivens, "The Zombie Robot Argument Lurches on: There Is No Evidence That Automation Leads to Joblessness or Inequality" (Washington, DC: Economic Policy Institute, May 24, 2017), http://www.epi.org/publication/the-zombie-robot-argument-lurches-on-there-is-no-evidence-that-automation-leads-to-job lessness-or-inequality/.
[13] Robert Seamans, "We Won't Even Know If A Robot Takes Your Job," *Forbes*, January 11, 2017, http://www.forbes.com/sites/washingtonbytes/2017/01/11/we-wont-even-know-if-a-robot-takes-your-job/.

AI and the Nature of Work

While the displacement of entire occupations, such as taxi or truck drivers,[14] is clearly an important concern, AI is also transforming a wide range of occupations and roles. Across sectors, automated management and hiring technologies are being introduced, promising to increase worker productivity and flexibility, but also exposing workers to new forms of monitoring, manipulation and control. This changes labor processes and power relations. Further research on this topic is needed to address how AI is transforming the nature of work itself, and how these transformations are manifesting for specific occupations within specific sectors.

Luke Stark and Alex Rosenblat's research with Uber drivers suggests one model for this approach. By listening to drivers, they identified algorithmic forms of management used by the company.[15] While its driver platform, which acts as a kind of remote management console, helps make more efficient use of driver time in this digital "matching market,"[16] the platform also exposes fundamental informational asymmetries between worker and platform owner. For example, drivers have about 15 seconds to accept ride requests via the platform, and are not shown the rider's destination. With drivers in the dark, they don't know when they will accept short, unprofitable fares. Meanwhile, Uber furthers its own goal of providing near-instantaneous service to all prospective riders.[17] Because Uber designs the platform and can change it at will, conflicts of interest between worker and platform owner are systematically settled in favor of Uber via the platform itself, not collective bargaining or other processes that allow for worker participation. This flatly contradicts any argument that the platform is "neutral." It will be interesting to see what comes of the recent New York administrative law judge's ruling, which classified Uber drivers as "employees" under New York law, contrary to Uber's claims otherwise.[18]

Of course, asymmetrical forms of workplace management and control long predate AI.[19] The task for researchers is to determine specifically what makes AI-powered asymmetries different from other forms of monitoring, such as Taylorist scientific management[20] and the audit culture of total quality control.[21] One clear difference is AI's reliance on workplace surveillance and the data it produces, and thus the normalization of workplace surveillance

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[14] Truckers, like ride-sharing drivers, are also subject to data-driven forms of surveillance and control. e.g. Karen E. C. Levy, "The Contexts of Control: Information, Power, and Truck-Driving Work," *The Information Society* 31, No. 2 (March 15, 2015): 160–74, doi:10.1080/01972243.2015.998105.

[15] Alex Rosenblat and Luke Stark, "Algorithmic Labor and Information Asymmetries: A Case Study of Uber's Drivers," International Journal of Communication 10 (July 27, 2016): 3758-3784, http://ijoc.org/index.php/ijoc/article/view/4892/1739.

[16] Eduardo M. Azevedo and E. Glen Weyl, "Matching Markets in the Digital Age," Science 352, no. 6289 (May 27, 2016): 1056–57, http://science.sciencemag.org/content/352/6289/1056.

[17] Rosenblat and Stark, "Algorithmic Labor and Information Asymmetries," 3762.

[18] Dana Rubenstein, "State Labor Judge Finds Uber an 'employer'," *Politico*, May 13, 2017, http://www.politico.com/states/new-york/albany/story/2017/06/13/state-labor-court-finds-uber-an-employer-112733.

[19] Ifeoma Ajunwa, Kate Crawford and Jason Schultz, "Limitless Worker Surveillance,"*California Law Review* 105, No. 3 , 2017.

[20] Hugh G. J Aitken, *Taylorism at Watertown Arsenal; Scientific Management in Action*, 1908-1915. (Cambridge: Harvard University Press, 1960).

[21] Marilyn Strathern, *Audit Cultures: Anthropological Studies in Accountability, Ethics and the Academy* (London: Routledge, 2000).

practices. Such systems provide employers with expansive and often invasive data about the workplace behaviors of their employees. It is this data that AI-powered management systems rely on to generate insights. As AI-driven management becomes more common, so will the data collection and worker surveillance practices on which it relies. Worryingly, this employee monitoring is not necessarily limited to the workplace, and can spill into private life, such as with fitness trackers, ubiquitous productivity apps, or company-issued smartphones equipped with monitoring features.

While we might assume this would be held in check by privacy laws and existing policy, Ifeoma Ajunwa, Kate Crawford and Jason Schultz published a study of existing legal frameworks, assessing if there are any meaningful limits on workplace surveillance. They found very few, some of which are already under threat from the Trump administration.[22] This degree of 24/7 surveillance has the potential to transform key features of prior management systems, potentially in ways workers won't be aware of or have a say in. Employers could easily use machine learning techniques to identify behavioral patterns both during and outside of work hours, and then exploit these one-sided insights to increase profits and manipulate behaviors, with potentially negative effects for workers.

Uber's platform demonstrates how workers are directly and indirectly manipulated in service of instant customer gratification. The company wants to keep up the number of available cars, even during times of low demand when drivers make less money. To address this, the ride-sharing company drew on behavioral economic research about the psychological tendency of taxi workers to set round earnings goals and stop working when they reach them.[23] Uber, with access to vast real-time data about driver activities, can quickly test such theories, using machine learning to identify exploitable behavioral patterns, even at an individual level. Uber discovered that drivers quickly abandon mental income targets in favor of working at times of high demand. To combat this tendency, Uber sent tailored nudge messages[24] to drivers indicating when they are close to revenue target during times when it was advantageous for Uber to keep its drivers on the road.[25] Until a recent feature in *The New York Times*, drivers were unaware that they were subjects in a large behavioral experiment that sought to modify their actions to benefit the company's goals. Given the opacity of these systems, there may be many more such experiments that

[22] Ifeoma Ajunwa, Kate Crawford and Jason Schultz, "Limitless Worker Surveillance,"*California Law Review* 105, No. 3 (June 1, 2017).

[23] Colin Camerer, Linda Babcock, George Loewenstein and Richard Thaler, "Labor Supply of New York City Cab Drivers: One Day at a Time," The Quarterly Journal of Economics 112, No. 2 (May 1, 1997): 407–41, doi:10.1162/003355397555244.

[24] The use of "nudge" as a more technical, policy-oriented term has emerged out of work in the decision and choice sciences, most influentially that of behavioral economist Richard Thaler and the legal scholar Cass Sunstein, who headed the Obama administration's Office of Information and Regulatory Affairs. They, in turn, draw on psychological studies of how people make decisions under conditions of uncertainty and avoid errors due to heuristics—like an earnings goal—and biases. These were first identified by the influential psychologists Amos Tversky and Daniel Kahneman. V.:Richard H. Thaler and Cass R. Sunstein, *Nudge: Improving Decisions About Health, Wealth, and Happiness* (New York: Penguin Books, 2009); Amos Tversky and Daniel Kahneman, "Judgment under Uncertainty: Heuristics and Biases," *Science* 185, No. 4157 (September 27, 1974): 1124–31, doi:10.1126/science.185.4157.1124.

[25] Noam Scheiber, "How Uber Uses Psychological Tricks to Push Its Drivers' Buttons," *The New York Times*, April 2, 2017, https://www.nytimes.com/interactive/2017/04/02/technology/uber-drivers-psychological-tricks.html?_r=0.

workers and the public will never know about.

This case illustrates how AI management might differ from past forms of incentive-based control. As companies gather more data on their workers, they no longer need to rely on generalized psychological theories or human-to-human assessments of merit. They can instead exploit information asymmetries to identify behavioral patterns at the *individual level* and nudge people toward the most profitable activities for the platform owners, even when these operate against the best interests of workers themselves. By selectively exploiting workers' behavior, often without workers' consent or even knowledge, these technologies have the potential to make workers complicit in their own exploitation. To address these emerging imbalances of workplace power, it will likely be necessary for unions, labor rights advocates and individual workers to participate in the design of worker platforms. It will also likely be necessary to give workers a democratic voice in shaping both whether and how they are monitored and how machine learning techniques will be used to process such data. This is a rich area of research and design for the technical architects of AI management systems, labor organizers and advocates to explore.

AI management systems also provide new and invasive methods for evaluating employees and making retention decisions. For example, the employee monitoring firm Veriato captures information from nearly any task a worker performs on a computer, from browsing history to email and chat, even taking periodic screenshots of workers' monitor displays. The firm's software aggregates this information, then uses machine learning to detect anomalous behaviors. The program can then send warning messages to employees who deviate from the norm.[26] What the consequences of such deviance are for workers is up to the employer. And this isn't all. Veriato's software also offers features to score email and chats for sentiment using natural language processing. Language that their program determines to be "negative" is interpreted by the company as an indication of a productivity risk, or of an employee who is getting ready to leave the company. Similarly, another company, Workday, assigns employees individualized risk score based on 60 factors.[27] Many employees who use a work-issued computer or mobile are already subject to this type of monitoring and software-driven ranking and assessment. Additionally, many of them likely have no idea that their value as an employee is being determined in part by software systems scoring everything from the emotional content of their emails to their frequency of accepting meeting requests.

Beyond employee surveillance, the combination of customer surveillance and AI has the potential to turn previously stable employment in sectors like food service and retail into a form of gig work. So-called scheduling software has allowed retailers to switch from standard shifts to a more "on call" model, based on algorithmic predictions about whether customers will be in a store at a given time. While the use of such software can cut an employer's costs by reducing staff during off-peak customer hours, as Solon Barocas and

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[26] Ted Greenwald, "How AI Is Transforming the Workplace," Wall Street Journal, March 10, 2017, sec. Business, https://www.wsj.com/articles/how-ai-is-transforming-the-workplace-1489371060.
[27] Ibid.

Karen Levy have observed, it is "highly destabilizing" for workers who never know ahead of time whether or not they will be called in for work.[28] The use of predictive scheduling software, whether by gig employers like Uber or more traditional employers, collapses work-life boundaries. It also puts workers at risk of over- or underwork, gives workers little to no control over shift times, and provides them with little ability to predict income flows or to plan ahead for things like child care or a second job. Recognizing the negative impacts that such precarious schedules can have on workers, the Oregon state Senate and House recently passed a bill mandating that large employers in retail, manufacturing and hospitality provide workers a written estimate of their schedule at least 7 days before the start of the work week.[29] Barring a veto from the state's Governor, Oregon will join New York, San Francisco and Seattle, who have also passed laws mandating predictable scheduling.

The increasing role of AI and automation within various labor sectors has the potential to revise our understanding of labor and our expectations of goods and services. As consumers grow accustomed to dealing with automated systems, there is a potential to ignore or devalue the human labor that remains essential in many instances. The *AI Now 2016 Labor Primer* emphasized that AI often demands "human caretakers"[30] — these vary, from workers who maintain and repair data centers to moderators who check the results of even the most sophisticated computer vision algorithms.[31] Since the *AI Now 2016 Labor Primer*, Facebook has announced the hiring of 3,000 workers to monitor its live video streaming services for violence, exploitation and hate speech.[32] This is both an acknowledgement that AI systems don't always do the work as intended, and an example of how essential human work happening behind the scenes of complex systems is often invisible. Not surprisingly, this work tends to be outsourced to countries where wages are very low. How will such maintenance and repair work be valued by consumers who have been led to believe that such services are entirely automated? How will companies that promote themselves as fully automated "AI magic" treat and recognize workers within these systems? Additionally, how will this lack of visibility impact workers' ability to organize and shape their own working conditions?

Managers too, will need to rethink how they formulate goals and use data, while acknowledging the limits and risks of automated systems. Michael Luca, Jon Kleinberg, and Sendhil Mullainathan argue that these systems can miss contextual details and may not

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[28]   Solon Barocas and Karen Levy, "What Customer Data Collection Could Mean for Workers," *Harvard Business Review*, August 31, 2016, https://hbr.org/2016/08/the-unintended-consequence-of-customer-data-collection.

[29]   Hillary Borrud, "Oregon on way to become first state to guarantee predictable work schedules," Oregonian, June 29, 2017, sec. Oregon Live, http://www.oregonlive.com/politics/index.ssf/2017/06/oregon_on_way_to_become_first.html

[30]   "AI's human caretakers" in the *2016 AI Now Labor and Automation Primer*, "Labor and AI," https://ainowinstitute.org/AI_Now_2016_Primers.pdf.

[31]   Sarah T. Roberts, "Commercial Content Moderation: Digital Laborers' Dirty Work," in *The Intersectional Internet: Race, Sex, Class and Culture Online*, ed. Safiya Umoja Noble and Brendesha M. Tynes (New York: Peter Lang, 2016), 147–60.

[32]   Kathleen Chaykowski, "Facebook Is Hiring 3,000 Moderators In Push To Curb Violent Videos," *Forbes*, accessed May 10, 2017, http://www.forbes.com/sites/kathleenchaykowski/2017/05/03/facebook-is-hiring-3000-moderators-in-push-to-curb-violent-videos/.

provide clear reasoning for decisions. They advise managers to ask employees and stakeholders to articulate concerns with such systems; more democratic input can often improve performance. Similarly they recommend that diverse data-inputs be used in pursuit of long-term goals and values, instead of focusing too narrowly on low-hanging fruit, which can often produce unintended consequences, like clickbait in search of social media engagement.[33]

Inequality and Redistribution

What happens to workers after their jobs have been automated? The potential for AI systems to exacerbate inequality has been widely acknowledged. To address what to do about it, some are turning to models of resource redistribution, and to the idea of a universal basic income (UBI). The past year has seen a number of high-profile experiments in redistributive social welfare, based on assumptions that AI and automation will require resource distribution not explicitly tied to the sale of individual labor. Some of the most visible efforts have come from governments and private actors running small trials where people receive direct cash transfers in the form of a basic income stipend. It bears noting that payments made as a part of these experiments cannot be considered "universal" insofar as they are provided to a limited number of people. Thus, while these experiments can gather informative data that tells us about individual reactions to the receipt of such funds, they cannot account for the society-wide impact of a universal payment. For example, in April of 2017, the government of Ontario began a UBI pilot research program with 4,000 participants that will provide up to C$16,989 per year for a single person and C$24,027 per year for a couple, less 50 percent of any earned income.[34] Y Combinator, a Silicon Valley-based startup incubator, began a one year UBI pilot study in Oakland in which one hundred families will receive $1,000 to $2,000 per month over the course of a year.[35] Y Combinator president (and OpenAI co-chairman) Sam Altman explicitly references job displacement due to technology as a motivating factor for UBI research.[36] While UBI remains a politically contentious idea with significant variations in approach and implementation, it is currently one of the most commonly proposed policy responses to AI-driven job losses, and as such deserves close assessment.

Bias and Inclusion

The word "bias" has multiple meanings that intersect with AI applications in ways that can overlap and occasionally contradict each other. This can add unnecessary confusion to what is a critically needed domain of research. In statistics—used in many machine learning

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[33] Michael Luca, Jon Kleinberg, and Sendhil Mullainathan, "Algorithms Need Managers, Too," *Harvard Business Review*, January 1, 2016, https://hbr.org/2016/01/algorithms-need-managers-too.

[34] Ministry of Community and Social Services, "Ontario's Basic Income Pilot," *News.ontario.ca*, April 24, 2017, https://news.ontario.ca/mcss/en/2017/04/ontarios-basic-income-pilot.html.

[35] Michael J. Coren, "Y Combinator Is Running a Basic Income Experiment with 100 Oakland Families," *Quartz*, June 1, 2017, https://qz.com/696377/y-combinator-is-running-a-basic-income-experiment-with-100-oakland-families/.

[36] Sam Altman, "Moving Forward on Basic Income," *Y Combinator*, May 31, 2016, https://blog.ycombinator.com/moving-forward-on-basic-income/.

applications—"bias" has a specific meaning that differs from the popular and social scientific definitions. For example, the idea of "selection bias" refers to errors in estimation that result when some members of a population are more likely to be sampled than others. So when a machine learning program trained to recognize, say, faces of a particular racial group is applied to larger or more diverse populations, it may produce biased results in the sense of having a lower measure of accuracy.

The word "bias" also has normative meanings in both colloquial and legal language, where it refers to judgement based on preconceived notions or prejudices, as opposed to the impartial evaluation of facts. Impartiality is a core value of many legal systems and governs many legal processes, from juror selection to the limitations placed on judges. For example, in the United States the Sixth Amendment to the Constitution mandates a right to an impartial jury and the Fourteenth mandates equal protection under the law. This sense of the word bias is closely linked to normative and ethical perspectives on fairness, and the idea that different groups should be treated equally.

When examining technical systems, there can be a temptation to, or vested interest in, limiting discussion of bias to the first more 'neutral' statistical sense of the term. However, in practice there is rarely a clear demarcation between the statistical and the normative definitions: biased models or learning algorithms, as defined statistically, can lead to unequal and unfair treatments and outcomes for different social or racial groups.

The danger of bias increases when these systems are applied, often in non-transparent ways, to critical institutions like criminal justice and healthcare. The social sciences and critical humanities have decades of research on bias within social systems that have much to offer the current debate on bias in AI and algorithmic systems.[37] Since *AI Now* is deeply interested in the social and political implications of AI, this report will use the word "bias" in its broader, normative sense in the following section, while acknowledging its close relationship with statistical usages.

While the potential impact of such biases are extremely worrying, solutions are complicated. This is in part because biased AI can result from a number of factors, alone or in combination, such as who develops systems, what goals system developers have in mind during development, what training data they use, and whether the the systems work well for different parts of the population.[38] This section addresses the latest research on bias in AI and discusses some of the emerging strategies being used to address it.

Where Bias Comes From

AI systems are taught what they "know" from training data. Training data can be

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[37] Barocas, Crawford, Shapiro and Wallach, "The Problem with Bias: Allocative versus Representational Harms in Machine Learning," SIGCIS conference, October 2017.
[38] Solon Barocas and Andrew D. Selbst, "Big Data's Disparate Impact," California Law Review 104, No. 3 (June 1, 2016): 671, doi:10.15779/Z38BG31; Sarah Bird, Solon Barocas, Kate Crawford, Fernando Diaz and Hanna Wallach, "Exploring or Exploiting? Social and Ethical Implications of Autonomous Experimentation in AI," (2016).

incomplete,[39] biased or otherwise skewed,[40] often drawing on limited and non-representative samples that are poorly defined before use.[41] Such problems with training data may not be obvious, as datasets may be constructed in non-transparent ways.[42] Additionally, given that humans must label much of the training data by hand, human biases and cultural assumptions are transmitted by classification choices.[43] Exclusion of certain data can, in turn, mean exclusion of sub-populations from what AI is able to "see" and "know."[44] While pernicious, these biases are difficult to find and understand, especially when systems are proprietary, treated as black boxes or taken at face value.[45] Computer scientists have noted that the complexity of machine learning systems not only must face difficulties in interpreting opaque, unsupervised models, but may also take on "technical debt" that makes maintenance and improvement costly—leading to situations where bias may be difficult to identify *and* mitigate.[46]

Non-representative collection of data can also produce bias. Data is expensive, and data at scale is hard to come by. Thus, those who want to train an AI system are drawn to the use of easily available data,[47] often crowd-sourced, scraped, or otherwise gathered from existing user-facing apps and properties. This type of data can easily privilege socioeconomically advantaged populations, those with greater access to connected devices and online services. These same types of bias can also exist when data is collected from particular groups and not others.[48] A recent example comes from an experiment by OpenAI in which a year's worth of messages from the discussion forum Reddit were used as data to train an AI model to "speak."[49] Reddit is itself a skewed sub-population of internet users, and this experiment can give us a sense of the types of bias that can occur when a small,

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[39] David J. Beymer, Karen W. Brannon, Ting Chen, Moritz AW Hardt, Ritwik K. Kumar and Tanveer F. Syeda-Mahmoo, "Machine learning with incomplete data sets," U.S. Patent 9,349,105, issued May 24, 2016.

[40] Lisa Gitelman, *Raw data is an oxymoron,* (MIT Press: 2013).

[41] Ishan Misra, C. Lawrence Zitnick, Margaret Mitchell and Ross Girshick, "Seeing through the Human Reporting Bias: Visual Classifiers from Noisy Human-Centric Labels," (In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, pp. 2930-2939, 2016).

[42] Josh Attenberg, Prem Melville, Foster Provost and Maytal Saar-Tsechansky, "Selective data acquisition for machine learning," In *Cost-sensitive machine learning*. (CRC Press: 2011), pp. 101-155; Christian Beyer, Georg Krempl and Vincent Lemaire, "How to select information that matters: a comparative study on active learning strategies for classification," In *Proceedings of the 15th International Conference on Knowledge Technologies and Data-driven Business*, p. 2. ACM, 2015.

[43] Moritz Hardt, Nimrod Megiddo, Christos Papadimitriou and Mary Wootters, "Strategic classification." (In Proceedings of the 2016 ACM Conference on Innovations in Theoretical Computer Science, pp. 111-122, 2016).

[44] Matthew Zook, Solon Barocas, Kate Crawford, Emily Keller, Seeta Peña Gangadharan, Alyssa Goodman, Rachelle Hollander, Barbara A. Koenig, Jacob Metcalf, Arvind Narayanan, Alondra Nelson and Frank Pasquale, "Ten simple rules for responsible big data research," PLoS Computational Biology 13, No. 3 (2017): e1005399.

[45] Frank Pasquale, *The black box society: The secret algorithms that control money and information*, (Harvard University Press, 2015).

[46] D. Sculley et al., "Machine Learning: The High Interest Credit Card of Technical Debt," SE4ML: Software Engineering for Machine Learning (NIPS 2014 Workshop), 2014, https://research.google.com/pubs/pub43146.html.

[47] Amanda Levendowski, "How copyright law creates biased artificial intelligence," http://www.werobot2017.com/wp-content/uploads/2017/03/Levendowski-How-Copyright-Law-Creates-Biased-Artificial-Intelligence-Abstract-and-Introduction-1.pdf.

[48] Josh Terrell, Andrew Kofink, Justin Middleton, Clarissa Rainear, Emerson Murphy-Hill, Chris Parnin and Jon Stallings, *Gender differences and bias in open source: Pull request acceptance of women versus men*, No. e1733v2. PeerJ Preprints, 2016.

[49] Ananya Bhattacharya, "Elon Musk's OpenAI is Using Reddit to Teach AI to Speak Like Humans," *Quartz*, October 12, 2016, https://qz.com/806321/open-ai-reddit-human-conversation.

nonrepresentative group is used as a stand-in for the whole.

Problems may also result from the disconnect between the context in which an AI system is used and the assumptions built into the AI system when it was designed. A group of researchers recently assessed how AI-based mapping apps often provide indirect routes to some users as a way to accomplish traffic load-balancing. The system will not be able to tell when the person asking for directions is driving to the hospital in an emergency. Such decontextualized assumptions can put non-consenting and unaware populations at risk while providing little opportunity for direct input.[50]

While widely acknowledged as a problem, bias within and beyond AI is difficult to measure. Unintended consequences[51] and inequalities are by nature collective, relative and contextual, making measurement and baseline comparisons difficult.[52] Information biases in particular are difficult to measure, given the many possible reference points in context: content, users, ranking and access.[53] There is potential for both over- and under-counting biases in measurement of distributions given the limits on observable circumstances for individuals, problems with population gaps and possible measurement errors.[54]

Given the difficulty (and sometimes even technical impossibility) of understanding exactly how AI systems have reached a given decision,[55] bias is often only revealed by demonstrating an inequality in outcomes, post-hoc. Examples of this are familiar from recent news stories. Julia Angwin's ProPublica piece on Northpointe's racially-biased COMPAS system, used to make sentencing decisions in courts across the United States, is an exemplar of the genre.[56] Similarly, Bloomberg found that Amazon's same-day delivery service was bypassing ZIP codes that are predominantly black. This decision may have been made for many reasons, but its result was racial bias.[57]

The AI Field is Not Diverse

Bias can also emerge in AI systems because of the very narrow subset of the population that design them. AI developers are mostly male, generally highly paid, and similarly

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[50] Sarah Bird, Solon Barocas, Kate Crawford, Fernando Diaz and Hanna Wallach, "Exploring or Exploiting? Social and Ethical Implications of Autonomous Experimentation in AI," *Workshop on Fairness, Accountability, and Transparency in Machine Learning*, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2846909 (2016).

[51] Marco J Haenssgen and Proochista Ariana, "The Social Implications of Technology Diffusion: Uncovering the Unintended Consequences of People's Health-Related Mobile Phone Use in Rural India and China," *World Development* 94 (2017): 286-304.

[52] Frank Cowell, *Measuring inequality*, (Oxford University Press, 2011).

[53] Evaggelia Pitoura, Panayiotis Tsaparas, Giorgos Flouris, Irini Fundulaki, Panagiotis Papadakos, Serge Abiteboul and Gerhard Weikum, "On Measuring Bias in Online Information," *arXiv preprint arXiv:1704.05730* (2017).

[54] Ashton Anderson, Jon Kleinberg and Sendhil Mullainathan, "Assessing Human Error Against a Benchmark of Perfection," arXiv preprint arXiv:1606.04956 (2016).

[55] Jenna Burrell, "How the machine 'thinks': Understanding opacity in machine learning algorithms," *Big Data & Society* 3, No. 1 (2016): DOI: https://doi.org/10.1177/2053951715622512.

[56] Angwin, Larson and Kirchner, "Machine Bias: There's Software Used Across the Country to Predict Future Criminals. And It's Biased Against Blacks," *ProPublica*, May 23, 2016 https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing

[57] David Ingold and Spencer Soper, "Amazon Doesn't Consider the Race of Its Customers. Should It?," Bloomberg, April 21, 2016, https://www.bloomberg.com/graphics/2016-amazon-same-day/.

technically educated. Their interests, needs, and life experiences will necessarily be reflected in the AI they create. Bias, whether conscious or unconscious,[58] reflects problems of inclusion and representation. The lack of women and minorities in tech fields, and artificial intelligence in particular, is well known.[59] But this was not always the case. Early programming and data entry work was characterized as secretarial, and was female-dominated. These women were themselves called "computers," and they were often undercompensated and rarely credited.[60] All the while, they were responsible for things like maintaining sophisticated systems that targeted bomb strikes in World War II[61] and tabulating decades of census data.[62]

The history of AI reflects this pattern of gender exclusion. The 1956 Dartmouth Summer Research Project on Artificial Intelligence, which initiated the concept of artificial intelligence,[63] was exclusively attended by men. Pioneering work in natural language processing and computational linguistics, key to contemporary AI systems, has been credited to male colleagues and students rather than to Margaret Masterman, who founded the Cambridge Language Research Unit and was one of the leaders in the field.[64] Intentional exclusion and unintentional "like-me" bias is responsible for a continued lack of demographic representation within the AI field and within the tech industry for women, Hispanics, and African Americans.[65]

Gender and racial disparities among developer cohorts in tech companies are even more skewed than the demographics of students or academics. In the United States, women make up about 18 percent of computer science (CS) graduates, yet only 11 percent of computer engineers are female. African Americans and Hispanics represent only 11 percent of total technology sector employees although they comprise 27 percent of the overall population.[66] Representation in the U.S. context has wide reaching implications, given that 33 percent of knowledge and technology intensive (KTI) jobs worldwide are U.S. based and those firms contribute 29 percent of global GDP, of which 39 percent are U.S. based.[67] Efforts to address gender biases in Google Ad Settings, revealed in 2015,[68] have failed to

[58] Cathy O'Neil, *Weapons of math destruction: How big data increases inequality and threatens democracy*, (New York: Crown Publishing Group, 2016).

[59] Kate Crawford, "Artificial Intelligence's White Guy Problem," *The New York Times*, June 25, 2016.

[60] Ellen Van Oost, "Making the Computer Masculine," In *Women, Work and Computerization* (2000), pp. 9-16.

[61] Nathan Ensmenger, "Making programming masculine," In *Gender codes: Why women are leaving computing* (2010): 115-42.

[62] Margaret Ann Boden, *Mind as machine: A history of cognitive science*, (Clarendon Press, 2006).

[63] Ronald Kline, "Cybernetics, automata studies, and the Dartmouth conference on artificial intelligence," *IEEE Annals of the History of Computing* 33, No. 4 (2011): 5-16.

[64] Margaret Masterman, "1 Personal background," *Early Years in Machine Translation: Memoirs and Biographies of Pioneers* 97 (2000): 279; William Williams and Frank Knowles, "Margaret Masterman: In memoriam," *Computers and translation* 2, No. 4 (1987): 197-203.

[65] Google, Inc. and Gallup, Inc., "Diversity Gaps in Computer Science: Exploring the Underrepresentation of Girls, Blacks, and Hispanics," Retrieved from http://goo.gl/PG34aH. Additional reports from Google's Computer Science Education Research are available at https://edu.google.com/resources/computerscience/research.

[66] National Science Foundation, "Science and Engineering Indicators," 2016, Chapter 2, https://nsf.gov/statistics/2016/nsb20161/#/report/chapter-2.

[67] National Science Foundation, "Science and Engineering Indicators," 2016, Chapter 6, https://nsf.gov/statistics/2016/nsb20161/#/report/chapter-6.

[68] Amit Datta, Michael Carl Tschantz and Anupam Datta, "Automated experiments on ad privacy settings," *Proceedings on*

stop inequality in presentation of STEM job ads, even when language in ads are controlled for gender-neutral language.[69]

AI is not impartial or neutral. Technologies are as much products of the context in which they are created as they are potential agents for change.[70] Machine predictions and performance are constrained by human decisions and values,[71] and those who design, develop, and maintain AI systems will shape such systems within their own understanding of the world.[72] Many of the biases embedded in AI systems are products of a complex history with respect to diversity and equality.

Recent Developments in Bias Research

In the year since the *AI Now 2016 Symposium,* there has been a bumper crop of new research on bias in machine learning. One promising development is that many of these studies have reflexively used AI techniques to understand the the ways by which AI systems introduce or perpetuate unequal treatment.

New research on word embeddings has shown the ways in which language, as it is used within our complex and often biased social contexts, reflects bias.[73] Word embeddings are set of natural language processing techniques that map the semantic relationship between words, creating a model that predicts which words are likely to be associated with which. Researchers looking at word embeddings showed that predictable gendered associations between words, such as "female" and "queen" are reflected in the models, as are stereotypes, such as "female" and "receptionist," while "man" and typically masculine names are associated with programming, engineering and other STEM professions.[74]

Such biases have daily, real-world impacts. Recent analysis of search results and advertisements similarly reveals persistent gendered, racial and cultural biases.[75]

Privacy Enhancing Technologies 2015, No. 1 (2015): 92-112.

[69] Anja Lambrecht and Catherine E. Tucker, "Algorithmic Bias? An Empirical Study into Apparent Gender-Based Discrimination in the Display of STEM Career Ads," October 13, 2016. Available at SSRN: https://ssrn.com/abstract=2852260 or http://dx.doi.org/10.2139/ssrn.2852260.

[70] Zdenek Smutny, "Social informatics as a concept: Widening the discourse," *Journal of Information Science* 42, No. 5 (2016): 681-710.

[71] Kenneth A. Bamberger and Deirdre Mulligan, "Public Values, Private Infrastructure and the Internet of Things: the Case of Automobile," *Journal of Law & Economic Regulation* 9 (2016): 7-44; Jon Kleinberg, Himabindu Lakkaraju, Jure Leskovec, Jens Ludwig and Sendhil Mullainathan, "Human decisions and machine predictions," No. w23180. National Bureau of Economic Research, 2017.

[72] Brent Daniel Mittelstadt, Patrick Allo, Mariarosaria Taddeo, Sandra Wachter and Luciano Floridi, "The ethics of algorithms: Mapping the debate," *Big Data & Society* 3, No. 2 (2016): 2053951716679679.

[73] Aylin Caliskan, Joanna J. Bryson and Arvind Narayanan, "Semantics derived automatically from language corpora contain human-like biases," *Science* 356, No. 6334 (2017): 183-186; Anthony G. Greenwald, "An AI stereotype catcher," *Science* 356, No. 6334 (2017): 133-134.

[74] Tolga Bolukbasi, Kai-Wei Chang, James Zou, Venkatesh Saligrama and Adam Kalai, "Quantifying and reducing stereotypes in word embeddings," *arXiv preprint arXiv:1606.06121* (2016); Tolga Bolukbasi, Kai-Wei Chang, James Y. Zou, Venkatesh Saligrama and Adam T. Kalai, "Man is to computer programmer as woman is to homemaker? Debiasing word embeddings," In *Advances in Neural Information Processing Systems*, pp. 4349-4357, 2016.

[75] Datta, Tschantz, and Datta, 2015; Tarleton Gillespie, "Algorithmically recognizable: Santorum's Google problem, and Google's Santorum problem," *Information, Communication & Society* 20, No. 1 (2017): 63-80; Safiya Umoja Noble, "Algorithms of Oppression: How Search Engines Enforce Racism," (NYU Press, forthcoming 2018).

New work has also highlighted the way in which AI poses risks of significant bias-driven impacts in the educational context, where K-12 educators subject children to treatment, discipline and tracking decisions based on AI-determined characterizations of their abilities and behaviors.[76] Analysis of large data sets reflecting STEM education in K-12 classrooms reveals racial disparities in disciplinary actions and recommendations for advanced coursework. These data, along with the biases they reflect, are very likely to be used to train these educational AI systems, which would then reproduce and further normalize these biases.

In a study that examined the potential for bias, the Human Rights Data Analysis Group demonstrated how commonly used predictive policing system PredPol, were it used in Oakland, CA, would reinforce racially-biased police practices by recommending increased police deployment in neighborhoods of color.[77] Decades of policing research has shown that foot patrols and community rapport decrease policing biases, while studies of "driving while black" and "hot spots" illustrate biases in routine strategies.[78] New technologies appear to prevent the former and amplify the latter, reproducing the most extreme racial stereotyping.[79]

Legal scholarship has also explored the applications of machine testimony at criminal trials,[80] among many possible instances identified in which these skewed systems and biased data could negatively impact human lives due to reproducing stereotypes, with the added challenge that the systems are poorly understood and proprietary.

When bias is embedded in AI health applications, it can have an incredibly high cost. Worryingly, data sets used to train health-related AI often rely on clinical trial data, which are historically skewed toward white men, even when the health conditions studied primarily affect people of color or women.[81] Even without AI amplifying such biases, African Americans with sickle cell anemia are overdiagnosed and unnecessarily treated for diabetes based on insights from studies that excluded them.[82] The prevalence of biases when combined with opacity and inscrutability leads to a lack of trust in AI currently being

[76] Benjamin Herold, "Algorithmic Bias as a Rising Concern for Ed-Tech Field, RAND Researchers Say," Education Week, April 11, 2017, http://blogs.edweek.org/edweek/DigitalEducation/2017/04/algorithmic_bias_edtech_RAND.html.

[77] Kristian Lum and William Isaac, "To predict and serve?," *Significance* 13, No. 5 (2016): 14-19.

[78] Prashan Ranasinghe, "Rethinking the Place of Crime in Police Patrol: A Re-Reading of Classic Police Ethnographies," *British Journal of Criminology* (2016): azw028; Patricia Warren, Donald Tomaskovic-Devey, William Smith, Matthew Zingraff and Marcinda Mason, "Driving while black: Bias processes and racial disparity in police stops," *Criminology* 44, No. 3 (2006): 709-738; David Weisburd, "Does Hot Spots Policing Inevitably Lead to Unfair and Abusive Police Practices, or Can We Maximize Both Fairness and Effectiveness in the New Proactive Policing," *University of Chicago Legal Forum* (2016): 661-689.

[79] Andrew Guthrie Ferguson, *The Rise of Big Data Policing: Surveillance, Race, and the Future of Law Enforcement*, (NYU Press, forthcoming 2017).

[80] Andrea Roth, "Machine Testimony," Yale Law Journal, forthcoming 2017.

[81] Anita Kurt, Lauren Semler, Jeanne L. Jacoby, Melanie B. Johnson, Beth A. Careyva, Brian Stello, Timothy Friel, Mark C. Knouse, Hope Kincaid and John C. Smulian, "Racial Differences Among Factors Associated with Participation in Clinical Research Trials," *Journal of Racial and Ethnic Health Disparities* (2016): 1-10.

[82] Mary E Lacy, Gregory A. Wellenius, Anne E. Sumner, Adolfo Correa, Mercedes R. Carnethon, Robert I. Liem, James G. Wilson, David B. Saks, David R. Jacobs Jr., April Carson, Xi Luo, Annie Gjelsvik, Alexander P. Reiner, Rhaki Naik, Simin Liu, Solomon K. Musani, Charles B. Eaton and Wen-Chih Wu, "Association of sickle cell trait with hemoglobin A1c in African Americans," *Jama* 317, No. 5 (2017): 507-515.

developed for neuroscience and mental health applications.[83] The prospect of misdiagnosis or improper treatment leading to patient death motivates some to avoid AI systems entirely in the health context.[84]

Emerging Strategies to Address Bias

There is an urgent need to expand cultural, disciplinary and ethnic diversity within the AI field in order to diminish groupthink, mitigate bias and broaden intellectual frames of reference beyond the purely technical. While some have suggested that AI systems can be used to address diversity problems at companies,[85] if AI development is not inclusive, the success of such a bootstrapped approach is doubtful. There have been positive developments prompting inclusion within the AI community, such as Fei-Fei Li's SAILORS summer camp, a program that helps high school girls acquire comfort and experience with AI.[86] Similarly, the Association of Computing Machinery (ACM) increasingly recognizes the need to address algorithmic bias and emphasize diversity.[87] Various conferences have also sought to explore accountability and transparency issues surrounding AI and algorithmic systems as a way to better understand and evaluate biases.[88] Among conferences, the Fairness, Accountability, and Transparency in Machine Learning (FAT/ML and now FAT*) Conferences are notable for a focus on technical research and experimentation dedicated to making AI more inclusive, legible and representative.[89]

While steps are being made to understand and combat bias in some sectors, bias can also be profitable. Insurance and financial lending have long discriminated for their financial advantage, choosing to serve the least risky and, sometimes, leaving the most vulnerable behind.[90] AI systems are now being used to make credit and lending decisions. When underwriting decisions are made by AI systems trained on data that reflects past biased practices and calibrated to detect nuanced signals of "risk," creditors will be able to make more profitable loans while leaving those in precarious situations behind. Due to misaligned interests and the information asymmetry that AI exacerbates in these industries, new incentives for fairness and new methods for validating fair practices need

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[83] Andreas Holzinger, "Interactive machine learning for health informatics: when do we need the human-in-the-loop?," *Brain Informatics* 3, No. 2 (2016): 119-131.

[84] Rich Caruana, "Intelligible Machine Learning for Critical Applications Such As Health Care," *2017 AAAS Annual Meeting (February 16-20, 2017)*, AAAS, 2017.

[85] Ji-A Min, "Ten ways HR tech leaders can make the most of artificial intelligence," Personnel Today, April 26, 2017, http://www.personneltoday.com/hr/ten-ways-hr-tech-leaders-can-make-artificial-intelligence/.

[86] Marie E Vachovsky, Grace Wu, Sorathan Chaturapruek, Olga Russakovsky, Richard Sommer and Li Fei-Fei, "Toward More Gender Diversity in CS through an Artificial Intelligence Summer Program for High School Girls," (In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education*, pp. 303-308), ACM, 2016.

[87] Kieth Kirkpatrick, "Battling algorithmic bias: how do we ensure algorithms treat us fairly?," *Communications of the ACM* 59, No. 10 (2016): 16-17.

[88] Algorithms and Explanations, Information Law Insitute, New York University, April 27-28, 2017, http://www.law.nyu.edu/centers/ili/events/algorithms-and-explanations.

[89] 3rd Workshop on Fairness, Accountability, and Transparency in Machine Learning, New York, November 18, 2016, http://www.fatml.org/.

[90] JM Schumacher, "Linear Versus Nonlinear Allocation Rules in Risk Sharing Under Financial Fairness," (March 2, 2017), http://dx.doi.org/10.2139/ssrn.2892760.

to be developed.[91]

Part of the fundamental difficulty in defining, understanding and measuring bias stems from the contentious and conceptually difficult task of defining fairness. Tradeoffs are inherent in the adoption of particular fairness definitions, possibly perpetuating particular biases in the service of addressing others.[92] Recent efforts have sought to implement fairness by mathematically specifying social norms and values, then using those specifications as constraints when training AI systems.[93] While these are hopeful developments, none of these methods cleanly solve the problem of bias. Understanding AI not as a purely technical implementation, but as a contextually-specific combination of norms, technical systems and strategic interests is an important step toward addressing bias in AI.[94] There continues to be a deep need for interdisciplinary, socially aware work that integrates the long history of bias research from the social sciences and humanities into the field of AI research.

Rights and Liberties

In the period since the *AI Now 2016 Symposium*, the global political landscape has shifted considerably. The election of Donald Trump is part of a larger wave of populist political movements across the globe, and shares with these a number of hallmark traits. In governing, populists seek to delegitimize political opposition—from opposition parties to institutions like the media and the judiciary—and to crack down on perceived threats to the imagined homogeneous people they claim to represent.[95] While regional instantiations vary, they share an opposition to existing political elites and a nationalist, anti-pluralist approach that claims a moral imperative to represent a silent majority.

The election of Emmanuel Macron in France and the gains by Labour in the UK may indicate a coming backlash to the global populist wave, but given the strong showing from Germany's far-right Alternative für Deutschland party in their 2017 elections, this is by no means certain.

It remains necessary to ask how AI systems are likely to be deployed in governing, and how

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[91] Hamid R. Ekbia and Bonnie A. Nardi, *Heteromation, and Other Stories of Computing and Capitalism*, (MIT Press, 2017); Sampath Kannan, Michael Kearns, Jamie Morgenstern, Mallesh Pai, Aaron Roth, Rakesh Vohra and Z. Steven Wu, "Fairness Incentives for Myopic Agents," arXiv preprint arXiv:1705.02321 (2017); Julia Lane, "Perspective: Fix the incentives," *Nature* 537, No. 7618 (2016): S20-S20.

[92] Jon Kleinberg, Sendhil Mullainathan and Manish Raghavan, "Inherent trade-offs in the fair determination of risk scores," arXiv preprint arXiv:1609.05807 (2016).

[93] Yiling Chen, Arpita Ghosh, Michael Kearns, Tim Roughgarden and Jennifer Wortman Vaughan, "Mathematical foundations for social computing," *Communications of the ACM* 59, No. 12 (2016): 102-108; Shahin Jabbari, Matthew Joseph, Michael Kearns, Jamie Morgenstern and Aaron Roth, "Fair Learning in Markovian Environments," arXiv preprint arXiv:1611.03071 (2016); Matthew Joseph, Michael Kearns, Jamie Morgenstern, Seth Neel and Aaron Roth, "Rawlsian fairness for machine learning," arXiv preprint arXiv:1610.09559 (2016).

[94] Mike Ananny, "Toward an ethics of algorithms: Convening, observation, probability, and timeliness," *Science, Technology, & Human Values* 41, No. 1 (2016): 93-117.

[95] Jan-Werner Müller, *What Is Populism?* (Philadelphia: University of Pennsylvania Press, 2016).

they might be used within populist and authoritarian contexts.[96] What effects will these systems have on vulnerable individuals and minorities? How will AI systems be used by law enforcement or national security agencies? How will AI's use in the criminal justice system affect our understanding of due process and the principle of equal justice under the law? How might complex AI systems centralize authority and power? This section examines these questions, describes applications of AI that pose challenges to rights and liberties, and touches on the technical and normative frameworks we might construct to ensure AI can be a force for good in the face of our contemporary political realities.

Population Registries and Computing Power

In political contexts where minorities or opposition points of view are seen as threats to an imagined homogeneous "people," information technology has been used to monitor and control these segments of a population. Such techno-political projects often build on older colonial histories of censuses and population registries,[97] as well as racialized modes of surveillance and control rooted in the Atlantic slave trade and the plantation system. In *Dark Matters*, Simone Browne connects this deep history of surveillance to contemporary biometric techniques of governing black bodies.[98]

The Book of Life registry project in apartheid South Africa is a useful modern example. In that project, which ran from 1967 to 1983, IBM assisted South Africa in classifying its population by racial descent. This system was used to move all so-called 'non-white citizens' from their homes into segregated neighborhoods.[99] The Book of Life was plagued by technical and operational problems and eventually abandoned. However, as Paul Edwards and Gabrielle Hecht note, "technopolitical projects do not need to fully achieve their technical goals in order to 'work' politically… The registries 'worked' to establish racialized personal identities as elements of governance."[100] As Kate Crawford has recently argued, registries like the Book of Life were reinforcing a way of thinking that was itself autocratic.[101]

More recent computerized registries like The National Security Entry-Exit Registration System (NSEERS) proliferated in the United States and among its allies following the attacks of September 11, 2001. NSEERS centralized documentation for non-citizens in the United States who hailed from a list of 25 predominantly Muslim countries that the Bush administration deemed dangerous. As with the Book of Life, NSEERS' effectiveness in its

[96] See Kate Crawford, "Dark Days: AI and the Rise of Fascism," SXSW featured talk, March 15 2017, https://www.youtube.com/watch?v=Dlr4O1aEJvI.

[97] For just one example in colonial India, v.: Radhika Singha, "Settle, Mobilize, Verify: Identification Practices in Colonial India," *Studies in History* 16, No. 2 (August 1, 2000): 151–98, doi:10.1177/025764300001600201.

[98] Simone Browne, *Dark Matters: On the Surveillance of Blackness,* (Durham: Duke University Press, 2015).

[99] National Action/Research on the Military-Industrial Complex and American Friends Service Committee, *Automating Apartheid: U.S. Computer Exports to South Africa and the Arms Embargo*, (Philadelphia: NARMIC/America Friends Service Committee, 1982), 19.

[100] Paul N. Edwards and Gabrielle Hecht, "History and the technopolitics of identity: The case of apartheid South Africa," *Journal of Southern African Studies* 36, No. 3 (2010): 619-639.

[101] Kate Crawford, "Dark Days: AI and the Rise of Fascism," SXSW featured talk, March 15 2017, https://www.youtube.com/watch?v=Dlr4O1aEJvI.

stated goal of stopping domestic terrorism was questionable, and it was dismantled in the final days of the Obama administration (although the data collected by the program still exists).[102] Consistent with Edwards' and Hecht's analysis, NSEERS set into motion state projects of Muslim surveillance and deportation.[103]

The history and political efficacy of registries exposes the urgent need for lines of research that can examine the way citizen registries work currently, enhanced by data mining and AI techniques, and how they may work in the future.[104] Contemporary AI systems intensify these longer-standing practices of surveillance and control. Such systems require the collection of massive amounts of data, which is now possible at large scale via the Internet and connected devices. When these practices are carried out by private enterprise in addition to states, as we will discuss in the next section, they introduce new forms of value extraction and population control unregulated and often unacknowledged by current legal frameworks.[105]

Corporate and Government Entanglements

It remains critically important to understand the history of AI and its shifting relationship to the state. In the mid-twentieth century, advanced computing projects tended to be closely associated with the state, and especially the military agencies who funded their fundamental research and development.[106] Although AI emerged from this context, its present is characterized by a more collaborative approach between state agencies and private corporations engaged in AI research and development. As Gary Marchant and Wendell Wallach argue, governance has expanded far beyond both governmental institutions and legal codes to include a wide range of industry standards and practices that will shape how AI systems are implemented.[107]

Palantir—co-founded by Trump supporter and advisor Peter Thiel with seed money from the CIA's venture capital fund In-Q-Tel—typifies this dynamic.[108] Gotham, Palantir's national security and government software, allows analysts to easily combine, query and visualize structured and unstructured data at large scales.[109] AI can now be used in Palantir products for activities such as lead generation, including a bank's ability to identify

[102] J. David Goodman and Ron Nixon, "Obama to Dismantle Visitor Registry Before Trump Can Revive It," *The New York Times*, December 22, 2016, https://www.nytimes.com/2016/12/22/nyregion/obama-to-dismantle-visitor-registry-before-trump-can-revive-it.html.

[103] "Raza v. City of New York - Legal Challenge to NYPD Muslim Surveillance Program," American Civil Liberties Union, March 6, 2017, https://www.aclu.org/cases/raza-v-city-new-york-legal-challenge-nypd-muslim-surveillance-program.

[104] Kate Crawford, "Letter to Silicon Valley," *Harper's Magazine*, Feb 9, 2017, https://harpers.org/archive/2017/02/trump-a-resisters-guide/11/.

[105] Julie E. Cohen, "The Biopolitical Public Domain: The Legal Construction of the Surveillance Economy," Philosophy & Technology, March 28, 2017, 1–21, doi:10.1007/s13347-017-0258-2.

[106] Paul N. Edwards, The Closed World: *Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: The MIT Press, 1996).

[107] Gary E. Marchant and Wendell Wallach, "Coordinating Technology Governance | Issues in Science and Technology," Issues in Science and Technology XXXI, no. 4 (Summer 2015), http://issues.org/31-4/coordinating-technology-governance/.

[108] Sam Biddle, "How Peter Thiel's Palantir Helped the NSA Spy on the Whole World," *The Intercept*, February 22, 2017, https://theintercept.com/2017/02/22/how-peter-thiels-palantir-helped-the-nsa-spy-on-the-whole-world/.

[109] Ibid.

anomalous credit card activity for fraud protection. More advanced capabilities are available to national security clients as well. How rights and liberties need to be understood and reconfigured in the face of opaque public-private AI systems is still an open question.

Immigration and law enforcement are critical within this debate. In the United States, Immigration and Customs Enforcement (ICE) is expanding its technological reach through tools like Investigative Case Management (ICM), a platform that allows agents to access a wide variety of previously separate databases, including information on a suspect's "schooling, family relationships, employment information, phone records, immigration history, foreign exchange program status, personal connections, biometric traits, criminal records and home and work addresses."[110] This is another Palantir system, first procured by the Obama administration in 2014 and scheduled to become operational late in 2017.

Other law enforcement agencies are currently integrating AI and related algorithmic decision-support systems from the private sector into their existing arsenals. Axon (formerly Taser International) is a publicly traded maker of law enforcement products, including their famous electroshock weapon. The company has now shifted toward body camera technologies, recently offering them for free to any police department in the U.S.[111] In 2017, Axon started an AI division following their acquisition of two machine vision companies. Among their goals is to more efficiently analyze the over 5.2 petabytes of data that they have already acquired from their existing camera systems. Video expands Axon's existing Digital Evidence Management System, signaling a larger shift beyond machine learning and natural language processing of textual sources.[112] Axon CEO Rick Smith has argued that the vast scale of existing law enforcement data could help drive research in machine vision as a whole: "We've got all of this law enforcement information with these videos, which is one of the richest treasure troves you could imagine for machine learning."[113] There are real concerns about the forms of bias embedded in these data sets, and how they would subsequently function as training data for an AI system.

There are some who argue in favor of body camera and machine vision systems for supporting civil liberties, including enhanced law enforcement transparency and accountability.[114] Axon promises that its AI techniques will reduce the time officers currently spend on report-writing and data entry.[115] However, Axon's new focus on

[110] Spencer Woodma, "Palantir Provides the Engine for Donald Trump's Deportation Machine," *The Intercept*, March 2, 2017, https://theintercept.com/2017/03/02/palantir-provides-the-engine-for-donald-trumps-deportation-machine/.

[111] Laurel Wamsley, "Taser Changes Its Name To Axon And Offers Free Body Cameras For Police," *NPR*, Arpil 7, 2017, http://www.npr.org/sections/thetwo-way/2017/04/07/522878573/we-re-more-than-stun-guns-says-taser-as-it-changes-company-name.

[112] "TASER Makes Two Acquisitions to Create 'Axon AI,'" *Police Magazine*, February 9, 2017, http://www.policemag.com/channel/technology/news/2017/02/09/taser-makes-two-acquisitions-to-create-axon-ai.aspx.

[113] Doug Wyllie, "What TASER's Acquisition of 2 AI Companies Means for the Future of Policing," *PoliceOne*, February 10, 2017, https://www.policeone.com/police-products/less-lethal/TASER/articles/289203006-What-TASERs-acquisition-of-2-AI-companies-means-for-the-future-of-policing/.

[114] Jay Stanley, "Police Body-Mounted Cameras: With Right Policies in Place, a Win for All," (ACLU, 2013), http://www.urbanaillinois.us/sites/default/files/attachments/police-body-mounted-cameras-stanley.pdf.

[115] Alex Pasternack, "Police Body Cameras Will Do More Than Just Record You," *Fast Company*, March 3, 2017, https://www.fastcompany.com/3061935/police-body-cameras-livestreaming-face-recognition-and-ai.

predictive methods of policing—inspired by Wal-Mart's and Google's embrace of deep learning to increase sales—raises new civil liberties concerns. Instead of purchasing patterns, these systems will be looking for much more vague, context-dependent targets, like "suspicious activity." Behind appearances of technical neutrality, these systems rely on deeply subjective assumptions about what constitutes suspicious behavior or who counts as a suspicious person.[116]

Unsurprisingly, machine vision techniques may reproduce and present as objective existing forms of racial bias.[117] Researchers affiliated with Google's Machine Intelligence Group and Columbia University make a compelling comparison between machine learning systems designed to predict criminality from facial photos and discredited theories of physiognomy—both of which problematically claim to be able to predict character or behavioral traits simply by examining physical features.[118] More generally, Cathy O'Neil identifies the potential for advanced AI systems in law enforcement to create a "pernicious feedback loop"—if these systems are built on top of racially-biased policing practices, then their training data will reflect these existing biases, and integrate such bias into the logic of decision making and prediction.[119]

Ethical questions of bias and accountability will become even more urgent in the context of rights and liberties as AI systems capable of violent force against humans are developed and deployed in law enforcement and military contexts. Robotic police officers, for example, recently debuted in Dubai.[120] If these were to carry weapons, new questions would arise about how to determine when the use of force is appropriate. Drawing on analysis of the Black Lives Matter movement, Peter Asaro has pointed to difficult ethical issues involving how lethal autonomous weapons systems (LAWS) will detect threats or gestures of cooperation, especially involving vulnerable populations. He concludes that AI and robotics researchers should adopt ethical and legal standards that maintain human control and accountability over these systems.[121]

Similar questions apply in the military use of LAWS. Heather Roff argues that fully autonomous systems would violate current legal definitions of war that require human judgment in the proportionate use of force, and guard against targeting of civilians. Furthermore, she argues that AI learning systems may make it difficult for commanders to even know how their weapons will respond in battle situations.[122] Given these legal, ethical

[116] Ava Kofman, "Taser Will Use Police Body Camera Videos 'to Anticipate Criminal Activity,'" *The Intercept*, April 30, 2017, https://theintercept.com/2017/04/30/taser-will-use-police-body-camera-videos-to-anticipate-criminal-activity/.

[117] Clare Garvie and Jonathan Frankle, "Facial-Recognition Software Might Have a Racial Bias Problem," *The Atlantic*, April 7, 2016, https://www.theatlantic.com/technology/archive/2016/04/the-underlying-bias-of-facial-recognition-systems/476991/.

[118] Blaise Agüera y Arcas, Margaret Mitchell and Alexander Todorov, "Physiognomy's New Clothes," *Medium*, May 7, 2017, https://medium.com/@blaisea/physiognomys-new-clothes-f2d4b59fdd6a.

[119] Kofman, "Taser Will Use Police Body Camera Videos 'to Anticipate Criminal Activity.'"

[120] Rory Cellan-Jones, "Robot Police Officer Goes on Duty in Dubai," *BBC News*, May 24, 2017, sec. Technology, http://www.bbc.com/news/technology-40026940.

[121] Peter Asaro, "'Hands Up, Don't Shoot!' HRI and the Automation of Police Use of Force," *Journal of Human-Robot Interaction* 5, No. 3 (December 14, 2016): 55–69.

[122] Heather M. Roff, "Meaningful Human Control or Appropriate Human Judgment? The Necessary Limits on Autonomous

and design concerns, both researchers call for strict limitations on the use of AI in weapons systems.

While predictive policing and the use of force have always been important issues, they take on new salience in populist or authoritarian contexts. As AI systems promise new forms of technical efficiency in the service of safety, we may need to confront a fundamental tension between technological efficiency and a commitment to ideals of justice.

AI and the Legal System

The legal system is the institution tasked with defending civil rights and liberties. Thus, there are two separate questions to consider regarding AI and the legal system: 1) Can the legal system serve the rights-protection functions it is expected to when an AI system produces an unfair result? And, 2) How and where (if at all) should the legal system incorporate AI?

Scholars like Kate Crawford and Jason Schultz have identified a series of conflicts between AI techniques and constitutional due process requirements,[123] such as how AI techniques affect procedural considerations and equal justice under the law. The proliferation of predictive systems demands new regulatory techniques to protect legal rights. Danielle Citron and Frank Pasquale argue that safeguards to rights should be introduced at all stages of the implementation of an AI system, from safeguarding privacy rights in data collection to public audits of scoring systems that critically affect the public in areas like employment and healthcare.[124]

In a similar vein, Andrew Selbst has argued that an impact assessment requirement can force those building and buying AI systems to make explicit the normative choices they are making before implementing them.[125] And as Lilian Edwards and Michael Veale[126] have pointed out, the new EU General Data Protection Regulation (GDPR) includes a requirement for data protection impact assessments, the import of which is unclear as yet. There is also a rapidly emerging scholarly debate about the value of requiring an explanation or interpretation of AI and machine learning systems as a regulatory technique to ensure individual rights,[127] how to operationalize such a requirement,[128] whether such a

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Weapons" (Geneva: Review Conference of the Convention on Certain Conventional Weapons, December 2016), https://globalsecurity.asu.edu/sites/default/files/files/Control-or-Judgment-Understanding-the-Scope.pdf.

[123] Kate Crawford and Jason Schultz, "Big Data and Due Process: Toward a Framework to Redress Predictive Privacy Harms," *Boston College Law Review* 55, No. 1 (January 29, 2014): 93.

[124] Danielle Keats Citron and Frank A. Pasquale, "The Scored Society: Due Process for Automated Predictions," *Washington Law Review* 89, No. 1 (2014): 1–33.

[125] Andrew D. Selbst, "Disparate Impact in Big Data Policing", Georgia Law Review, forthcoming 2017. SSRN preprint: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2819182.

[126] Lilian Edwards and Michael Veale, "Slave to the Algorithm? Why a 'Right to Explanation' is Probably Not the Remedy You are Looking for", SSRN preprint, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2972855.

[127] Ibid; Kiel Brennan-Marquez, "'Plausible Cause': Explanatory Standards in the Age of Powerful Machines, *Vanderbilt Law Review* (2017) vol. 70, p. 1249; Andrew D. Selbst, "A Mild Defense of Our New Machine Overlords," *Vanderbilt Law Review En Banc* (2017) vol. 70, p. 87; Katherine Jo Strandburg, "Decisionmaking, machine learning and the value of explanation," (The Human Use of Machine Learning: An Interdisciplinary Workshop, 16 December 2016), http://www.dsi.unive.it/HUML2016/assets/Slides/Talk%202.pdf.

requirement presently exists under the GDPR[129] and more generally how competing interpretations or explanations might be technically formulated and understood by different stakeholders.[130]

The criminal justice system's implementation of risk assessment algorithms provides an example of the legal system's use of AI and its attendant risks.[131] Proponents of risk-based sentencing argue that evidence-based machine learning techniques can be used in concert with the expertise of judges to improve the accuracy of prior statistical and actuarial methods for risk forecasting, such as regression analysis.[132] Along these lines, a recent study by computer scientist Jon Kleinberg, Sendhil Mullainathan, and their co-authors showed that a predictive machine learning algorithm could be used by judges to reduce the number of defendants held in jail as they await trial by making more accurate predictions of future crimes.[133]

While algorithmic decision-making tools show promise, many of these researchers caution against misleading performance measures for emerging AI-assisted legal techniques.[134] For example, the value of recidivism as a means to evaluate the correctness of an algorithmically-assigned risk score is questionable because judges make decisions about risk in sentencing, which, in turn, influences recidivism – or, those assessed as "low risk" and subsequently released are the only ones who will have an opportunity to re-offend, making it difficult to measure the accuracy of such scoring. Meanwhile, Rebecca Wexler has documented the disturbing trend of trade secret doctrine being expressly adopted in courts to prevent criminal defendants from asserting their rights at trial.[135]

Sandra Mayson has recently written on risk assessment in the bail reform movement. Well-intentioned proponents of bail reform argue that risk assessment can be used to spare poor, low-risk defendants from onerous bail requirements or pretrial incarceration. Such arguments tend to miss the potential of risk assessment to "legitimize and entrench" problematic reliance on statistical correlation, and to "[lend such assessments] the aura of scientific reliability."[136] Mayson argues that we also need to ask deeper questions about

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[128] Andrew D. Selbst and Solon Barocas, "Regulating Inscrutable Systems," in progress.

[129] Bryce Goodman and Seth Flaxman, "European Union regulations on algorithmic decision-making and a 'right to explanation,'" ICML Workshop on Human Interpretability in Machine Learning, *arXiv preprint*: arXiv:1606.08813 (v3) (2016); forthcoming, *AI Magazine* (2017); Sandra Wachter, Brent Mittelstadt and Luciano Floridi, "Why a right to explanation of automated decision-making does not exist in the General Data Protection Regulation," *International Data Protection Law* (2017), https://doi.org/10.1093/idpl/ipx005.

[130] Zachary C. Lipton, "The Mythos of Model Interpretability," arXiv preprint [Cs, Stat], June 10, 2016, http://arxiv.org/abs/1606.03490.

[131] Richard Berk and Jordan Hyatt, "Machine Learning Forecasts of Risk to Inform Sentencing Decisions," *Federal Sentencing Reporter* 27, No. 4 (April 1, 2015): 222–28, doi:10.1525/fsr.2015.27.4.222.

[132] Berk and Hyatt, "Machine Learning Forecasts of Risk to Inform Sentencing Decisions," 222.

[133] Jon Kleinberg et al., "Human Decisions and Machine Predictions," Working Paper (National Bureau of Economic Research, February 2017), doi:10.3386/w23180. http://nber.org/papers/w23180.

[134] Jon Kleinberg, Jens Ludwig and Sendhil Mullainathan, "A Guide to Solving Social Problems with Machine Learning," *Harvard Business Review*, December 8, 2016, https://hbr.org/2016/12/a-guide-to-solving-social-problems-with-machine-learning.

[135] Rebecca Wexler, "Life, Liberty, and Trade Secrets: Intellectual Property in the Criminal Justice System," SSRN preprint: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2920883.

[136] Sandra G. Mayson, "Bail Reform and Restraint for Dangerousness: Are Defendants a Special Case?",*SSRN Scholarly Paper*

how pretrial restraints are justified in the first place. In other words, policymakers who hope to employ risk assessment in bail reform and pretrial forms of detention need to publicly specify what types of risks can justify these such restraints on liberty, as defendants receiving these scores have not been convicted of anything and these restraints are not imposed on dangerous individuals in the rest of society.

Separately, criminologist Richard Berk and his colleagues argue that there are intractable tradeoffs between accuracy and fairness—the occurrence of false positives and negatives—in populations where base rates (the percentage of a given population that fall into a specific category) vary between different social groups.[137] Difficult decisions need to be made about how we value fairness and accuracy in risk assessment. It is not merely a technical problem, but one that involves important value judgments about how society should work. Left unchecked, the legal system is thus as susceptible to perpetuating AI-driven harm as any other institution.

Finally, machine learning and data analysis techniques are also being used to identify and explain the abuses of rights. Working with human rights advocates in Mexico, the Human Rights Data Analysis Group created a machine learning model that can help guide the search for mass graves.[138]

AI and Privacy

AI challenges current understandings of privacy and strains the laws and regulations we have in place to protect personal information. Established approaches to privacy have become less and less effective because they are focused on previous metaphors of computing, ones where adversaries were primarily human. AI systems' intelligence, as such, depends on ingesting as much training data as possible. This primary objective is adverse to the goals of privacy. AI thus poses significant challenges to traditional efforts to minimize data collection and to reform government and industry surveillance practices.

Of course, privacy as a "right" has always been unevenly distributed. Rights-based discourses are regularly critiqued as being disproportionately beneficial to the privileged while leaving many vulnerable populations partially or entirely exposed. Yet what is different with AI and privacy is that while individualistic and rights-based conceptualizations of privacy remain important to some of the systems at work today, computational systems are now operating outside of the data collection metaphors that privacy law is built on. We are in new terrain, and one that 20th century models of privacy are not designed to contend with.

For example, privacy discourse has not sufficiently accounted for the growing power asymmetries between the institutions that accumulate data and the people who generate

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(Rochester, NY: Social Science Research Network, August 15, 2016), https://papers.ssrn.com/abstract=2826600, 2.

[137] Richard Berk, Hoda Heidari, Shahin Jabbari, Michael Kearns and Aaron Roth, "Fairness in Criminal Justice Risk Assessments: The State of the Art," arXiv:1703.09207, March 27, 2017.

[138] J. M. Porup, "Hunting for Mexico's Mass Graves with Machine Learning," Ars Technica UK, April 17, 2017, https://arstechnica.co.uk/information-technology/2017/04/hunting-for-mexicos-mass-graves-with-machine-learning/.

that data, even as they are approaching threshold levels which may make these asymmetries very hard to reverse. Models of privacy based on data as a tradable good fail to contend with this power difference. People cannot trade effectively with systems they do not understand, particularly when the system understands them all too well and knows how to manipulate their preferences. Additionally, adaptive algorithms are changing constantly, such that even the designers who created them cannot fully explain the results they generate. In this new model of computational privacy adversaries, both power and knowledge gaps will continue to widen. We must ask how 'notice and consent' is possible or what it would mean to have 'access to your data' or to 'control your data' when so much is unknown or in flux.

There has also been a shift in the quality of the data used for AI. In order to help develop sophisticated diagnostic models, designers often seek to use inputs that are extremely sensitive in nature. For example, in the case of DeepMind's partnership with the UK's National Health Service, the company acquired large amounts of very sensitive public health data. Even though this data may have been required for some of the project's goals, the resulting backlash and government censure[139] illustrate the emerging tensions related to the AI industry's use of such data and the current limits of democratic processes to address questions of agency, accountability and oversight for these endeavors.

The expansion of AI into diverse realms like urban planning also raises privacy concerns over the deployment of IoT devices and sensors, arrayed throughout our daily lives, tracking human movements, preferences and environments.[140] These devices and sensors collect the data AI requires to function in these realms. Not only does this expansion significantly increase the amount and type of data being gathered on individuals, it also raises significant questions around security and accuracy as IoT devices are notoriously insecure, and often difficult to update and maintain.[141]

AI's capacity for prediction and inference also adds to the set of privacy concerns. Much of the value that AI offers is the ability to predict or "imagine" information about individuals and groups that is otherwise difficult to collect, compute or distribute. As more AI systems are deployed and focus on ever-more granular levels of detail, such "predictive privacy harms" will become greater concerns, especially if there are few or no due process constraints on how such information impacts vulnerable individuals.[142] Part of the promise of predictive techniques is to make accurate, often intimate deductions based on a seemingly-unrelated pieces of data or information, such as detecting substance abusers from Facebook posts[143], or identifying gang members based on Twitter data.[144] Significant

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[139] Information Commissioner's Office, "Royal Free - Google DeepMind trial failed to comply with data protection law," July 3 (2017) https://ico.org.uk/about-the-ico/news-and-events/news-and-blogs/2017/07/royal-free-google-deepmind-trial-failed-to-comply-with-data-protection-law/

[140] See, for example, Nvida's Deep Learning for Smart Cities: https://www.nvidia.com/en-us/deep-learning-ai/industries/ai-cities/

[141] There have been several serious attacks on network infrastructure and logistics from hacked IoT networked devices in the last 12 months. For example: Andrew Peterson, "Internet of Things compounded Friday's hack of major web sites," *Washington Post,* October 21 (2016)

[142] Kate Crawford and Jason Schultz, "Big Data and Due Process: Toward a Framework to Redress Predictive Privacy Harms," *Boston College Law Review* 55, No. 1 (January 29, 2014): 93.

[143] Tao Ding, Warren Bickel and Shimei Pan, "Social Media-based Substance Use Prediction," May 16 (2017)

shifts are needed in the legal and regulatory approaches to privacy if they are to keep pace with the emerging capacities of AI systems.

Ethics and Governance

So far, this report has addressed issues of power, markets, bias, fairness and rights and liberties – all subjects closely tied to ethics. This section presents a distinct discussion of ethics in the uses, deployment and creation of AI.[145]

Ethical questions surrounding AI systems are wide-ranging, spanning creation, uses and outcomes. There are important questions about which set of values and interests are reflected in AI, as well as how machines can recognize values and ethical paradigms. An important distinction in this area is between what is called 'machine ethics' and the wider domain of the ethics of AI. Machine ethics is more narrowly and explicitly concerned with the ethics of artificially intelligent beings and systems; Isaac Asimov's laws of robotics are one example that captured the popular imagination. AI ethics concerns wider social concerns about the effects of AI systems and the choices made by their designers and users. Here, we are mostly concerned with the latter approach.

AI is certainly not unique among emerging technologies in creating ethical quandaries, and, similar to other computational technologies, AI ethics have roots in the complex history of military influence on computing development and the more recent commercialization and corporate dominance of networked technologies. Yet ethical questions in AI research and development present unique challenges in that they ask us to consider whether, when and how machines should to make decisions about human lives - and whose values should guide those decisions.

Ethical Concerns in AI

Articulating ethical values for AI systems has never been simple. In the 1960s, AI pioneer Joseph Weizenbaum created the early chatbot system ELIZA as a technical demonstration of a system capable of maintaining an interrogative "conversation" with a human counterpart. Rudimentary as it was by today's standards, some psychologists adopted it as a tool for treatment, much to the creator's concern and dismay. In response, Weizenbaum raised ethical concerns around our reflexive reliance and trust in automated systems that may appear to be objective and "intelligent," but are ultimately simplistic and prone to error.[146]

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https://arxiv.org/abs/1705.05633

[144] See Lakshika Balasuriya et al., "Finding Street Gang Members on Twitter," 2016 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM 2016) http://knoesis.wright.edu/sites/default/files/ASONAM2016_GANG_MEMBER_IDENTIFICATION_LAKSHIKA.pdf

[145] Vincent Conitzer, Walter Sinnott-Armstrong, Jana Schaich Borg, Yuan Deng and Max Kramer, "Moral Decision Making Frameworks for Artificial Intelligence," (Association for the Advancement of Artificial Intelligence, 2017).

[146] Hans Pruijt, "Social Interaction With Computers: An Interpretation of Weizenbaum's ELIZA and Her Heritage," *Social science computer review* 24, No. 4 (2006): 516-523; Joseph Weizenbaum, *Computer power and human reason: From judgement to calculation,* Harmondsworth, UK: Penguin, 1984.

Currently there are heated debates about whether AI systems should be used in sensitive or high-stakes contexts, who gets to make these important decisions , and what the proper degree of human involvement should be in various types of decision-making.[147] These are ethical questions with a longstanding history. In examining these questions, we must also look at the power dynamics of current AI development and deployment – and the way in which decision-making, both by AI systems and the people who build them, is often obscured from public view and accountability practices.

Just in the last year, we've learned how Facebook mines user data to reveal teenagers' emotional state for advertisers, specifically targeting depressed teens.[148] Cambridge Analytica, a controversial data analytics firm that claims to be able to shift election results through micro-targeting, has been reported to have expansive *individual* profiles on 220 million adult Americans,[149] and fake news has been instrumented to gain traction within algorithmically filtered news feeds and search rankings in order to influence elections.[150] There are now multiple approaches for using machine learning techniques to synthesize audio- and video-realistic representations of public figures and news events.[151] Each of these examples shows how the interests of those deploying advanced data systems can overshadow the public interest, acting in ways contrary to individual autonomy and collective welfare, often without this being visible at all to those affected.[152]

AI Reflects Its Origins

The U.S. military has been one of the single most influential institutions in shaping modern AI, with DARPA's funding of AI being among the most visible.[153] Indeed, AI has historically been shaped largely by military goals, with its capabilities and incentives defined by military objectives and desires.[154] AI development continues to be supported by DARPA and other national defense agencies, particularly in the area of lethal autonomous weapons systems, as discussed above.

However, current research into AI technology is highly industry-driven, with proprietary systems supplementing military-funded classified systems and AI research increasingly

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[147] Sue Newell and Marco Marabelli, "Strategic opportunities (and challenges) of algorithmic decision-making: A call for action on the long-term societal effects of 'datification'," *The Journal of Strategic Information Systems* 24, No. 1 (2015): 3-14.

[148] Darren Davidson, "Facebook targets 'insecure' young people," The Australian, May 1, 2017.

[149] Hannes Grassegger and Mikael Krogerus, "TheData That Turned the World Upside Down," *Motherboard*, 2017, https://publicpolicy.stanford.edu/news/data-turned-world-upside-down.

[150] Chengcheng Shao, Giovanni Luca Ciampaglia, Alessandro Flammini and Filippo Menczer, "Hoaxy: A platform for tracking online misinformation," In *Proceedings of the 25th International Conference Companion on World Wide Web*, pp. 745-750. International World Wide Web Conferences Steering Committee, 2016.

[151] Simon Adler, "Breaking News," Radiolab, July 27, 2017, http://www.radiolab.org/story/breaking-news/.

[152] Kate Crawford and Meredith Whittaker, "Artificial Intelligence is Hard to See," *Medium*, September 11, 2016, : https://medium.com/@katecrawford/artificial-intelligence-is-hard-to-see-a71e74f386db.

[153] Sidney G Reed, Richard H. Van Atta and Seymour J. Dietman, "DARPA Technical Accomplishments: An Historical Review of Selected DARPA Projects," Defense Advanced Research Projects Agency, Vol. 1, 1990.
Sidney G Reed, Richard H. Van Atta and Seymour J. Dietman, "DARPA Technical Accomplishments: An Historical Review of Selected DARPA Projects," Defense Advanced Research Projects Agency, Vol. 2, 1991.

[154] Alex Roland and Philip Shiman, *Strategic computing: DARPA and the quest for machine intelligence, 1983-1993*, (MIT Press, 2002).

taking place in closed-door industry settings, often without peer review or oversight. Accordingly, user consent, privacy and transparency are often overlooked in favor of frictionless functionality that supports profit-driven business models based on aggregated data profiles.[155] While there are those advocating for clearer laws and policies, the ambiguous space in which information rights are governed does not clearly regulate in favor of individual control over personal technologies or online services.[156]

The make up of AI researchers – what is and is not considered "AI research" – also has a history which influences the current state of AI and its ethical parameters. Beginning with the Dartmouth Conference in 1956, AI researchers established a male-dominated, narrowly-defined community. The boundaries of participation in the AI community were relatively closed, and privileged mathematics, computer science and engineering over perspectives that would provide for a more rigorous discussion of AI's ethical implications.[157] Producing technologies that work within complex social realities and existing systems requires understanding social, legal and ethical contexts, which can only be done by incorporating diverse perspectives and disciplinary expertise.

Ethical Codes

While decades of AI research have cited Asimov's three laws of robotics,[158] and some applied AI systems have been designed to comply with biomedical ethics,[159] the tools that have been available to developers to contend with social and ethical questions have been relatively limited. Ethical codes are gradually being developed in the AI research space, as we discuss below, but they are necessarily incomplete: they will always need to evolve in ways that are sensitive to the rapidly changing contexts and conditions in which AI systems are deployed. These codes constitute one form of soft governance, where industry standards and technical practices serve as alternatives to more traditional "hard" forms of government regulation and legal oversight of AI. As AI systems are woven through a growing number of domains, the needs for such a contextually-anchored approach to ethics and governance only grows.[160]

Two related problems have emerged: there is no tracking of adherence to ethical guidelines or soft governance standards in the AI industry, and we have not developed ways to link the adherence to ethical guidelines to the ultimate impact of an AI systems in

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[155] Elaine Sedenberg and Ann Lauren Hoffmann, "Recovering the History of Informed Consent for Data Science and Internet Industry Research Ethics" (September 12, 2016). Available at SSRN: https://ssrn.com/abstract=2837585.

[156] United States (2016) Executive Office of the President and Jason Furman, John P. Holdren, Cecilia Muñoz, Megan Smith and Jeffery Zients, "Artificial Intelligence, Automation, and the Economy," Technical report, National Science and Technology Council, Washington D.C. 20502, October 2016, https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/documents/Artificial-Intelligence-Automation-Economy.PDF.

[157] Nils J Nilsson, *The quest for artificial intelligence*, (Cambridge University Press, 2009).

[158] Susan Leigh Anderson, "Asimov's "three laws of robotics" and machine metaethics," *Ai & Society* 22, No. 4 (2008): 477-493.

[159] Raymond Heatherly, "Privacy and security within biobanking: The role of information technology," *The Journal of Law, Medicine & Ethics* 44, No. 1 (2016): 156-160.

[160] Robert Rosenberger, "Phenomenological Approaches to Technological Ethics," *The Ethics of Technology: Methods and Approaches* (2017): 67.

the world.

Examples of intertwined practice and ethics can be found in the biomedical uses of AI. Bioethics already offers a series of standards, values and procedures,[161] along with enforcement and accountability mechanisms. But how these should apply to medical AI systems is often unclear, and researchers have been tracking the disparities.[162] This is also true of privacy requirements, which, given modern AI's capability to make very personal inferences given only limited data, are increasingly insufficient.[163] Where ethical standards aimed at protecting patient privacy have been proposed, some biomedical researchers have rejected them, seeing them as an impediment to innovation.[164]

A more intentional approach to ethics is needed, and some are working toward this. Teaching ethics to practitioners is one such example.[165] The Blue Sky Agenda for AI Education, a collection of ideas for ethics education in AI, seeks democratization of AI education and emphasizes inclusiveness in development toward the goal of respecting the values and rights of diverse populations.[166] But education is not enough. Opportunities must open up for ethics to be integrated in early stage design, and incentives for designing and implementing AI ethically must be built into the companies and institutions currently driving development.

Ethical values and norms around accountability,[167] social and political responsibility, inclusion and connectivity,[168] legibility and security and privacy[169] are embedded in every system via their default settings, whether intentionally or not.[170] Often, these invisibly-embedded values reflect the status quo, the context and interests of their developers, and matters of convenience and profit. Once set, these implicit values are hard to change for a variety of reasons,[171] even as they tend to shape the capabilities and roles of systems within various lived contexts.[172] Ethical codes should work to ensure that these

[161] Stephen Brotherton, Audiey Kao, and B. J. Crigger, "Professing the values of medicine: the modernized AMA Code of Medical Ethics," *JAMA* 316, No. 10 (2016): 1041-1042.

[162] Jake Metcalf and Kate Crawford, "Where are human subjects in big data research? The emerging ethics divide," *Big Data & Society* 3.1 (2016): http://journals.sagepub.com/doi/pdf/10.1177/2053951716650211

[163] Stephen J Tipton, Sara Forkey and Young B Choi, "Toward Proper Authentication Methods in Electronic Medical Record Access Compliant to HIPAA and CIA Triangle," *Journal of medical systems* 40, No. 4 (2016): 1-8.

[164] Wendy Lipworth and Renata Axler, "Towards a bioethics of innovation," *Journal of medical ethics* (2016): medethics-2015.

[165] Judy Goldsmith and Emanuelle Burton, "Why Teaching Ethics to AI Practitioners Is Important," (2017).

[166] Eric Eaton, Sven Koenig, Claudia Schulz, Francesco Maurelli, John Lee, Joshua Eckroth, Mark Crowley, Richard G. Freedman, Rogelio E. Cardona-Rivera, Tiago Machado and Tom Williams, "Blue Sky Ideas in Artificial Intelligence Education from the EAAI 2017 New and Future AI Educator Program," *arXiv preprint arXiv:1702.00137* (2017).

[167] Wendell Wallach, *A Dangerous Master: How to keep technology from slipping beyond our control*, (Basic Books, 2014).

[168] Anna Lauren Hoffmann, Nicholas Proferes and Michael Zimmer, ""Making the world more open and connected": Mark Zuckerberg and the discursive construction of Facebook and its users." *new media & society* (2016): 1461444816660784.

[169] John Wilbanks, "Public domain, copyright licenses and the freedom to integrate science," *Public Communication of Science and Technology* 25 (2016): 11.

[170] Ian Kerr, "The Devil is in the Defaults," *Critical Analysis of Law* 4, No. 1 (2017).

[171] Dylan Wesley Mulvin, "Embedded dangers: The history of the year 2000 problem and the politics of technological repair," A*oIR Selected Papers of Internet Research* 6 (2017).

[172] Narendra Kumar, Nidhi Kharkwal, Rashi Kohli and Shakeeluddin Choudhary, "Ethical aspects and future of artificial intelligence," (In *Innovation and Challenges in Cyber Security (ICICCS-INBUSH), 2016 International Conference on*, pp. 111-114), IEEE, 2016.

values are expressly designed into AI systems through processes of open and well-documented decision-making that center the populations who will be most affected.

While nascent, efforts to address these concerns have emerged in recent years. A series of White House reports under President Obama examined tensions between social interests and ethical values on one hand, and business and industry objectives on the other.[173] Recent soft governance efforts from IEEE,[174] The Future of LIfe Institute,[175] the ACM[176] and the Oxford Internet Institute[177] have produced principles and codes of ethics for AI. Perspectives from diverse industry and intellectual leaders are often reflected in these documents. While these are positive steps, they have real limitations. Key among these is that they share an assumption that industry will voluntarily begin to adopt their approaches. They rarely mention the power asymmetries that complicate and underlie terms like "social good," and the means by which such a term would be defined and measured. The codes are necessarily limited in what they address, how much insider information they have access to and what mechanisms would be used for monitoring and enforcement.[178] While these efforts set moral precedents and start conversations,[179] they provide little to help practitioners in navigating daily ethical problems in practice[180] or in diagnosing ethical harms,[181] and do little to directly change ethics in the design and use of AI.[182]

Challenges and Concerns Going Forward

Current framings of AI ethics are failing partly because they rely on individual responsibility, placing the onus of appropriate information flow with users and concentrating decision-making power in individual AI developers and designers.[183] In order to achieve ethical AI systems in which their wider implications are addressed, there must be

[173] United States (2016) Executive Office of the President and M. Holden, J.P. and Smith. "Preparing for the future of artificial intelligence," Technical report, National Science and Technology Council, Washington D.C. 20502, October 2016, https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf.

[174] IEEE, "Ethically Aligned Design: A Vision for Prioritizing Human Wellbeing with Artificial Intelligence and Autonomous Systems," The IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems, December 13, 2016, http://standards.ieee.org/develop/indconn/ec/ead_v1.pdf.

[175] "Asilomar AI Principles," 2017, https://futureoflife.org/ai-principles/.

[176] ACM, "Code 2018," version 2, 2017, https://ethics.acm.org/2018-code-draft-2/.

[177] Mike Wooldridge, Peter Millican, and Paula Boddington, "Towards a Code of Ethics for Artificial Intelligence Research," Oxford, 2017 https://www.cs.ox.ac.uk/efai/towards-a-code-of-ethics-for-artificial-intelligence/.

[178] Bo Brinkman, Catherine Flick, Don Gotterbarn, Keith Miller, Kate Vazansky and Marty J. Wolf, "Listening to professional voices: draft 2 of the ACM code of ethics and professional conduct," *Communications of the ACM* 60, No. 5 (2017): 105-111.

[179] Eugene Schlossberger, "Engineering Codes of Ethics and the Duty to Set a Moral Precedent," *Science and engineering ethics* 22, No. 5 (2016): 1333-1344.

[180] Stuart Ferguson, Clare Thornley and Forbes Gibb, "Beyond codes of ethics: how library and information professionals navigate ethical dilemmas in a complex and dynamic information environment," *International Journal of Information Management* 36, No. 4 (2016): 543-556.

[181] Christian Sandvig, Kevin Hamilton, Karrie Karahalios and Cedric Langbort, "Automation, Algorithms, and Politics| When the Algorithm Itself is a Racist: Diagnosing Ethical Harm in the Basic Components of Software," *International Journal of Communication* 10 (2016): 19.

[182] Mike Ananny, "Toward an ethics of algorithms: Convening, observation, probability, and timeliness," *Science, Technology, & Human Values* 41, No. 1 (2016): 93-117.

[183] Florencia Marotta-Wurgler, "Self-Regulation and Competition in Privacy Policies." *The Journal of Legal Studies* 45, No. S2 (2016): S13-S39.

institutional changes to hold power accountable.[184] Yet, there are obvious challenges to this approach, such as disagreement about the risks of AI,[185] the potential for greenwashing ethical AI as a superficial marketing strategy rather than a substantive commitment,[186] the practical challenges of stopping unethical AI research designed to privilege the interests of a few over the many[187] and the current economic system within which the incentives driving AI development are embedded. In addition, the effective invisibility of many of these systems to the people on whom they act, the obscurity of their algorithmic mechanisms, the ambiguity of their origins and their inescapable pervasiveness make public discourse difficult and opting-out impossible.[188] The responsibility to strive for better outcomes thus falls squarely on creators and regulators, who are only beginning to establish dialogue[189] even as there are few incentives for change and significant tension between ethics and "compliance."[190]

This brings us to the wider political landscape in which AI is being created in the U.S.: how will the Trump administration affect the use of these technologies? Prior to the election, over 100 technology sector leaders articulated their priorities: "freedom of expression, openness to newcomers, equality of opportunity, public investments in research and infrastructure and respect for the rule of law. We embrace an optimistic vision for a more inclusive country where American innovation continues to fuel opportunity, prosperity and leadership."[191] President Trump's policies do not reflect these priorities. Rather, there has been significant defunding of research, an increase in deportations, and heightened screening of personal communications and social media at national borders, among many other concerning policy shifts. Simply put, it does not appear that the current administration can be counted on to support the creation and adoption of ethical frameworks for AI.

[184] Ira S. Rubinstein, "The Future of Self-Regulation is Co-Regulation" (October 5, 2016). The Cambridge Handbook of Consumer Privacy, From Cambridge University Press (Forthcoming). Available at SSRN: https://ssrn.com/abstract=2848513.

[185] Vincent C Müller, ed. *Risks of artificial intelligence*. CRC Press, 2016.

[186] Michael Stocker, "Decision-making: Be wary of 'ethical' artificial intelligence," *Nature* 540, No. 7634 (2016): 525-525.

[187] Federico Pistono and Roman V. Yampolskiy, "Unethical Research: How to Create a Malevolent Artificial Intelligence," *arXiv preprint arXiv:1605.02817* (2016).

[188] Jatin Borana, "Applications of Artificial Intelligence & Associated Technologies." *Proceeding of International Conference on Emerging Technologies in Engineering, Biomedical, Management and Science [ETEBMS-2016]* 5 (2016): 64-67; Ira S. Rubinstein, "Big Data: The End of Privacy or a New Beginning?." *International Data Privacy Law* (2013): ips036; Fred Turner. "Can we write a cultural history of the Internet? If so, how?." Internet Histories 1, No. 1-2 (2017): 39-46.

[189] Kate Darling and Ryan Calo, "Introduction to Journal of Human-Robot Interaction Special Issue on Law and Policy," Journal of Human-Robot Interaction 5, No. 3 (2016): 1-2.

[190] Kate Crawford and Ryan Calo, "There is a blind spot in AI research," *Nature* 538 (2016): 311-313; Gary E Merchant and Wendell Wallach, *Emerging Technologies: Ethics, Law and Governance,* (Ashgate Publishing, 2017).

[191] Marvin Ammori, Adrian Aoun, Greg Badros, Clayton Banks, Phin Barnes, Niti Bashambu, et al., "An open letter from technology sector leaders on Donald Trump's candidacy for President," 2016, https://shift.newco.co/an-open-letter-from-technology-sector-leaders-on-donald-trumps-candidacy-for-president-5bf734c159e4.

Conclusion

AI systems are now being adopted across multiple sectors, and the social effects are already being felt: so far, the benefits and risks are unevenly distributed. Too often, those effects simply happen, without public understanding or deliberation, led by technology companies and governments that are yet to understand the broader implications of their technologies once they are released into complex social systems. We urgently need rigorous research that incorporates diverse disciplines and perspectives to help us measure and understand the short and long-term effects of AI across our core social and economic institutions.

Fortunately, more researchers are turning to these tasks all the time. But research is just the beginning. Advocates, members of affected communities and those with practical domain expertise should be included at the center of decision making around how AI is deployed, assessed and governed. Processes must be developed to accommodate and act on these perspectives, which are traditionally far removed from engineering and product development practices. There is a pressing need now to understand these technologies in the context of existing social systems, to connect technological development to social and political concerns, to develop ethical codes with force and accountability, to diversify the field of AI and to integrate diverse social scientific and humanistic research practices into the core of AI development. Only then can the AI industry ensure that its decisions and practices are sensitive to the complex social domains into which these technologies are rapidly moving.

TAB 10

GSG(2017)1

GLOBAL STRATEGY GROUP

Global Strategy Group

UNPRECEDENTED UNPREDICTABILITY: DIGITAL TRANSFORMATION - THE FUTURE OF JOBS AND TRADE IN A DIGITALISED WORLD

Discussion notes for the 2017 Global Strategy Group

28-29 November 2017, Paris.

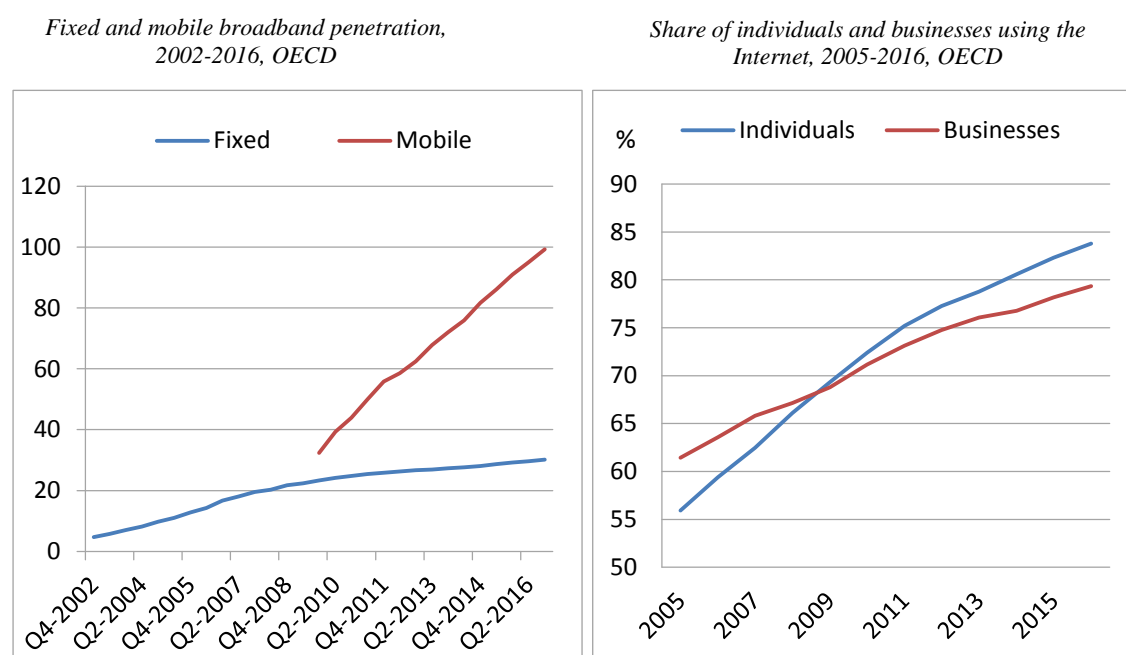JT03422886

Introduction: Setting the Scene

1.   Starting in the back-offices of businesses, the digital transformation has already been under way for about half a century, yet it is only now that it has risen to the top of the policy agenda. In 2016, 83% of adults in the OECD area accessed the Internet (Figure 1) and 95% of firms in OECD countries had a high-speed connection to the Internet. Another distinguishing feature of the era is the invention and global surge of smartphones – today, there are 99 mobile broadband subscriptions per 100 people in the OECD, almost one per person (Figure 1) with OECD mobile data use surging by 37% between 2015 and 2016. The fact that most people now own a constantly connected super-computer (equivalent to a super-computer from the mid-1990s) shifts the impact from the economy to broader society.

2.   As a "general purpose technology" akin to electricity, digital technologies have induced a digital transformation which already affects the way the economy and society operates. Ongoing shifts can be categorised into "vectors" that propel change in: 1) the scale, scope and speed of business; 2) the ownership, assets and economics of value generation; and 3) the nature of relationships, the operation of markets and the formation of digital ecosystems.[1] Changes in scale, scope and speed are the result of converting information into digital bits that can be processed and analysed by computers. This process has become exponentially cheaper and faster and affects the nature of assets that generate value, how ownership is imparted and where value is generated. In turn, these changes affect the structure and operation of markets, allow the formation of platforms and ecosystems and ultimately affect how relationships – both economic and social – are developed, maintained and located. Data, which is processed through software and transmitted over networks, is a key driver that underpins these changes.

3.   The digital transformation creates unprecedented opportunities for productivity growth, environmental protection and improved well-being. At the same time, it raises new issues for inclusive growth and ensuring that digitalisation does not increase inequalities in well-being. Related concerns range from how to address the impact of screens on children, to issues about competition raised by the network effects in some parts of the digital industry and the rise of data as a tool for gaining competitive advantage, how to maintain equality before taxation across companies, or avoid or mitigate the potential threats to individuals' privacy and the arrival of new security risks.

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[1] See "Vectors of Digital Transformation", DSTI/CDEP/GD(2017)4/REV1, prepared under the Going Digital project.

Figure 1. The growth of digital connectivity across the OECD

*Fixed and mobile broadband penetration,
2002-2016, OECD*

*Share of individuals and businesses using the
Internet, 2005-2016, OECD*

Source: OECD, Broadband Portal, http://oe.cd/broadband, and estimates based on OECD, ICT usage databases for households and businesses: http://oe.cd/hhind and http://oe.cd/bus.

4.   Many benefits of the digital revolution are accruing to those towards the bottom of the income distribution and excluded or marginalised. For example, digital tools have made possible services like mobile payments that allow disadvantaged populations to be banked and gain access to government services, reducing disparities. And the Internet can be a powerful democratising device, making an essentially limitless amount of information available to virtually everyone. At the same time, however, the digital revolution can be the source of new divides or exacerbate existing ones. Notably, as the connectivity gap diminishes for the OECD, new gaps are emerging based on the ability of businesses and individuals to actively exploit the new functionalities of digital tools. This gap may be fuelling a split in productivity gains between the frontier firms and others, which may in turn be a contributing factor to income inequality.

5.   While progress is being made, there is some urgency to ensure that an inclusive foundation for the digital era is set as we embark on another stage of transformation that involves the deployment of interconnected things and people with networked devices generating constant flows of data. These ("Big") data can be analysed using powerful new tools which in turn can feed machine learning and further progress in artificial intelligence. This combinatorial innovation will redefine competitiveness across a wide cross-section of industries and businesses, and it is incumbent upon policy to use this shift to reduce differences and address long standing policy challenges, rather than to accentuate existing gaps and problems.

6.   In this sense, the digital transformation does not affect governments' fundamental policy objectives such as the need for quality jobs, good health, more equal opportunities, or clean air, but it does affect how these goals can be achieved. In transportation for instance, policy must now factor in automated vehicles that provide new opportunities, as

well as risks. In education, the digital transformation has the potential to make life-long learning accessible to everyone. And with respect to taxation, the digital transformation raises fundamental questions about longstanding tax principles, at the same time as potentially helping tax administrations broaden the base for tax revenues.

7. The digital transformation is a particularly difficult challenge for governments for several reasons. First, there is the speed at which the transformation is happening, making it hard for policy to keep up. The industrial revolution took place over the course of a century, but the digital revolution, and especially the current phase, has been underway for less than a generation and may be accelerating. The second issue is the rise of new digital intermediaries or platforms that are displacing old intermediaries and redefining markets and relationships more broadly. Due to the economies of scale and network externalities inherent in digital businesses, these platforms are currently controlled by a handful of firms. Nevertheless, they are also shaping a new space for entrepreneurial decisions, strategies and business models, whose implications are still unfolding. Thirdly, the virtual nature of these platforms means that they can have a near global presence with a very small physical footprint. This complicates traditional standard policies based on national boundaries such as taxation, country-of-origin or physical-presence requirements governing trade and the concept of relevant market in competition policy. These factors underscore the multi-disciplinary nature of digital transformation, which requires policymaking to rise above today's policy silos and work across governmental and national boundaries. The lack of an integrated approach to the digital transformation increases the risk that policies in one area will have unintended, and possibly adverse, impacts on another, or that opportunities for synergies that enhance positive effects will be missed.

8. There is uncertainty on how the digital transformation will unfold, but it is clear that governments can use digital tools to improve policy design, deployment and evaluation while still adhering to legitimate restrictions to protect privacy and enhance security. Moreover, they can help shape the digital transformation so that it supports core policy objectives and helps improve people's lives. With the ongoing development of digital technologies (i.e. the so-called "Internet of Things") and new techniques (e.g. machine learning and artificial intelligence), policy makers must work to ensure that the opportunities offered by the digital transformation are used to improve the well-being of all citizens. This requires understanding the challenges, working collectively to learn from each other, engaging with stakeholders including civil society to build consensus, and devising policies that help workers and citizens in adjusting to the transition, ensuring that these changes do not come at the cost of inclusion.

9. In this regard, the global reach of the Internet and the characteristics of the digital era in turn may require a global, multi-stakeholder approach to achieving policy objectives. For example, the proliferation of embedded sensors in many objects ("Internet of Things") which generate data provides an ability to monitor the environment, optimise traffic, improve agricultural yields and measure changes in the ocean (e.g. stocks of fish), amongst other possibilities. Realising these opportunities for the benefit of all will require large cross-border data flows, which can be analysed, interpreted and acted on by individual entities (i.e. countries, international organisations, firms). These expanded data flows will underscore the need for new multilateral approaches that embrace the digital era and the new solutions it makes possible. For instance, expanding approaches based on interoperability among policy regimes, such as the one between the US and Europe on transborder flows of personal data (first agreed as a "safe harbour" agreement and now revised as the EU-US "privacy shield") are more compatible with the digital era.

Such approaches may help avoid fragmentation of the network and serve to maintain network openness and the economic and social gains this brings.

10. As borders become more porous due to the digital era, new multilateral agreements may also be needed for previously "domestic" rules such as competition policy, labour tax allocation and the provisioning of public services, potentially necessitating rethinking how these policies are administered. In this regard, large digital firmss are beginning to match or exceed the public role once played by the post office, public broadcasting, civil defence agencies, libraries or public meeting places, by providing basic public services like maps, libraries, public video, mail, messaging, emergency messages and employment offers. In other cases, dominant global platforms may be asked by governments to help in the implementation of public policies on the behalf of the public. Examples are already emerging of platforms working closely with IGOs to respond to emergencies. In some cases, governments may choose to develop or support multilateral platforms that meet specific public needs, effectively creating "virtual" multilateral institutions. An example is the OECD Global Recalls Portal where, rather than creating a new international body to collect and exchange information on product recalls, a platform performs this function[2]. Existing services now provided by international organisations such as response to epidemics or emergencies are increasingly augmented by global platforms, many of which are provided by private firms[3]. Such global platforms may also be asked by governments to help in the implementation of public policies on the behalf of the public.

11. Against this backdrop, a key objective of the OECD's "Going Digital" project[4] is to improve awareness and understanding of the issues and their policy implications, help governments learn from each other and share the fruits of the active policy experimentation currently under way. The window for action is now, so that effective measures and strategies are in place when they are needed.

Session 1 – Harnessing Digital for Inclusive Growth: Opportunities and Challenges

Breakout 1: Building the Skills of the Future

12. The digital transformation, coupled with globalisation, demographic changes and other megatrends, is deeply affecting the nature of work in OECD economies - including the types of jobs, and where and how they are carried out. It is transforming the skills workers need; moreover, workers will increasingly have to learn new skills during their working lives to adapt to changes in their jobs. To benefit from new, higher wage employment opportunities, workers need ICT foundation skills, as well as socio-emotional skills, such as teamwork, flexibility and resilience. Higher levels of education provide an important safeguard against the risk of automation – according to OECD estimates, fewer than 5% of workers with a tertiary degree are currently at a high risk of losing their job to automation, on average, compared to 40% of workers with a lower secondary degree[5].

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[2] See: https://globalrecalls.oecd.org/front/index.html#/recalls

[3] (e.g. https://www.google.org/publicalerts)

[4] http://www.oecd.org/going-digital

[5] See Arntz, M., T. Gregory and U. Zierahn (2016), "The Risk of Automation in OECD Countries: A Comparative Analysis", *OECD Social, Employment and Migration Working Papers*, No. 189,

13.   Yet more than 20% of workers in OECD countries lack the basic literacy and numeracy skills that provide the basis for future learning (Figure 2). Data from the PIAAC Survey of Adult Skills show that, on average across the 33 participating countries and regions, 55% of workers lack the basic problem-solving skills that are needed in a technology-rich environment. Younger people are better prepared for the digital era than older people but even among youth, many are only able to solve simple problems. Worryingly, shortages in computer skills are emerging in almost all countries for which data is available. Moreover, only half of citizens in OECD countries have basic financial digital literacy skills. This jeopardises their short- and long-term financial resilience and wellbeing, and weakens their ability to benefit from digitalisation.

14.   On the positive side, gender gaps in general ICT skills and the use of software at work tend to be quite small in most countries, and gender differences in the frequency of the performance of tasks at work involving the use of socio-emotional skills, such as self-organisation, are almost negligible. However, women lag behind men when it comes to numeracy, which may limit their ability to grasp new job opportunities in some fields[6].

Figure 2. The proportion of low performers in literacy and/or numeracy, workers
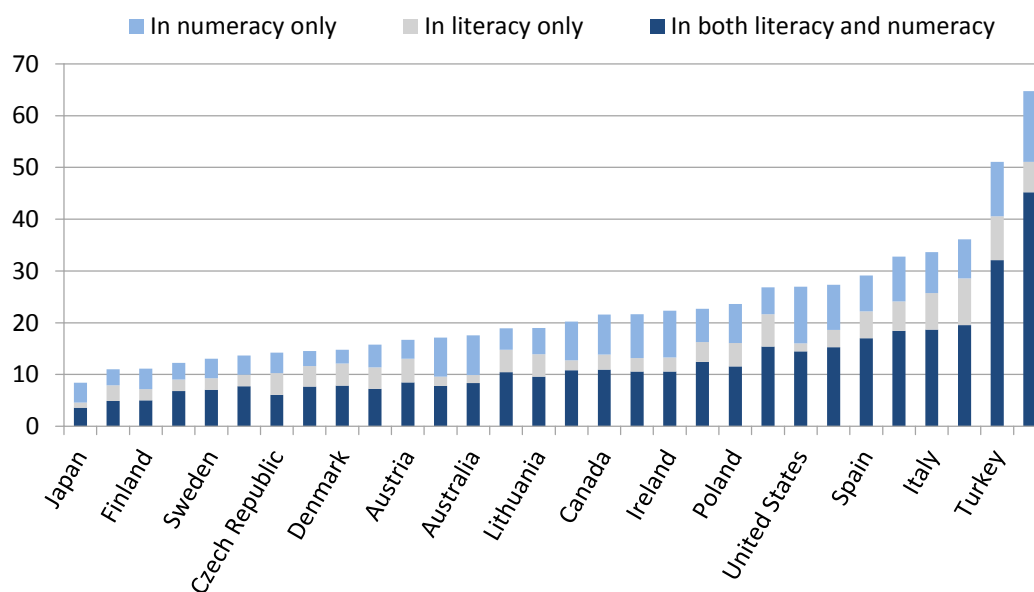
Source: OECD, 2017 Skills Outlook, calculations based on the Survey of Adult Skills (PIAAC) (2012 and 2015), www.oecd.org/skills/piaac/publicdataandanalysis.

OECD Publishing, Paris, http://dx.doi.org/10.1787/5jlz9h56dvq7-en and OECD (2016), "Automation and independent work in a Digital Economy", *OECD Policy Briefs on the Future of Work*, May 2016, http://www.oecd.org/ employment/emp/Policy%20brief%20-%20Automation%20and%20Independent%20Work%2 0in%20a%20Digital%20Economy.pdf

[6] See Grundke, R., et al. (2017), "Skills and Global Value Chains: A Characterisation", OECD Science, Technology and Industry Working Papers, No. 2017/05, OECD Publishing, Paris, http://dx.doi.org/10.1787/cdb5de9b-en and OECD(2016), Skills Matter: Further Results from the Survey of Adult Skills, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264258051-en

15.　　OECD countries must ensure that education equips students with the necessary knowledge, skills and abilities so that they have the best possible foundation to "learn how to learn" over their lifetimes. Longer working lives and technological change will make adult learning even more important to give workers – and especially low-skilled workers – opportunities to upskill and reskill. Workers with the lowest levels of skills face additional barriers to training in the form of higher risk aversion, more binding credit constraints and reduced access to information, and are 40 to 60 percentage points less likely to receive training than higher skilled workers.[7] Countries should encourage on-the-job training, certification of skills acquired through work experience, better skills use in the workplace and improved skills assessment and anticipation systems. Older workers and citizens will present particular challenges for skills policies. Ensuring that women and other underrepresented parts of the population have the requisite digital skills and opportunities to fully engage in the digital era, as workers and as citizens, will be an important part of making the digital transformation inclusive. This will entail promoting female participation in STEM studies, ensuring that women do not face biases that curtail entrepreneurship, have access to training opportunities, and do not face barriers to lifelong learning.

- *How can policy support lifelong learning for workers and especially those who lack basic digital skills (e.g. low-skilled, the aged)? What good practices are emerging?*

- *Which digital skills are going to be crucial to thrive in the labour markets of tomorrow? How should skills development be financed and delivered meeting local and national needs?*

- *To what extent does ensuring that citizens have the right skills to prosper in the digital age require broader policies encouraging social mobility?*

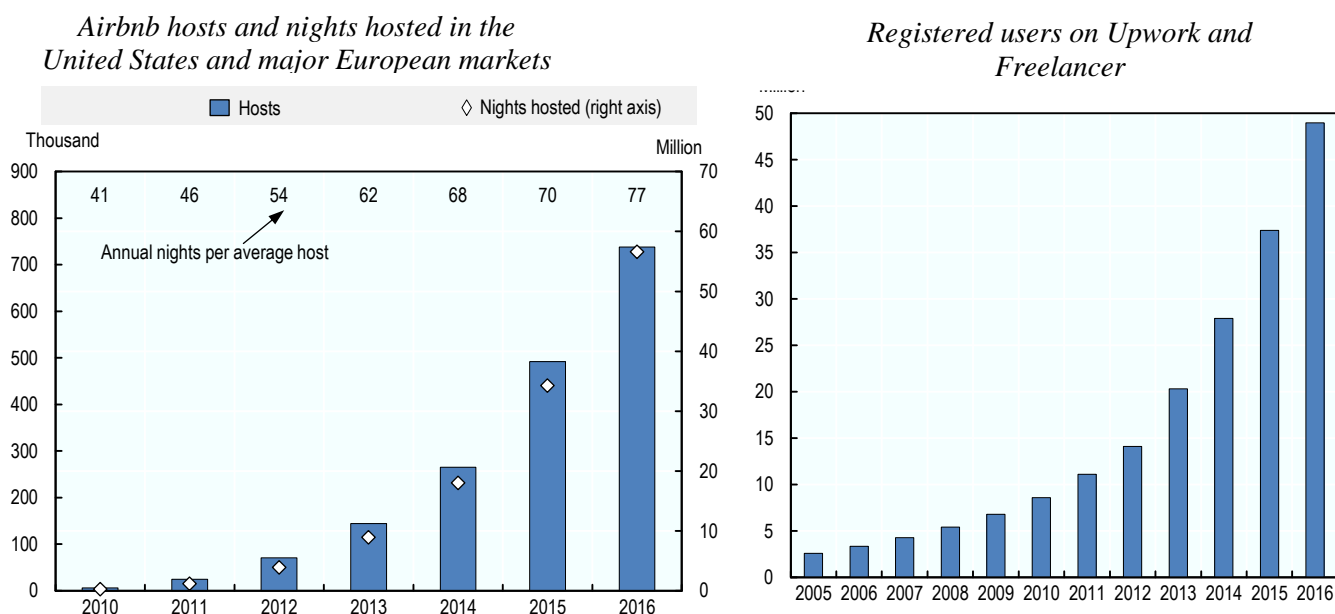### Breakout 2: Accompanying the impact of digital transformation on jobs, remuneration, social protection

16.　　As with previous major technological innovations such as the steam engine, electricity or the assembly line, digital transformation will be economically and socially disruptive and will lead to important job gains and job losses. Major innovations of the past often resulted in net job losses in the short-term, but these were quickly unwound, and the innovations made possible the creation of much larger numbers of new jobs, many of them more productive and rewarding than those that they replaced. The most recent OECD estimates indicate that, based on existing technology, 14% of jobs in OECD countries are currently at a high risk of automation. However, with technologies like artificial intelligence moving quickly ahead, estimates of job automation are a moving target. On the one hand, the introduction of new technologies is a slow process due to economic, legal and societal hurdles, and often does not take place as expected. On the other hand, routine work in sectors like legal services, radiology, financial services and software engineering is increasingly becoming susceptible to automation.

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[7] OECD (2013), OECD Skills Outlook 2013: First Results from the Survey of Adult Skills, OECD Publishing, Paris.
http://dx.doi.org/10.1787/9789264204256-en

17.   Digital transformation is also changing the way work is organised. The 'sharing' economy, though still small in scale (Figure 3), allows businesses to access a larger pool of potential workers and suppliers, enabling some people to access work for the first time and others to take advantage of more flexible work options. However, there are also real concerns that new forms of work could lead to lower job security and quality. 'Sharing' economy jobs potentially limit workers' access to union representation, wage setting mechanisms and social protection. Women for example may be able to take advantage of the opportunity to work with increased flexibility, but often at the risk of foregoing significant benefits: for example across the European Union, an estimated 46% of self-employed women aged 15-49 are not entitled to maternity benefits (EC, 2015).

Figure 3. The growth of the platform economy

Airbnb hosts and nights hosted in the United States and major European markets

Registered users on Upwork and Freelancer

Source: OECD, 2017 Digital Economy Outlook.

18.   Therefore, while beneficial on the whole, the digital transformation will inevitably create losers as well as winners. National and local governments have an important role in helping people adapt to these changes and help people affected move to a new and high-quality jobs as quickly as possible and provide support to those who are unable to make this shift. Governments need broad policy action to help people adapt to these changes and support those who lose out from the transformation in the world of work, helping them move to a new and high-quality job as quickly as possible. In addition to action on skills, countries should provide workers displaced by digital transformation with active job search assistance, measures to improve their employability and adequate income support. Interventions need to come early in the unemployment spell, and be coupled with retraining and requalification so that displaced workers can take advantage of new job opportunities arising elsewhere in the economy. Re-training opportunities should be skill-centred (as opposed to job-centred) so that displaced workers can move between different jobs or sectors by building on the skills they already possess rather than starting from scratch.

19.   Countries will also need to adapt social protection policies to emerging forms of work. Social protection systems need to be modernised to extend coverage and ensure portability of social benefit entitlements, including potentially through individual accounts, universal basic income programmes, and new technological tools that enable better service delivery, administration, and identification of needs.

- *How can workers be supported in finding new job and career pathways through public/private as well as national/local efforts? How should social policy instruments be adapted to accompany the impacts of digital transformation? What good practices are emerging?*

- *How can governments better engage with social partners and civil society to address the challenges that lie ahead?*

Breakout 3: Facing the challenges of data management

20.   More data are being generated every week than in the last millennium: a figure that will rise further as more people, devices and objects become connected to the Internet. Data are not new, but their management was cumbersome and labour-intensive before they became digital. The growing use of data holds the promise of significantly accelerating research and the development of new products, processes, organisational methods and markets – a phenomenon known as data-driven innovation (DDI)[8]. The economic and social benefits of DDI are particularly noticeable in data-rich sectors such as science, health care, transportation and public administration. More generally, Big Data and analytics are increasingly being used to enhance public service delivery and facilitate the identification of emerging governmental and societal needs and transform the ways in which governments operate. Data and their analysis can result in greater productivity across the economy, and firms using DDI have raised productivity faster than non-users.

21.   Despite the acknowledgment of its economic and social benefits, re-use of data across organisations, sectors and countries remains below its potential, as individuals, businesses and governments often face barriers to data re-use, while sometimes also being reluctant to share. Competition and the social and economic risks associated with the possible revelation of confidential information (i.e. personal data and trade secrets) are often cited as the main reasons for individuals and organisations not to share their data. Identifying which data to share and defining the scope and the right mechanism for sharing and re-using (restriction) may pose a challenge, in particular for individuals, who are increasingly wary of the re-use of their personal data, and SMEs, which tend to have limited knowledge and face greater resource constraints for investments in digital security.

22.   A key challenge for citizens, businesses and governments is how to participate in the global data ecosystem while at the same time respecting legitimate considerations of individuals' and organisations' interests and different policy approaches among countries. Striking this balance will be difficult, but failing to recognise the relative costs and benefits will be a large lost opportunity. Policy makers will be challenged by a bundle of

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[8] OECD (2015), *Data-Driven Innovation: Big Data for Growth and Well-Being*, OECD Publishing, Paris.
DOI: http://dx.doi.org/10.1787/9789264229358-en

new issues as they grapple with data such as the attribution of responsibility and liability for inappropriate decisions. The potential risk of significant social and economic costs to third parties from automated, data-driven decisions will require careful examination of the appropriateness of fully automated decision-making, and an assessment of when human intervention may be required. It will also require considering the means through which the transparency of the processes and algorithms underlying these automated decisions (i.e. algorithmic transparency) can be increased, while preserving intellectual property rights (IPRs). Data analytics that enable precise discrimination may result in greater efficiencies, but also reinforce stereotypes limiting individuals' freedom; conversely it could help correct for inherent human biases. The key challenge to tapping into the potential of DDI includes addressing individuals' concerns of harms caused by privacy violations and the potential to undermine societal core values and principles, such as autonomy, equality and free speech.

23.   Seizing the benefits from data for growth and well-being therefore requires government action. Policies are needed to encourage investments in data, to promote data sharing and reuse, including across borders (see also discussion of digital trade in Session 2 below), and to protect security and privacy. Moreover, new concerns are emerging that will require a policy response, e.g. around automated decision making, discrimination based on algorithms, and the emergence of a "data divide," based on who owns, collects and analyses the data.

- *How can policy foster the benefits of data-driven innovation while ensuring security and privacy? How can countries ensure that data flows across borders? In which situations should legitimate public policy concerns restrict these data flows? How can differences between countries be accommodated to ensure that information flows freely over the Internet? What good practices are emerging?*

- *Given the importance of data and its analysis to economic performance and social welfare, how can governments better utilise data in the provision of services?*

Breakout 4: Harnessing the digital transformation for firms

24.   With 95% of firms in OECD countries having high-speed Internet in 2016, a good foundation is available for firms to harness the benefits of digital transformation, although regional variations (particularly in more rural areas) persist. But access alone does not imply that firms are able to use the technology effectively; many firms are not yet using many of the productivity-enhancing applications that can drive productivity and improve business performance. For example, only some 40% of large firms and 20% of all firms in OECD countries are engaged in selling via e-commerce (Figure 4). Indeed, the widening of productivity differences across OECD countries between leading and lagging firms (and, in parallel, leading and lagging regions) suggests that many firms are not yet able to turn the potential of digital technologies into stronger productivity performance. Partly, this is because the digital transformation is not just about the technology, but about the way technology is combined with other changes and investments within firms.

25.   Effective use of new technology requires that workers have appropriate skills to use the technology; that firms invest in new business models, organisational change and innovation and adopt new management practices; and that digital-intensive start-ups can grow and prosper. Ensuring sound competition is key in allowing new firms to challenge incumbents, efficient firms to grow, and inefficient ones to exit, thus helping boost economic growth and living standards. This in turn requires well-designed product and

labour market regulations, insolvency regimes that do not unduly inhibit corporate restructuring and penalise entrepreneurial failure, and a set of financial and tax policies that do not discourage financing for early stages and growth, including equity. The potential for digitalisation to improve the efficiency of financial systems and result in the provision of cheaper and more demand-driven financial products and services can further bolster this process.

26.   SMEs, in particular, face challenges in the use of ICT, although they also have important opportunities, such as the development of "born global" small firms, global e-commerce, better access to a range of financing instruments, improved understanding of internal processes, markets and the business environment through data analytics, or the outsourcing of key business functions, all of which can help improve performance. Platforms, where peer-to-peer transactions often take place, increase the supply of a number of products and services and allow trades that otherwise would not happen. This can facilitate SMEs' access to customers and help them reach international markets. The adoption lag of SMEs is mainly due to a lack of key capabilities, e.g. human resources and management expertise, and a lack of investment in complementary assets. For instance, lack of investment in in-house innovation and organisational capabilities limits the capacity of SMEs to take full advantage of new technologies to enhance data analytics, engage in e-commerce, or increase participation in knowledge networks. Enabling SMEs to fully harness the digital transformation to boost their competitiveness and take up entrepreneurial opportunities can help ensure growth is inclusive, as well as boost productivity as these firms find new niches in global value chains[9].

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[9] See OECD (2015), The Future of Productivity, OECD Publishing, Paris.

Figure 4: Enterprises engaged in sales via e-commerce, by size of firm, 2015

As a percentage of enterprises in each employment size class
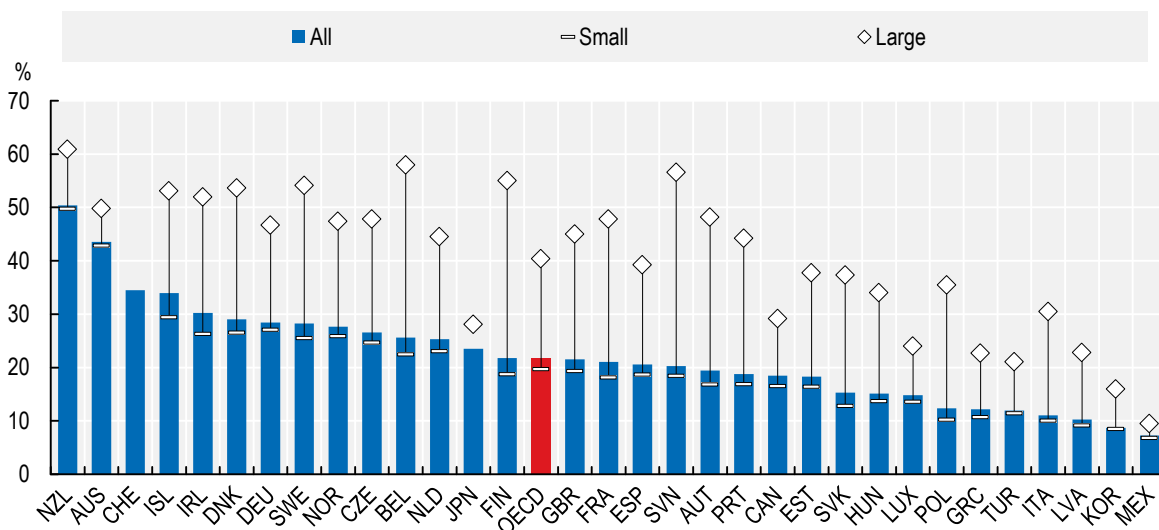
Source: OECD (forthcoming), Science, Technology and Innovation Scoreboard 2017, OECD Publishing, Paris.

27.   Comprehensive national digital strategies that take into account SMEs, policies that facilitate access to finance, and SME engagement with competency centres and/or technology extension services, can be helpful for SMEs. National digital security strategies can also help address the specific needs of SMEs by providing them with practical guidance and the appropriate incentives to adopting good practices. More generally, the digital transformation and the emergence of new business models is changing the world faster than many rules and regulations affecting business have evolved. Governments should therefore periodically review their regulatory frameworks and, where appropriate, update them to ensure that they are well-suited to the increasingly digitalised world and continue to support growth and well-being.

- *What policies can governments pursue to encourage investment in the digital transformation? What are the key elements of an enabling environment and what policy approaches can government take?*

- *How can policy best enable firms in all cities and regions to harness the digital revolution? What good practices are emerging that can help SMEs seize the benefits of the digital transformation?*

Session 2: Digital transformation across borders: Taxation, Trade, Competition and Development

Breakout 1: Cross-border digitalisation and trade

28. The digital transformation is enabling firms to adapt their business models to respond rapidly to changing demand, increasingly tailoring solutions that combine goods and services. The distinction between goods and services is becoming increasingly difficult and porous, with consequences for how we think about trade and market openness in a digital world.

29. Goods and services have generally been addressed separately in trade negotiations, yet the absence of commitments in some services could undermine access for some goods, and vice versa. While traditional trade issues such as trade facilitation are becoming more important as e-commerce is leading to a large increase in small parcel trade, new issues are arising from measures affecting the cross-border flow of data.

30. Data now form an integral part of the production process in many industries and firms, are an asset that can be traded and a means to deliver services. As noted in Session 1 above, the growing volume of data exchanged across borders has given rise to concerns about security, the protection of privacy, intellectual property rights and audit and regulatory reach. This has in turn led to government actions to restrict cross-border transfers of data or to require that data be stored locally (Figure 5). Reaping the benefits of digital trade will require dialogue among countries and stakeholders on approaches to ensure the interoperability of differing regulatory regimes for data, and to identify least trade restrictive ways of meeting key public policy objectives.

Figure 5: Stock of identified data measures

a. cross-border transfer restrictions　　　　*b. local storage requirements*
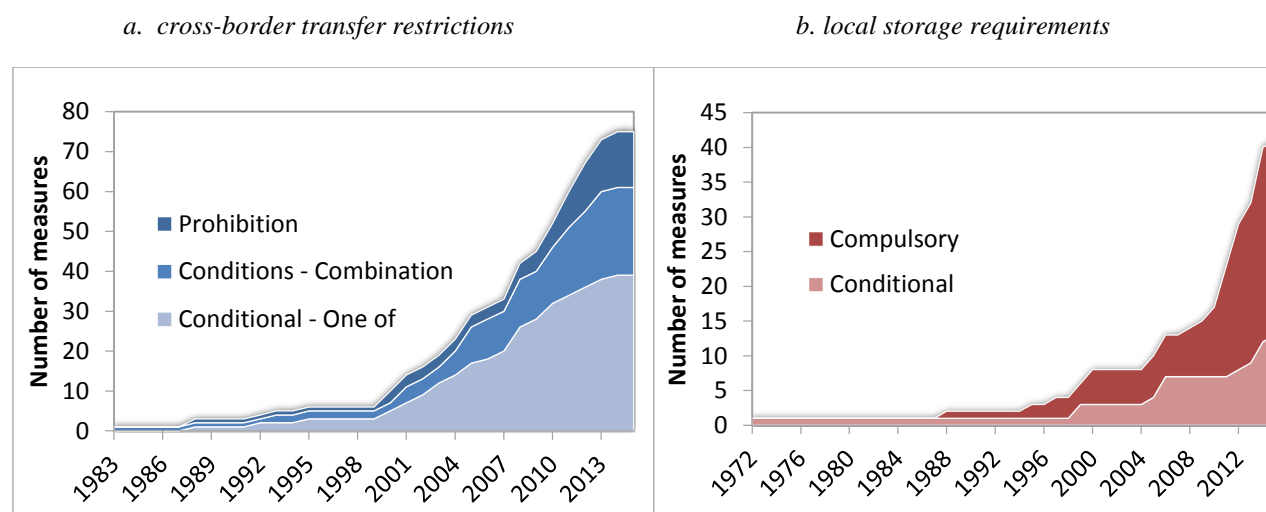
Source: OECD.

31. Digital technologies change trade relationships, between and within goods and services. There can be substitution effects - as when streaming services replace DVDs (goods). Or combinations of goods and services, as when a business sends plans for a toy

to a consumer who 3D prints it abroad -- in which case, a design service crosses the border, but ultimately produces a good, raising questions for trade policy about whether trade rules covering goods (more liberal) or services should apply. Digital transformation creates new relationships -- both substitution and complements -- between modes of service supply: businesses may no longer need to establish a commercial presence in a country (mode 3) to offer services, but can do so through cross-border digital delivery (mode 1) -- but they may also need to send personnel to support the sale (mode 4). In goods, e-commerce platforms have led to huge increase in the number of small packages crossing borders, posing new challenges for customs processes, risk management (e.g., for counterfeits) and revenue collection. Small packages are placing the de minimis threshold (the minimum value below which no tariffs or taxes are collected) under pressure: too low a threshold risks longer clearance times undermining just-in-time delivery and making it harder for SMEs to benefit from digital trade, but too high a threshold may favour foreign over domestic producers, if only foreign producers are VAT exempt, as well as having revenue implications.

- *What are the implications of digital trade for international trade agreements and the current trade rules?*

- *Trade negotiators have long sought to balance the legitimate pursuit of key public-policy objectives and the benefits of open global trade. Are there lessons that could be helpful for balancing the free flow of data, security, and privacy? Are trade agreements the right forum for addressing this issue? What scope is there for a greater international dialogue on such issues, who should this dialogue involve and where might such a dialogue take place?*

Breakout 2: Cross-border digitalisation and tax

32.   The emergence of new business models and changes in the value chain as a result of digitalisation of the economy raises important questions for tax policymakers.

33.   The 2015 report on Action 1 of the OECD/G20 Base Erosion and Profit Shifting (BEPS) Project focused on this issue, and concluded that the digital economy cannot be ring-fenced, with digitalisation increasingly permeating the entire economy. The report concluded that there were no unique BEPS issues arising from digitalisation, but recognised that certain features of digitalisation and the new business models associated with it were exacerbating some BEPS issues. While it was clear that the full range of measures outlined in the OECD/G20 BEPS Package would mitigate some aspects of these BEPS issues, the report also identified a number of "broader" direct and indirect tax challenges of digitalisation. In the area of indirect taxation, the new rules applying the "destination principle" to VAT/GST on cross-border sales has given countries the tools needed to effectively tax cross-border digital transactions. Nonetheless, a number of broader direct tax challenges remain, such as nexus (the fact that businesses can have a large economic presence in a jurisdiction with minimal or no physical presence), data (namely, the increasing role of data and the growing value of its analysis in new business models), and characterisation of payments (the blurring of traditional distinctions, such as for example, between goods and services as evidenced in the case of cloud computing).

34.   At the same time, new technologies are offering new opportunities to tax administrations allowing them to enhance services to taxpayers, improve tax compliance and reduce the informal economy, as well as to more effectively detect and investigate tax evasion and avoidance. This includes new tools such as the OECD-procured Common Transmission System for the secure exchange of tax information, which has proven to be

a cost-efficient platform for governments that deploys new technology to enhance international cooperation. The tax system itself can also be used to support investments in research & development, driving innovation.

- *How can the right balance be found between the need to foster innovation and secure the benefits of digitalisation, while at the same time ensuring an efficient tax system that treats all firms equitably regardless of their business model?*

- *Are further efforts required to ensure that tax administrations can collaborate and draw on new technologies to achieve their objectives in the most efficient and effective ways?*

Breakout 3: Cross-border digitalisation and competition

35.   Digital transformation has the potential of increasing cross-border transactions and indeed many innovative companies operate in a number of countries worldwide, yielding substantial consumer benefits, as judged by consumers' interest in using new services. But globalisation can only bring its full benefits in an inclusive manner if competition is fair in a well-functioning market. Some barriers remain, for instance different regulatory frameworks across countries can make it difficult and costly for companies to expand internationally, and regulations often restrict the circulation of data. In some sectors, cross-border sales are still negligible[10].

36.   Whether regulations and enforcement tools should be adapted in light of digital transformation is an open question. Many competition authorities actively engage in advocacy activities in their jurisdictions and have over time recommended specific changes to their countries' regulations.

37.   Examples of sectors whose traditional business models are changing in response to the digital transformation abound, ranging from retail to financial services and transportation. The digital transformation has enabled the creation of new markets and has blurred the boundaries between sectors, therefore potentially enhancing competition further. Other trends led by the transformation may have unclear effects on competition. Innovative companies sometimes collect vast amounts of data from consumers and use Big Data to offer data-driven services. Data-driven "network effects can improve the quality of the product or the service", but can lead to the concentration of users and data[11]. While Big Data can improve competition by increasing innovation and the creation of customised products, it can also become an asset or input used by firms to enhance their market power and engage in exclusionary practices. Collection of Big Data is common in industries that benefit from strong network effects, such as social networks, and economies of scale and scope can be substantial in this area, which may contribute to enhance market power. Computer algorithms are increasingly being used by companies to improve their pricing models, to customise services, to predict market trends and to

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[10] One example is the financial sector, as reported by a 2016 study for the European Commission, see https://ec.europa.eu/info/system/files/study-digitalisation-01072016_en.pdf.

[11] OECD (2016), Big Data: Bringing competition policy to the digital era, Secretariat Background Paper, DAF/COMP(2016)14, http://www.oecd.org/daf/competition/big-data-bringing-competition-policy-to-the-digital-era.htm.

optimise business processes. Algorithms can potentially enhance competition or, on occasion, could increase the risks of collusion, though there are few known cases so far[12].

38.   Platforms enable peer-to-peer transactions while creating new business models or disrupting traditional business methods. Platforms can reach customers more easily and, in many instances, retailers use them to sell on the internet. A hearing held by the OECD in June 2017 suggested that existing principles answer the key questions that arise in the context of platforms, for example on determining the market boundaries and assessing market power, provided that small but important adjustments are made to the techniques used in the analysis[13]. The most important of these adjustments is to account for network effects, taking into account the fact that platforms are often more attractive to users on one side when they successfully recruit users on another side. Competition law enforcers should give particularly careful consideration to allegedly exclusionary conduct in platform markets. Some features of the digital sector, such as economies of scale and scope and network effects, can favour the emergence of dominant firms. While care should be taken not to confuse market gains by more competitive companies and abuse of dominant positions, it is worth exploring whether economies of scale may be a greater challenge for maintaining competition than previously realised. In addition, the growing use of computer algorithms by firms to improve their pricing models, customise services and predict market trends, while undoubtedly associated to significant efficiencies and better and more tailored products and services, is also raising concerns of possible anti-competitive behaviour as they can make it easier for firms to achieve and sustain collusion without any formal agreement or human interaction.[14] To avoid possible difficulties in the future, it is important to reflect on whether there is a need to modernise antitrust regulations and enforcement to accommodate this new reality.

39.   Competition authorities are taking action against situations involving improper conduct or undue extension of market power. However, enforcement challenges from cross-border digitalisation will require enhanced cooperation among competition authorities, reinforcing information-sharing and investigation assistance, notably in order to prevent businesses from taking advantage of jurisdictional inconsistencies.

- *What are the main competition issues as a result of increasing cross-border digitalisation?*

- *Are economic efficiency and consumer welfare enhanced by cross-border digitalisation?*

- *Are policy changes needed to address these competition issues or is the current structure of competition law and regulatory oversight sufficient?*

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[12] OECD (2017), Algorithms and Collusion: Competition Policy in the Digital Age www.oecd.org/competition/algorithms-collusion-competition-policy-in-the-digital-age.htm.

[13] See the Competition Committee Hearing on "Rethinking the use of traditional antitrust enforcement tools in multi-sided markets" at http://www.oecd.org/daf/competition/rethinking-antitrust-enforcement-tools-in-multi-sided-markets.htm.

[14] OECD (2017), Algorithms and collusion: competition policy in the digital age, available at http://www.oecd.org/competition/Algorithms-collusion-competition-policy-in-the-digital-age.htm

Breakout 4: Harnessing digitalisation for development

40.   Digitalisation is not just a rich world phenomenon - across the globe, people and governments are taking advantage of digital technologies to enhance their businesses, public services and social activities. Broadband networks can play a transformative role in enabling individuals, businesses and governments to interact with and among each other, and 40% of the world population is now connected to networks, up from 4% in 1995. A large body of evidence is now emerging that shows digitalisation can give rise to a more inclusive society and better governance arrangements; enhance access to key services such as health, education and banking; improve the quality and coverage of public services and political participation; expand the way individuals collaborate and create content; and enable people to benefit from access to global markets and greater diversity and choice in products, as well as lower prices. It is not for nothing that the United Nations Sustainable Development Goals pick out access to information and communications technology and universal and affordable access to the Internet as one of the key targets (9c) to transform our world, echoing the objective already elaborated by the UN's Broadband Commission for Sustainable Development.

41.   The digital transformation also offers the chance to empower women in developing countries, if the digital gender divide can be narrowed. This challenge has been recognised at the highest levels, including the recent G20 Roadmap for Digitalisation agreed by G20 Digital Economy Ministers in April, which foreshadowed action across a range of policy areas to address the barriers that may prevent women from fully participating in the digital economy. For women, digital technologies could make a significant contribution to engagement in the formal labour market and seizing the full benefits of their efforts. In a study by GSMA, for instance 64% of working women across 11 low- and middle-income countries said that they have (or would have) greater access to business and employment opportunities because of mobile phone technologies[15]. A survey of Kenyan women found that almost all had a M-pesa mobile banking account and over three-quarters of them transacted at least twice a week, with 95% saying they sent money to their relatives and (for the 37% owning a business) 96% saying M-pesa helped them scale their venture[16]. At a more basic level, the "Better than Cash Alliance" initiative to spur digital payments is helping to boost transparency, security and financial inclusion for women. A case study of Bangladesh's garment production sector (whose worker population is 80% female) found that digital payments reduced the risk of loss or theft of wages for workers, and enhanced the ability to save[17].

42.   However, there are significant challenges, the first being the critical role of digital infrastructure in the ability of countries to take full advantage of the digital transformation. Here, there is much room for improvement, not least because of major "supply side" challenges in encouraging investment and competition, extending

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[15] GSMA (2015), Connected Women 2015: Bridging the Gender Gap: Mobile access and usage in low- and middle-income countries, GSMA Connected Women Global Development Alliance. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2016/02/Connected-Women-Gender-Gap.pdf

[16] Kombo, L. (2017), "Mobile money is growing women's empires in Kenya", 21 March. http://msurvey.co.ke/blog/2017/3/21/mobile-money-is-growing-womens-empires-in-kenya.

[17] Better than Cash Alliance (2017), "Digitizing Wage Payments in Bangladesh's Garment Production Sector", March. https://www.betterthancash.org/tools-research/case-studies/digitizing-wage-payments-in-bangladeshs-garment-production-sector

broadband beyond urban areas into rural and remote areas, and upgrading networks to match rising demand. Demand-side issues such as low levels of income, education and local content production add additional challenges to improving affordability and ensuring services are relevant to users[18]. In addition, in some countries, a lack of basic electricity and road infrastructure are primary hurdles to overcome before digital technologies can reveal their promise. Experience shows that well-designed regulatory tools and ambitious digital strategies with robust competitive forces can make a substantial difference.[19]

43.   A second challenge for developing countries may be the evolution of global value chains in a world where the digitalisation of production could reverse the importance and length of GVCs and reorient global production and trade back towards OECD countries. A recent forward-looking exercise based on the formulation of different scenarios for the next 10-15 years has explored the way in which the future of GVCs may be different to the past[20]. Robotics, automation, computerised manufacturing and artificial intelligence all could reduce the advantages of production in low-labour-cost emerging economies, posing some concerns about premature deindustrialisation. Moreover, the absorption of these technologies in developing countries could pose challenges for governments in managing structural adjustment, notwithstanding the important gains for productivity and sustainable economic growth that could be made. While certain labour-intensive industries which predominate in many developing countries, such as garments, shoes and leather, furniture, textiles and food, may be less susceptible to automation, technological change could quickly alter the equation[21]. Governments in developing countries need to prepare, not least though sound labour, skills and social policies, as well as robust framework policies that underpin business dynamism and unleash the potential of entrepreneurs.

- *What are the main blockages for developing countries to harness digital technologies for their economic and social advancement?*

- *What role can international collaboration play in ensuring a globally inclusive digital transformation?*

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[18] OECD (2016), "Digital Convergence and Beyond: Innovation, Investment and Competition in Communication Policy and Regulation for the 21st Century", OECD Digital Economy Papers, No. 251, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jlwvzzj5wvl-en

[19] OECD and IDB (2016), Broadband Policies for Latin America and the Caribbean: A Digital Economy Toolkit, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264251823-en

[20] De Backer, K. and D. Flaig (2017), "The future of global value chains: Business as usual or "a new normal"?", OECD Science, Technology and Industry Policy Papers, No. 41, OECD Publishing, Paris. http://dx.doi.org/10.1787/d8da8760-en

[21] OECD (2017), The Next Production Revolution: A report for the G20, OECD. https://www.oecd.org/g20/summits/hamburg/the-next-production-revolution-G20-report.pdf

Session 4. Addressing Challenges to International trade and Investment

44.   Making trade work for all requires governments to take a much more integrated policy approach, both domestically and internationally. Domestically, governments need to create the environments where the benefits from trade can materialise through policies that encourage opportunity, innovation, and competition. They also need to do more to bring everyone along, to ensure that temporary setbacks do not turn into lifelong disadvantages, through investments in inclusive growth.

45.   But domestic action is not enough. Governments also need to work together, using the full range of international economic cooperation tools, to address concerns about the level playing field for international trade and investment. This international economic cooperation toolkit is how countries manage exchange across difference, and it ranges from legally binding multilateral rules, to international standards, to voluntary guidelines and codes of conduct, to dialogue. Countries agree international 'rules of the road' because it is in their interests to do so: for fair competition, or because benefits are greater and risks avoided where everyone acts together. Yet there is more to do to fill the gaps and unfinished business in the rules governing international economic exchange, and also to ensure that everyone is sticking to the rules.

46.   Central to this system is the rules-based international trading system embodied in the WTO, complemented by rules that countries agree under plurilateral and bilateral trade agreements, as well as bilateral investment treaties. Many other tools of international economic cooperation exist, including for example ILO core labour standards and various OECD initiatives.

OECD standards: contributing to a level playing field for international trade & investment

47.   The 2017 OECD Business and Finance Outlook highlighted the negative impacts caused by the lack of a level playing field in international trade and investment. While the impact on business opportunities, jobs, wages, and overall well-being also depends on the specific circumstances of the country, industry and region concerned, there are a number of areas where OECD standards and instruments could play a greater role:

- *Cross-border cartels.* Collusion through cross-border cartels denies consumers and growth firms the benefits of competition. The average number of countries with firms participating in known cartels has tripled in 10 years. More than two hundred and forty cross-border cartels were detected and fined in the recent 15 years, affecting USD 7.5 trillion in sales. OECD instruments on bid rigging, dealing with hard-core cartels, and the way to enhance co-operation between competition agencies are all designed to deal with this problem.

- *Undue government support to internationally active SOEs*. Today a quarter of the top 50 global companies are state-owned enterprises compared with just a couple of them 15 years ago. SOEs operating internationally can enjoy special advantages from governments that undermine competitive neutrality, generate negative excess capacity spillovers, and prompt restrictive responses from recipient countries. Adhering to the OECD Guidelines on Corporate Governance of SOEs, together with the development of a global transparency standard for SOEs as called for by the 2017 MCM, could go a long way to addressing the problem.

- *Transnational anti-bribery.* Almost 40 per cent of world exports today originate from countries that are not Parties to the OECD Anti-Bribery Convention, double the percentage when the Convention entered into force. A recent OECD quantitative study shows that only investors from countries Party to the Convention have reduced their exposure to corrupt destinations. Major G20 and other economies not yet Party to the Convention could make a significant contribution to a fairer trading system by joining the Convention.

- *Social and environment standards.* Human right abuses, breaches of labour rights, and serious harm to the environment too often continue to affect global supply chains, particularly in industries such as extractives or textiles and clothing. Due-diligence strategies in supply chain management have strong potential to improve social and environmental outcomes and reduce disruptions to trade and international investment flows with benefits for productivity and sustainable growth. The OECD Guidelines for Multinational Enterprises and related supply chain due diligence guidance are well suited to this task.

- *Uneven levels of market openness for investment.* While they have made progress in recent years, G20 countries that do not adhere to the OECD Investment Declaration and its National Treatment instruments are still many times more restrictive toward inward international investment than the average of adhering countries, based on the OECD FDI Restrictiveness Index. More large economies adhering to the OECD investment instruments including the Codes of Liberalisation would improve mutual market access and benefits from FDI openness.

48.   The complex system of rules and instruments that countries use to govern their international economic relations is critical for both individual countries and the global economy, but raises challenges in ensuring coherence across the system. This coherence is becoming ever more important at a time where global integration and digitalisation are seeing the development of new business models, with new interdependencies between trade and investment.

Trade and investment, evolving business strategies, and GVCs

49.   The channels through which the relationship between trade and investment works are still not well understood, and complementarities are generally not taken into account in liberalisation and other policy-reform efforts. While Global Value Chains (GVCs) have sharpened the interdependencies between trade and investment and enhanced their complementary effects, at the international level trade and investment rules are neither comprehensive nor inter-linked, and as a result are inadequate to address the reality of new business models.

50.   The fragmentation of the international regime, in turn, often reflects lack of adequate mechanisms for policy coordination between trade and investment at the national level. The resulting complexity engenders costs and uncertainty, which reduce investor confidence and can impact decisions on international operations, especially for small and medium-sized enterprises (SMEs) who could be viable investors but which are ill-equipped to manage the costs and risks they face. Improving policy coherence can be one of the best opportunities to make global GVCs more inclusive and productivity-enhancing.

51.   To help address this gap, the OECD is developing a range of new tools and analysis to better understand the linkages between trade and investment, from developing new data on MNEs and interdependencies between trade and investment in GVCs to deepen understanding of the benefits for countries and the rules that impact on firm strategies, to analysing provisions in trade agreements and related investment agreements to help countries identify where greater coherence can be achieved.

●   *How can governments make the international trade system work better for more people? What are the priorities for filling gaps in international rules?*

●   *How can OECD standards contribute to levelling the global playing field for trade and investment? What can be done to reinforce their effective implementation and to expand adherence to major players?*

●   *How can improved understanding of the interdependencies between trade and investment contribute to greater coherence of trade and investment policies at the international level? How can the international trade and investment regime work better so that benefits are more widely shared?*

TAB 11

2018

Crowd-Based Capitalism, Digital Automation, and the Future of Work

Arun Sundararajan

Crowd-Based Capitalism, Digital Automation, and the Future of Work

Arun Sundararajan[†]

ABSTRACT

The confluence of two digital forces—a shift towards platform-mediated peer-to-peer exchange, and a rise in the cognitive capabilities of artificial intelligence and robotics technologies—will dramatically reshape tomorrow's workplace by making it difficult for a growing fraction of the population to earn a living as a provider of labor and talent. I contend that the emerging economic model of crowd-based capitalism could offer an alternative to the traditional employer-employee relationship. I discuss the factors that have led to the recent advent of crowd-based capitalism, arguing that the model becomes increasingly attractive as digital technologies blur the boundaries between institutions of differing scale that have historically facilitated the provision of trust and the use of intellectual capital. Facilitating this transition will require policy that favors the redistribution of capital rather than of income. Governments must cede a significant fraction of their regulatory responsibility to platforms and other self-regulatory bodies, while catalyzing the emergence of new educational infrastructure and providing incentives that favor platform models that decentralize the ownership of structural capital over those whose providers are simply sources of on-demand labor. These policy prescriptions are a politically feasible path towards the redistribution of capital ownership and in contrast with other proposed radical interventions like a universal basic income.

I. INTRODUCTION

Over the last decade, new digital platforms have enabled ways of organizing economic activity that shift much of what was traditionally accomplished by full-time workers within an organization to a distributed crowd of individual entrepreneurs and on-demand workers. This shift creates an economy that relies more extensively on short-term freelance relationships as opposed to full-time employment. Simultaneously, parallel improvements in the capabilities of artificial intelligence (AI) and robotics-enabled technologies threaten to automate many of

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[†] Professor of Business and Robert L. & Dale Atkins Faculty Fellow at New York University's Stern School of Business, Center for Urban Science and Progress, and Center for Data Science.

the cognitive and physical tasks that comprise today's human work. Predictions of "a world without work"[1] have led many to believe that drastic solutions like a universal basic income—guaranteed monetary transfers from the government to the individual each month—are essential to counter the specter of social unrest projected to result from widespread unemployment.

While history suggests that the threat of technological unemployment is always overstated, today's ongoing structural changes in how work is organized increase the rate at which capital can be substituted for human labor, requiring work arrangements to shift away from the status quo. In this Essay, I argue that we must plan a future of "crowd-based capitalism" in which a majority of the workforce shifts away from holding a full-time job as a talent or labor provider, and instead runs a individual business, one that perhaps uses a mix of labor and talent inputs from themselves and from others. This will allow millions of newly minted owners to capture a tiny slice of the economy's capital. Digital technologies reshape the institutions that provide commercial trust and the institutions that are repositories of an economy's structural intellectual capital, and blur the boundaries between these institutions. These institutional changes are what make this potential decentralization of capital feasible.

Such a shift will challenge many facets of the social contract. A new approach to business regulation that divides responsibility for intervention between government agencies and non-governmental organizations is necessary. Some of this division has already happened, *de facto*, over the last decade, and I provide a set of heuristics that can help draw the right lines. The transition to crowd-based capitalism should also be accompanied by a shift in the focus of higher education, away from two- or four-year post-secondary colleges that educate early in life, and towards continuing education and mid-career transitions. A significant new government intervention like the Morrill Land-Grant Act of 1862[2] which spawned over 100 land-grant universities that still exist today (and that include some of the country's top educational institutions like Cornell, MIT, Ohio State University and the University of Minnesota), might facilitate the emergence of new educational institutions that may otherwise be underprovided by the market. Societies may also benefit from rethinking the emphasis placed on STEM subjects in middle and high school. Our social safety net, constructed and funded in many

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[1] *See, e.g.*, Derek Thompson, *A World Without Work*, ATLANTIC (July 2015), https://www.theatlantic.com/magazine/archive/2015/07/world-without-work/395294/ [https://perma.cc/YQ7F-C RRH].

[2] 7 U.S.C. §§ 301–309 (2012).

countries with the assumption of full-time employment rather than entrepreneurship, must be fundamentally re-conceptualized.

II.   WHAT IS CROWD-BASED CAPITALISM?

As I studied the "sharing economy" between 2011 and 2015, a frequent conversation at conferences and in the popular press was about what set of activities, business models or economic systems this term actually encompassed,[3] and whether it was in fact an appropriate label for commercial on-demand businesses like Uber and labor markets like Upwork whose connection to "sharing" seemed tenuous at best. As I explain in my 2016 book, "[a]lthough I find 'crowd-based capitalism' most precisely descriptive of the subject matter I cover, I continue to use 'sharing economy' as I write this book because it maximizes the number of people who seem to get what I'm talking about."[4]

The central distinguishing feature of the "crowd-based capitalism" I refer to is a shift in the primary institutions that organize economic activity, away from the quintessential twentieth century managerial hierarchy, and towards new hybrids between the firm and the market. The "visible hand" of Alfred Chandler[5] remains, but its role changes. Many of the economic activities traditionally performed by large hierarchical organizations that employ full-time workers are instead delegated to a distributed and heterogeneous crowd of producers of varying size, independence, and capability.

Let me illustrate the idea of crowd-based capitalism with some examples. Consider the effects that video entertainment platforms like YouTube have had over the last fifteen years. In the 1970s and 1980s,

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[3] For a useful summary of the ambiguity surrounding the term in 2013, see Rachel Botsman, *The Sharing Economy Lacks a Shared Definition*, FAST COMPANY (Nov. 21, 2013), https://www.fast company.com/3022028/the-sharing-economy-lacks-a-shared-definition [https://perma.cc/AJ8C-HD T8]; *see also* Kenneth Olmstead & Aaron Smith, *How Americans Define the Sharing Economy*, PEW RESEARCH CENTER FACT TANK (May 20, 2016), http://www.pewresearch.org/fact-tank/2016/05/20/ how-americans-define-the-sharing-economy/ [https://perma.cc/6UE9-PEU8] (highlighting the diversity of perceptions that Americans associate with the term, ranging from charity and socialism to asset rental marketplaces).

[4] ARUN SUNDARARAJAN, THE SHARING ECONOMY: THE END OF EMPLOYMENT AND THE RISE OF CROWD-BASED CAPITALISM 27 (2016).

[5] In his 1977 book The Visible Hand, Alfred Chandler traces the evolution of the US economy from the early 1800s through the late twentieth century, from what was largely a market economy through a steady transition to hierarchies of increasing complexity as a consequence of a series of technological changes spanning 200 years: the creation of plantations, the emergence of textile mills, the use of armories, the railroad and the telegraph, the ascent of mass distribution, of mass production and the emergence of the modern corporation through the integration of mass production and mass distribution, leading up to the dominance of modern managerial hierarchies through the twentieth century. *See generally* ALFRED D. CHANDLER, JR., THE VISIBLE HAND: THE MANAGERIAL REVOLUTION IN AMERICAN BUSINESS (1977).

most television content in the United States was created by large television or motion picture studios; this content was then distributed to consumers via television stations that were owned by or affiliated with one of the "Big Three" networks: NBC, CBS, or ABC.[6] Thus, both content production and content distribution were done by what one might consider traditional hierarchies.

Contrast this with the production and distribution model of a service like YouTube, currently owned by Alphabet (formerly Google). The YouTube platform centralizes the aggregation of demand, provides search and discovery capabilities, and performs some content filtering. The demand aggregation and content distribution activities are thus still handled by a traditional hierarchical organization. Content production, by contrast, is done by a distributed and varied "crowd." Some content comes from large studios, traditional entertainment firms that also produce music videos and internet-customized programming. However, there are also millions of independent and semi-professional producers who create media "microbusinesses" that generate revenue from the advertising shown to users who view their content. Some of these producers boast tens of millions of subscribers and earn millions of dollars in annual revenue,[7] like Lilly Singh (comedy sketches and music videos, $7.5 million in 2016) and Rosanna Pansino (unconventional baking ideas, $6 million in 2016). Numerous others cater to a niche audience and generate more modest incomes. For example, Tim Wood, who creates content related to ghost hunts and paranormal activity, generated about $6000 in monthly revenue in 2016.[8] Still millions of other YouTube content creators are amateurs who simply post content for fun.

Contrary to what one might believe, YouTube is no longer on the fringes of video entertainment. It boasts over 1 billion monthly active users, a number far greater than the viewer base of any television network.[9] A good leading indicator of the impending shift in US video advertising revenues away from television and towards YouTube over the

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[6] *See generally* CHRISTOPHER H. STERLING & JOHN M. KITTROSS, STAY TUNED: A CONCISE HISTORY OF AMERICAN BROADCASTING (1978).

[7] Nathan McAlone, *Meet the YouTube Millionaires: These are the Highest-Paid YouTube Stars of 2016*, BUS. INSIDER (Dec. 9, 2016), http://www.businessinsider.com/youtube-stars-who-make-the-most-money-in-2016-2016-12 [https://perma.cc/YKM8-GGKU].

[8] Sapna Maheshwari, *Candid, Comedic, and Macabre YouTube Stars Feel an Advertising Pinch*, N.Y. TIMES (May 7. 2017), https://www.nytimes.com/2017/05/07/business/media/youtube-stars-feel-advertising-pinch.html [https://perma.cc/73ZM-RKS8].

[9] For an interesting early analysis of the potential of crowd-based systems in this industry, see CLAY SHIRKY, HERE COMES EVERYBODY: THE POWER OF ORGANIZING WITHOUT ORGANIZATIONS (2008).

coming decade comes from China: in 2016, Chinese digital video advertising revenue was over 20% of total advertising spending on video (digital and television), a fraction that is projected to rise to over 50% by 2021.[10]

A different example of crowd-based capitalism comes from the business of providing short-term accommodation. By many measures, the platform Airbnb may already, in early 2017, be the world's single largest provider of short-term accommodation.[11] A typical commercial hotel (whether owned by a franchisee or directly by a parent brand like Marriott Starwood) functions like a traditional twentieth century organization: it employs professionally-trained workers and managers full-time, invests in real estate dedicated to the provision of short-term accommodation, and receives some assistance from the parent company to attract demand, set standards, and maintain customer loyalty. Analogously, in the crowd-based version of the short-term accommodation business, Airbnb is not a mere marketplace that aggregates and helps match supply and demand. Rather, it provides the reassurance that comes with a global brand, employs over 600 people in its trust and safety team as of 2017[12], while also setting and enforcing some standards (almost like a next-generation franchising operation). However, the productive role of the individual shifts from salaried worker to small business owner, responsible for the actual running of the tiny enterprise that eventually provides the short-term accommodation. The pricing, inventory management, positioning, merchandizing, and customer interaction is done by the millions of Airbnb hosts who are concurrently building their own micro-brands on Airbnb's online reputation systems.

Put differently, a feature that the Airbnb platform model shares with the YouTube platform model is the potential creation of *genuinely decentralized capital ownership*. Both Airbnb hosts and YouTube content creators are closer to running a microbusiness than providing labor for a commission or salary. They are (very) small business owners, in

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[10] *China's Video Ad Spend Forecast to Overtake TV by 2021*, EMARKETER, http://totalaccess. emarketer.com/article.aspx?r=1016452 (last visited on Nov. 13, 2017).

[11] On December 31st, 2016, over 2 million people were staying in an Airbnb. The platform also reports having over 4 million listings, although the occupancy of a listing is typically a lot lower than the occupancy of a hotel room. Alison Griswold, *This New Year's, Airbnb Got the Hockey-Stick Growth That Every Startup Envies*, QUARTZ (Jan. 3, 2017), https://qz.com/877080/airbnbs-growth-in-guests-on-new-years-is-the-hockey-stick-curve-that-every-startup-wants/ [https://perma.cc/C6 XL-TGJ8]. The world's largest hotel chain, Marriott-Starwood, has an inventory of 1.1 million rooms. *Marriott International Completes Acquisition of Starwood Hotels & Resorts Worldwide, Creating World's Largest and Best Hotel Company While Providing Unparalleled Guest Experience*, MARRIOTT (Sept. 9, 2016), http://news.marriott.com/2016/09/marriotts-acquisition-of-starwood-complete/ [https://perma.cc/NB6C-3DJ4].

[12] Conversation with Nick Shapiro, Global Head of Trust and Safety, Airbnb (Aug. 24, 2017).

contrast with providers on a labor platform like Amazon's Mechanical Turk, where the transaction is very clearly one of exchanging labor for money.

This distinction between capital owner and labor provider is a critical one. As I explain in what follows, structural changes in how economic activity is organized coupled with accelerating automation will make it increasingly infeasible for a nation's workforce to make a living as providers of labor and talent, whether as full-time employees or as on-demand contractors. Avoiding mass unemployment or underemployment and the need for massive new government welfare programs requires us to reimagine the role of the individual in the productive activities of an economy.

III. Digital Automation and Non-employment Work Arrangements

Fears of widespread technological unemployment are hardly new. The Luddite rebellions, labor riots between 1811 and 1816 in the five central manufacturing counties of England, saw British textile workers destroying weaving machinery they believed were replacing their role in production.[13] Similar apprehensions were voiced by a 1960s presidential commission on technology, automation and economic progress: "The fear has even been expressed by some that technological change would in the near future not only cause increasing unemployment, but that eventually it would eliminate all but a few jobs, with the major portion of what we now call work being performed automatically by machine."[14]

There is no denying that technological progress leads to radical changes in the demand for certain types of human labor. Perhaps the most significant shift of this kind in the United States took place during the twentieth century, as the fraction of the workforce earning a living as farm laborers dropped from over 40% in 1900 to under 2% in 2000.[15] These changes were most dramatic in the first half of the century, as illustrated in Figure 1.

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[13] *See* Nicols Fox, Against The Machine: The Hidden Luddite Tradition in Literature, Art, and Individual Lives 24–25 (2002). As discussed in this book, the rebellions were not the first act of resistance by the workers, but followed failed attempts at collective bargaining.

[14] U.S. Dept. of Health, Education & Welfare Office of Education, Technology and the American Economy, (Feb. 1966), http://files.eric.ed.gov/fulltext/ED023803.pdf [https://perma.cc/56D4-Z5LK].

[15] *See* David H. Autor, *Why Are There Still So Many Jobs? The History and Future of Workplace Automation*, 29 J. Econ. Perspectives 3, 5 (2015).
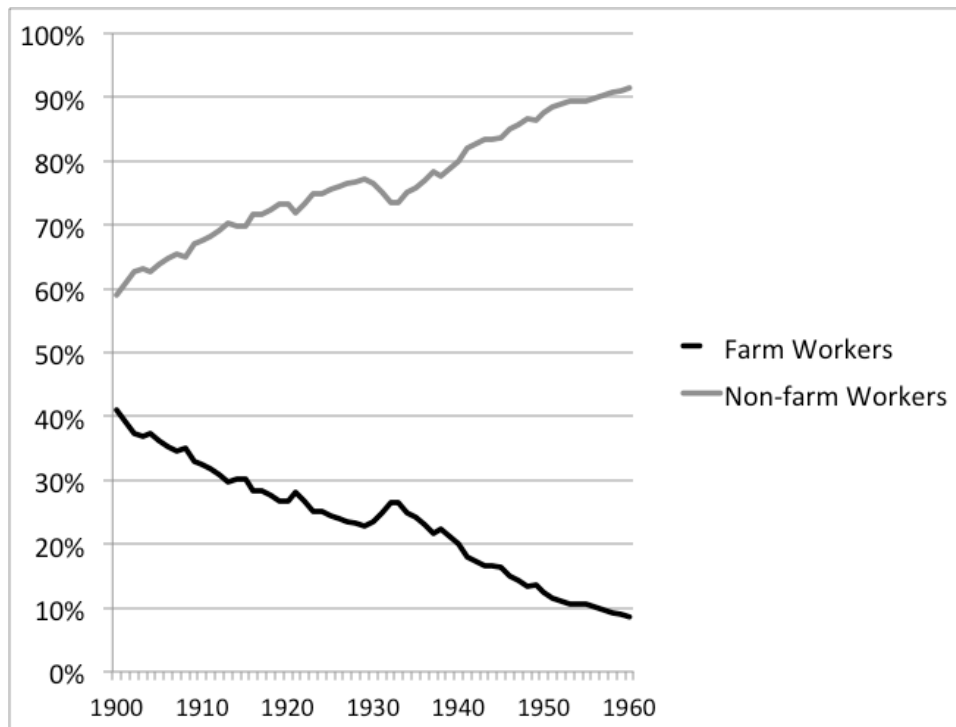
Figure 1: Farm and non-farm employment in the United States, 1900–1960

A more recent casualty of workplace automation is manufacturing employment in the United States. After peaking at close to 20 million jobs in the late 1970s, it has fallen sharply, from 22% of nonfarm payroll employment in 1977 to less than 10% of it in 2016,[16] with a vast majority of the job losses over the last decade attributable to factory robots rather than offshoring.[17] This trend may be especially ominous for China, where urban manufacturing employment, a massive 80 million in 2014,[18] is bound to drop quite steeply in the coming decades.

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[16] U.S. DEP'T OF LABOR, BUREAU OF LABOR STATISTICS, THE EMPLOYMENT SITUATION: AUGUST 2017 (Sept. 1, 2017), https://www.bls.gov/news.release/pdf/empsit.pdf [https://perma.cc/MT4R-GJEY].

[17] *See* MICHAEL J. HICKS & SRIKANT DEVARAJ, THE MYTH AND THE REALITY OF MANUFACTURING IN AMERICA 6 (June 2015), http://projects.cberdata.org/reports/MfgReality.pdf [https://perma.cc/BG3P-ZG9D] (arguing that 87.8% of manufacturing job losses in the US between 2000 and 2010 can be attributed to automation rather than offshoring); *see also* David H. Autor, David Dorn & Gordon H. Hansen, *The China Shock: Learning From Labor Market Adjustment to Large Changes* (National Bureau of Economic Research Working Paper No. 21906, 2016), http://www.nber.org/papers/w21906.pdf [https://perma.cc/W2PP-37XE].

[18] Nicholas R. Lardy, *Manufacturing Employment in China* (Dec. 21, 2015), https://piie.com/blogs/realtime-economic-issues-watch/manufacturing-employment-china [https://perma.cc/FLN5-54G5].

Even in the U.S. economy, which has enjoyed low levels of unemployment despite farming and manufacturing falling to a relatively small fraction of total employment, the more menacing automation threat comes from the "second machine age" predicted by Erik Brynjolfsson and Andrew McAfee, wherein technologies start to perform the cognitive tasks that used to be the exclusive domain of humans.[19] There are a number of recent early examples of this expansion in the capabilities of such automating "machines." IBM's Watson technology promises AI-powered solutions for financial compliance, medical diagnostics, and legal services. Self-checkout counters are available at a growing number of retail stores. Self-driving automobile technologies seem poised to threaten tens of millions of trucking jobs globally.

If machines transcend automating physical labor and start to challenge the demand for human cognitive capabilities as well, one may wonder what will be left for us humans to do. A glance at the recent history of job displacement from automation provides some perspective. As farming was steadily mechanized in the U.S., progress in the technologies underlying farming automation spawned job creation in parallel.[20] And more saliently, entirely new industries, ones that fulfill different human desires and needs, emerged and expanded. For example, tourism, barely an industry in 1900, employed more than 235 million people globally in 2010, which constituted 8% of all of global employment.[21] Similarly, the healthcare sector, which was virtually non-existent at the time of the Luddite rebellions, accounts for about 12% of US employment today.[22] A pattern emerges: activities that used to be informal or done within the household or local community (like communication, entertainment, travel, education, or tending to the ill) become industries in the formal economy. Thus, as the labor demands of industries that fulfill contemporary societal needs continue to be automated by the latest generation of technologies, people become available to pursue the fulfillment of new societal needs, or of new underserved human aspirations. Perhaps we will witness a dramatic scaling of economic activity to counter climate change, or to educate the world, or the formalizing of the "care" economy.

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[19] *See generally* ERIK BRYNJOLFSSON & ANDREW MCAFEE, THE SECOND MACHINE AGE: WORK, PROGRESS, AND PROSPERITY IN A TIME OF BRILLIANT TECHNOLOGIES (2014).

[20] *See, e.g.*, Autor, *supra* note 15, at 7 (as passenger cars displaced equestrian travel and its supporting industries, this led to the emergence of the automobile industry, highways, gas stations, as well as the rise of the roadside motel and fast food industries).

[21] *Employment in the Tourism Industry to Grow Significantly*, INT'L LAB. ORG. (May 1, 2011), http://www.ilo.org/global/publications/world-of-work-magazine/articles/WCMS_157893/lang--en/index.htm [https://perma.cc/92LY-FFKT].

[22] U.S. DEP'T OF LABOR, BUREAU OF LABOR STATISTICS, *supra* note 16.

Nevertheless, there is cause for caution. This is in part because the labor displacement effects of the current wave of automation are likely to be exacerbated by a more recent trend in the United States: the growth of the fraction of the workforce engaged in *non-employment work arrangements*.[23] Estimates of the total number of such "independent" workers in the United States ranges from 40 million to 68 million.[24] These numbers include individuals who derive their primary income from non-employment work arrangements, as well as people who supplement their employment income by moonlighting as freelancers. According to one recent study, almost all of the net "employment" growth in the United States between 2005 and 2015 seems to have occurred in these kind of new work arrangements.[25]

Whichever estimate one embraces, between 25% and 40% of the US civilian labor force of 160 million generates all or part of their income from such arrangements. More saliently, such arrangements represent a radical reversal of a different transition in the first half of the twentieth century, during which the US workforce shifted quite dramatically away from independent and towards full-time employment work arrangements (see Figure 2).

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[23] "Non-employment work arrangements" is my preferred term for work arrangements other than employment. For example, independent contracting, temporary work, freelance work, running a zero-employee business, and other forms of non-employment independent work that generate income. I prefer this term to the more frequently used "contingent work."

[24] At the high end of these estimates is the 2016 study by the McKinsey Global Institute, which pegs the number of Americans who rely on non-employment work arrangements as their primary source of income at 32 million and the "moonlighters" at 36 million. *See* JAMES MANYIKA ET AL., INDEPENDENT WORK: CHOICE, NECESSITY, AND THE GIG ECONOMY 49 (Oct. 2016), http://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Employment%20and%20Growth/Independent%20work%20Choice%20necessity%20and%20the%20gig%20economy/Independent-Work-Choice-necessity-and-the-gig-economy-Full-report.ashx [https://perma.cc/6VZZ-LF22]. On the lower end of the spectrum is a 2016 study by MBO Partners, which estimates about 17 million primary and 23 million supplementary. *See* MBO PARTNERS, 2016 STATE OF INDEPENDENCE IN AMERICA REPORT 2–4 (2016), http://info.mbopartners.com/rs/mbo/images/2016_MBO_Partners_State_of_Independence_Report.pdf [https://perma.cc/5RRG-2H8Z]. Another influential study, by the Freelancers Union and Upwork in 2016, estimates a total of 55 million independent workers. *See New Study Finds Freelance Economy Grew to 55 Million Americans This Year, 35% of Total U.S. Workforce*, UPWORK (Oct. 6, 2016), https://www.upwork.com/press/2016/10/06/freelancing-in-america-2016/ [https://perma.cc/S23E-DC7F].

[25] LAWRENCE F. KATZ & ALAN B. KRUEGER, THE RISE AND NATURE OF ALTERNATIVE WORK ARRANGEMENTS IN THE UNITED STATES, 1995-2015 7 (2016) https://krueger.princeton.edu/sites/default/files/akrueger/files/katz_krueger_cws_-_march_29_20165.pdf [https://perma.cc/GKK4-RTS8].
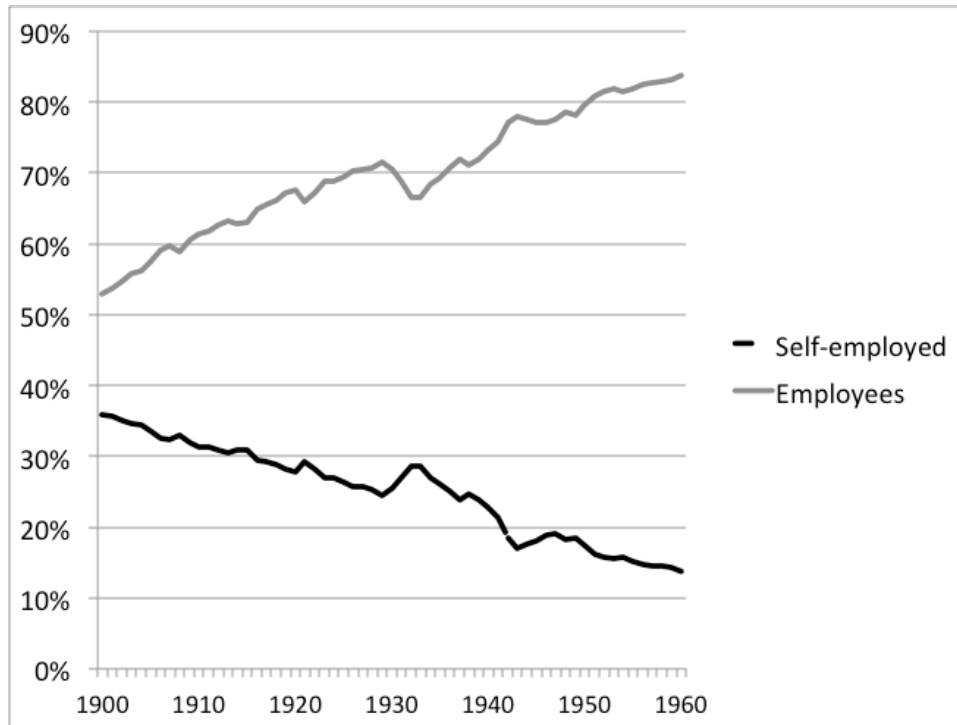
Figure 2: Changes in paid work arrangements in the United States, 1900-1960, the percentage (as a fraction of the total US civilian workforce) of workers of each type. The percentages do not add up to 100% because there were still a fraction of workers who were categorized as unpaid family workers.

This recent trend towards non-employment work arrangements is accompanied by another threat to salaried employment: the decomposition of work into "tasks" or "projects." In the past, hiring thousands of workers on short-term contracts to carry out small slices of work was simply infeasible because of the high associated administrative and transaction costs. Today, however, numerous digital platforms are enabling this deconstruction.[26] Perhaps the most extreme enabler is Amazon's Mechanical Turk, on which workers bid to complete very small units of work (for example, suggesting a few words that are best associated with a digital image), typically getting paid a few cents per "microtask" completed. But this kind of platform-mediated task and project work is not restricted to simple tasks that humans currently perform better than software. There are a growing number of on-demand labor platforms for more complex task and project work. Some, like Upwork and Thumbtack, span a broad range of professions, from accounting and

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[26]   *See* Sundararajan, *supra* note 4, at 131–58, 173–75.

copy editing to personal fitness and photography. Others, like Handy, concentrate on a cluster of related services like house cleaning, moving, and home maintenance. Still other platforms focus on one specific profession, like Catalant for management consulting (over 40,000 providers), Gigster (whose providers are highly curated software engineers), and Upcounsel for legal services, which lists over 20,000 active providers, including professional solo law practitioners, stay-at-home parents who work part-time through the platform, and boutique law firms.[27]

It is now possible to reimagine what might have been a work arrangement involving full-time employees as one that is instead a succession of short-term contracts with best-of-breed providers, as enterprise software like the WorkMarket suite facilitates integrating on-demand labor into traditional corporate workflows.[28] Additionally, the popularity of on-demand *consumer* platforms in specific verticals like transportation (Uber and Lyft in the US, Didi Chuxing in China, BlaBlaCar in France, Ola in India and Grab in Southeast Asia) suggests that businesses may follow the lead of consumers and start to access certain services on an as-needed basis, which may further lower the need for certain kinds of employment (like full-time corporate drivers). Granted, many early "Uber-for-X" consumer services (like those for on-demand laundry and valet parking) are proving to have unsustainable unit economics, but others, like on-demand food, appear to be growing rapidly.

This two-pronged assault on salaried employment—the rise of non-employment work and the increasing cognitive capabilities of machines—makes it necessary for society's model of earning a living to evolve. There are many reasons why the *confluence* of these two forces is more disruptive than the sum of the effects of each in isolation. First, the pace at which human work may be displaced by automation could be increased when the strength of the relationship between the human and the institutional source of demand for the labor is weakened. Put simply, it is easier for an organization to terminate independent contract workers than full-time employees. Thus, as non-employee work arrangements expand, the immediacy of the human labor displacement effects of automation technologies will be greater.

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[27] Based on my conversations with their CEO, 70% of Upcounsel's lawyers (who have an average of 15 years of experience) have worked at top-200 law firms, and 50% of them have worked at Fortune-500 firms. Essentially, Upcounsel is building the infrastructure of a law firm to support a highly skilled crowd-based provider population by aggregating demand, managing client relationships, and guaranteeing client payment for them.

[28] For a discussion about how the New York Times uses such software to manage its freelance workforce, see Jim Thompson, *The New York Times Talks Automation with WorkMarket*, WORKMARKET (July 18, 2017), https://www.workmarket.com/blog/new-york-times-talks-workforce-automation-with-workmarket [https://perma.cc/N6U2-F2SE].

Second, at a specific level of technological progress, different tasks that comprise a job are automatable to different degrees. Now, work arrangements that involve full-time and long-term employees allow for greater slack in the design of work systems: the people performing the tasks are collocated, there is a greater level of fault tolerance, and it is consequently harder to isolate the specific tasks suited for automation immediately and more challenging to seamlessly replace the associated human labor with a machine. In contrast, if the work associated with today's full-time jobs is "unbundled" and farmed out to on-demand labor platforms, this must necessarily be accompanied by a far more structured production process, one that is designed to make tasks more separable and modular. This will naturally increase the pace and precision at which such tasks can be automated when the technology is ready, which in turn will accelerate the pace of displacement of human labor.

Third, certain work arrangements lower the collective bargaining power of labor because of legal rather than economic reasons. For example, unlike employees, independent contractors in the United States do not have collective bargaining rights covered by the National Labor Relations Act. The prospect of impending automation, which translates into an increase in the rate at which capital can be substituted for labor or talent, puts downward pressure on the wages associated with the provision of this labor or talent. With lower labor bargaining power, the realized negative effect on wages will be more pronounced, lowering the desirability of being a labor or talent provider.

Finally, the labor displacement effects of technological progress are affected by the differential speed with which it lowers the cost of doing different tasks that comprise a job. Of the many tasks that comprise a production process, if only a few are automated, the variable cost of production associated with these tasks is lowered. As a consequence, even without any corresponding shock to the demand system, production may increase, thereby increasing the demand for the human labor associated with the other tasks. This mitigating effect may be higher when the tasks are done as a "bundle" of work, and less so when separated.

IV. Why Crowd-Based Capitalism May Be a Solution

Faced with the prospect of this multifaceted attack on its primary model of work, any advanced economy needs to redefine how its citizens earn a living. I have discussed many reasons why the shift must be away from relying on a model of work in which humans earning money by providing their labor and talent to a large organization which owns the capital associated with the economic activity. Instead, the model we

must move towards is a workforce of capital owners who run tiny businesses that use a mix of labor and talent inputs, while retaining ownership of some fraction of the organizational and intellectual property capital associated with the service. Under this future model, as an increasing fraction of these inputs shift away from human labor and toward AI and robotics technologies, humans can retain their ability to earn a living.

In order to assess the viability of an economy based on crowd-based capitalism, it seems important to understand (1) what factors have enabled early examples of crowd-based capitalism to emerge in the last decade, (2) what exactly is the nature of the "capital" whose ownership is potentially distributed more evenly under this model, and (3) are there specific characteristics of an industry that afford the model of decentralized capital ownership at scale an inherent long-run economic advantage?

Two key technological factors that have led to the recent emergence of today's crowd-based platforms are the ubiquity of powerful digital technologies in *consumer* products (one would be hard-pressed to imagine Uber or Didi Chuxing emerging in the absence of mass-market GPS-enabled smartphones), and the increased sophistication of digital systems that can facilitate *trusted exchange*.[29] I first explain the evolution of these systems that are reshaping commercial trust. Next, I explain these changes in trust systems are related to a blurring of boundaries between stakeholders in production that hold the human capital and those that hold the other structural intellectual capital, and how the emergence of crowd-based capitalism is connected to these shifting borders. I conclude with a discussion about how changes in work arrangements might alter the trend of rising income and wealth inequality.

A.   New Mechanisms for Trust

It helps at this point to define "trust." Of course, in many ways, the definition depends on the context. Trust in a romantic relationship might mean something different from trust in a commercial transaction. A definition in the commerce context comes from the sociologist James Coleman, who defined trust as "a willingness to commit to a collaborative effort before you know how the other person will behave."[30]

For economic activity that is organized primarily the way that it was at the end of the twentieth century in the United States and West-

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[29]   *See* Sundararajan, *supra* note 4, at 47–67 (discussing these and other factors).

[30]   NETWORKS AND MARKETS 25 (James E. Rauch & Alessandra Casella eds., 2001).

ern Europe—production done by large organizations that employ individuals full-time, paying salaries in exchange for labor and talent—the commercial trust needs of the economy are met primarily by *government standards*, *economic institutions*, and *corporate brand*. The trust required for transactions between large trading partners is well addressed by contracts enforceable in a court of law. The relatively high transaction costs associated with writing (and potentially enforcing) a contract can be absorbed by exchange of sufficiently high value. On the other hand, it may not be economically feasible for a consumer to sign and enforce a contract about the quality of the cup of coffee he or she purchases in the morning. This kind of trust is established in part by government standards for food safety (if the coffee is hazardous to the consumer's health, the seller is penalized) and in part through the profit motive of corporate brand (if the quality of coffee is consistently low, the consumer will take his or her business elsewhere).[31] These three forms of trust provision, and especially economic institutions and corporate brand, are relatively recent developments and contrast quite starkly with the social trust that enabled most of the world's commercial activity until a few hundred years ago.[32] They have led to dramatic increases in the scale of the world economy.[33]

Given the central role that such trust systems play in shaping the nature of economic activity, the emergence of a new digitally enabled infrastructure for commercial trust is noteworthy because it explicitly involves a re-integration of social ties into commercial exchange. In the past, I have proposed that when using such infrastructures, the information needed to verify identity, intentions, and capabilities stems from multiple cues.[34] These cues include learning from one's own prior interaction; learning through familiarity that comes from the nature of

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[31] Some of the earliest government regulations in human history were for food safety. *See generally* Peter Barton Hutt & Peter Barton Hutt II, *A History of Government Regulation of Adulteration and Misbranding of Food*, 39 FOOD DRUG COSM. L. J. 2 (1984) (discussing the role of government in preventing the adulteration of food in the past, and tracing guidelines that existed in ancient times, as well as specific rules and penalties that were in the Theodosian Code of 438 A.D.).

[32] A vast majority of early commercial exchanges were between individuals who shared social ties. For a discussion about the social enforcement mechanisms used by traders who wished to extend their scope beyond their immediate community, see generally Avner Greif, *Reputation and Coalitions in Medieval Trade: Evidence on the Maghribi Traders*, 49 J. ECON. HIST. 857 (1989). For an overview of the evolution of trust mechanisms for commerce, see also Sundararajan, *supra* note 4, at 142–46.

[33] To understand the central role that institutions play in economic development, see generally DARON ACEMOGLU & JAMES A. ROBINSON, WHY NATIONS FAIL: THE ORIGINS OF POWER, PROSPERITY, AND POVERTY (2012); Douglass C. North, *Economic Performance Through Time*, 84 AM. ECON. REV. 359, (1994). For a contrasting perspective, see PETER BLAIR HENRY, TURNAROUND: THIRD WORLD LESSONS FOR FIRST WORLD GROWTH (2013).

[34] *See, e.g.*, Frédéric Mazzella, Arun Sundararajan, Verena Butt D'Espous, & Mareike Möhlmann, *How Digital Trust Powers the Sharing Economy* 30 IESE INSIGHT 24 (2016).

exchange (being part of the "cultural dialogue"); learning from the explicit experiences of others (such as what is learned by reading reviews written by prior customers); learning by relying on digitized social capital (such as what one might infer by viewing someone's Facebook or LinkedIn network); and the reliance on digitized forms of real-world identity (validated by external institutions or entities, government and non-government, digital and otherwise). In a non-face-to-face (and sometimes face-to-face) setting, these cues can establish authenticity; they can assist in assessing goals; and they can help assess expertise or quality.

Every platform of crowd-based capitalism has some combination of these cues available digitally. In many ways, the lower the stakes of the interaction, the easier it is to establish sufficient digital trust. This is why examples such as YouTube and the crowd-based retailing platform eBay scaled early—the stakes are lower when buying a product from a stranger, or viewing a video from an unknown source, than when getting into a stranger's car and saying "drive me to another city." But while we have had digital access to some of these sources of trust since eBay was established in 1995, the final two—reliable verification of real-world identity, and access to social capital—have become digitally available at scale only recently.

B.   Trust, Intellectual Capital, and the Fractal Nature of New Institutions

An even closer look at platforms like Airbnb and its brethren suggests that while they all share some form of digital trust infrastructure, there is a tremendous amount of variety in the production and intermediation activities that they facilitate. My research in 2015 and 2016 into the details of over 100 such platforms that span multiple industries has identified over 20 dimensions along which they vary. One might traditionally associate many of these dimensions with an organizational hierarchy. Other dimensions involve features that are decidedly market-like, and other capabilities seemed uniquely created to facilitate digitally-enabled exchange at scale.[35] Table 1 summarizes some of these dimensions for five crowd-based platforms that are popular in 2017: Airbnb, Uber, retailing platform Etsy, labor marketplace TaskRabbit, and city-to-city ridesharing platform BlaBlaCar.

Feature	Airbnb	Uber	Etsy	TaskRabbit	BlaBlaCar
Hierarchy-like					
Platform provides "production" financing to providers	No	Yes	No	No	Yes*
Platform provides centralized mentoring	Yes	No	No	Yes	No
Platform facilitates peer-to-peer mentoring	Yes	No	Yes	No	Yes
Platform facilitates community groups among providers	Yes	Yes	Yes	No	Yes
Platform provides centralized customer support	Yes	Yes	No	Yes	No
Platform handles payment processing	Yes	Yes	Yes	Yes	Yes
Platform takes care of logistics in getting service to customers	No	Yes	No	No	No
Platform assigns provider to customers	No	Yes	No	No****	No
Platform assigns customer to providers	No	No	No	No**	No
Platform provides insurance, escrow, other risk-minimization	Yes	Yes	Yes	Yes	Yes
Platform provides day-to-day operational input to providers	No	Yes	No	No	No
Market-like					
Easy for provider to enter and exit provision	Yes	Yes	Yes	Yes	Yes
Provider acquires or uses owned assets for production	Yes	Yes	Yes	Yes	Yes
Provider takes on complex tasks of 'managing inventory/supply'	Yes	Yes**	Yes	Yes	Yes
Provider chooses pricing	Yes***	No	Yes	Yes	Yes
Provider free to merchandise as they see fit (description, photo)	Yes	No	Yes	Yes	Yes
Provider has in-person customer contact	Yes	Yes	No	Yes	Yes
Provider has virtual direct customer contact	Yes	No	Yes	Yes	Yes
New "hybrid" capabilities					
Peer-to-peer feedback systems	Yes	Yes	Yes	Yes	Yes
Transparent peer-to-peer feedback systems	Yes	No	Yes	Yes	Yes
Platform-based provider screening	Yes	Yes	No	Yes	Yes*****
Conduits to external trust indicators	Yes	No	Yes	Yes	Yes

*: As of April 2017, BlaBlaCar offers auto financing to selected highly active drivers
**: In some cities, Uber's staff may send information to drivers suggesting when to be available and where
***: Airbnb has a pricing tool built into the platform, but as of April 2017, its use is voluntary
****: TaskRabbit makes active suggestions, and restricts customers from browsing all available providers
*****: The screening varies by country; in some cases, it simply involves verifying a phone number

Table 1: Characteristics of five crowd-based capitalism platforms in 2017

A distinction here is between which factors facilitate *production* and which facilitate *exchange*. Much of what is embedded in these new platforms resembles what organization theorists might consider social or intellectual capital, the "knowledge and knowing capability of a social collectivity, such as an organization, intellectual community, or professional practice."[36] Rather than merely making it easier for peers to exchange goods or services with other peers, these are capabilities that enable the production of these goods and services by providers, and include many of the forms of capital one might normally find embedded within a hierarchical organization.

For example, a Lyft driver gains access to the codified knowledge about where to look for their next ride from the "heat maps" that the application delivers to each of its drivers, the procedural knowledge about what route is best from the platform's custom GPS navigator, and

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[36] This definition of intellectual capital is from Janine Nahapiet & Sumantra Ghoshal, *Social Capital, Intellectual Capital and the Organizational Advantage*, 23 ACAD. MGMT. REV. 242, 245 (1998).

the codified knowledge from Lyft of what constitutes an acceptable interior for their vehicle, while also acquiring (by doing) tacit knowledge about what mode of customer interaction is more likely to generate a tip, or what specific pockets of demand for higher fare rides might exist in different locations at different points in time. An Airbnb host acquires knowledge about pricing from a variety of sources: from the host's own experimentation and learning by doing; from the intellectual capital codified in Airbnb's pricing tool; by attending Airbnb-organized host events; and from conversations with the informal community of hosts that operate in the same city. A high-performing host acquires intangible "brand" capital, which, while embedded in the proprietary Airbnb review system and not legally owned by the host, is inextricably associated with that specific host and cannot simply be appropriated by Airbnb and transferred to a different host.[37]

The intellectual capital represented by this knowledge appears to be both in the form of what Gary Becker[38] might consider human capital, "the knowledge, information, ideas, skills, and health of individuals," as well as what some management theorists would label structural capital, the infrastructure and processes traditionally held by a firm that allow human capital to function. Put differently, the individual may be acquiring some of the structural capital that was previously held by the company the individual was employed by. Each of the four forms of knowledge described by Spender that comprise an organization's intellectual capital—individual explicit, individual tacit, social explicit, and social tacit—seem to both be made available by a platform, as well as acquired and "held" by individual providers.[39]

Digital technologies are thus shifting the scale, mix, and roles of the institutions that have historically facilitated the provision of trust and the use of structural intellectual capital in economic activity. In a simplified view of twentieth century industrial capitalism, individuals who held human capital would work as salaried labor and talent providers for organizations, which developed and held other forms of intellectual capital and intangible capital to enhance the value of the individual human capital. Economic exchange between these organizations

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[37] An interesting example of the transferability of this kind of personal "brand" across platforms was illustrated when ridesharing platform Juno entered the Manhattan market in April 2016, allowing only those Uber drivers who had a rating on Uber of 4.65 or above to join and provide transportation through the Juno platform. *See* Sheelah Kolhatkar, *Juno Takes on Uber*, NEW YORKER (Oct. 10, 2016), http://www.newyorker.com/magazine/2016/10/10/juno-takes-on-uber [https://perma.cc/2T75-U5HE].

[38] *See generally* GARY S. BECKER, HUMAN CAPITAL: A THEORETICAL AND EMPIRICAL ANALYSIS, WITH SPECIAL REFERENCE TO EDUCATION (1964).

[39] *See generally* J.C. Spender, *Making Knowledge the Basis of a Dynamic Theory of the Firm*, 17 STRATEGIC MGMT. J. 45 (1996).

was facilitated by the trust systems in economic institutions that included banking, contracts, and courts of law, as well as by government regulations often aimed to protect smaller businesses from larger ones. A mix of brand and government regulation created enough trust for consumers to interact with these organizations.

In the emerging world of crowd-based capitalism, many of these boundaries are blurred. The scale of a provider is often reduced to that of an individual microbusiness, and what used to be enabled by government regulation and economic institutions is often facilitated by trust systems the platform provides. The intellectual capital and intangible capital held by organizations are redistributed between platforms and individual microbusinesses. In some cases, like that of transportation services using Uber, much of this capital remains with the large institution, the platform. In other cases, like that of short-term accommodation businesses run through Airbnb, or retailing businesses through Etsy, the provider appears to hold a greater fraction of this capital.

C.   Crowd-Based Capitalism and Value Distribution

This division of intellectual capital (and in particular, structural capital) and intangible capital between the platform and the provider is a central determinant of an equitable future of work. The lens used to study inequality shifts by French economist Thomas Piketty helps understand why this is the case. At the core of Piketty's 2014 book is a simple argument: inequality persists because the historical returns on capital (r) are persistently higher than the overall rate of growth (g) in the economy, while the rate of growth of wages that are paid in exchange for labor and talent is roughly the same as this overall rate of growth g.[40] As articulated by Piketty:

> The inequality r > g implies that wealth accumulated in the past grows more rapidly than output and wages. This inequality expresses a fundamental logical contradiction. The entrepreneur inevitably tends to become a rentier, more and more dominant over those who own nothing but their labor. Once constituted, capital reproduces itself faster than output increases.[41]

This observation, aimed at explaining the persistent recent rise in income and wealth inequality, also highlights the promise of crowd-based capitalism that genuinely decentralizes the ownership of capital. It can increase the fraction of a workforce that makes money through

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[40]   *See generally* THOMAS PIKETTY, CAPITAL IN THE TWENTY-FIRST CENTURY (2014).

[41]   *Id.* at 571.

investing or owning rather than providing labor in exchange for a salary, allowing a greater fraction to occupy new locations in the established economic equation, moving from wage receivers to capital owners, thus expanding the fraction of the population that have the "r" kind of growth in their returns rather than the "g" kind.

Although state intervention to preserve the viability of business models of existing large corporations (and especially those that employ large numbers of workers) seem quite likely, and may slow the pace of evolution to crowd-based capitalism, a government's resources might be better spent instead shaping a transition that favors those platform models that are creating genuine individual-owned businesses. An expansion of the fraction of the population engaged in capital ownership will better insulate the workforce from improvements in the capabilities of automating machines.

In the future, an aspiring law associate might instead become a tiny law firm operating through a legal services platform, gaining access to corporate clients the platform aggregates and maintains relationships with, while leveraging AI enabled legal research capabilities. Micro-entrepreneurs might run urban transportation local trucking businesses using fleets of autonomous cars or trucks through a ridesharing platform (much like the numerous entrepreneurs who offer fleets of five to ten vehicles for rental through the peer-to-peer car rental platform Getaround today). Global consulting firms might evolve into platforms through which millions of individuals run micro-consulting practices (or even small partnerships). A wide variety of highly differentiated micro-educators, aided by online materials and AI-enabled teaching tools, could dramatically increase the supply of supplementary education at different levels and life stages. Over time, a percentage of these new "micro-entrepreneurship" opportunities that empower individuals previously constrained by employment at traditional corporations may evolve into enterprises larger than sole proprietorships. In contrast, if crowd-based capitalism converges towards systems where the humans in the crowd are simply sources of labor and talent, it is far more likely that there will be widespread workforce displacement.

Given these two potential futures, it is natural to ask whether there are specific economic characteristics associated with an industry that predict how prevalent crowd-based capitalism will eventually be, and whether there are specific government interventions that can steer outcomes towards the societally optimal level of decentralized capital ownership. I do not have a clear analytical answer to either question as yet. A model of crowd-based capitalism with genuinely decentralized capital

ownership seems to have emerged naturally in short-term accommodation and in peer-to-peer retailing, but not in decentralized transportation.

Examining what trajectory is likely in one specific industry and the factors that shape this trajectory may be illustrative nevertheless. It is widely believed, for example, that at some point in the not so distant future, fully autonomous (or what is currently called "level 5" autonomy) vehicles that can drive themselves will be prevalent. As this future emerges, are we likely to see today's Uber, Lyft and taxi drivers in the United States evolve into millions of fleet owners who earn a living as capital owners by deploying their vehicles through a platform? Or will we end up with centralized platforms that operate millions of owned or leased vehicles?

The answer depends on a number of factors, some relating to the economic fundamentals of transportation, and others to regulatory path. It is widely accepted that as assets, owned personal vehicles are utilized with what seems to be a very low degree of efficiency.[42] The persistence of this inefficiency is in part because, with the current technology, owning a car and using it sparingly is still more economically attractive than calling a taxi every time one needs transportation. However, this inefficiency may also persist because the identity of many individuals is tied to their car ownership, and perhaps also because there is value perceived by consumers in having transportation available immediately when needed.

When fully autonomous vehicles arrive, lowering the average cost per mile of on-demand transportation, and expanding the fraction of the population for whom calling a car on-demand costs less than owning a car, the eventual industry structure depends in part on how large this expansion will be. If just 50% of current car owners are potential on-demand transportation customers (the rest perhaps living in parts of the country where residences and businesses are too far away from each other to share transportation effectively), an active market for purchasing personal vehicles will remain, which will in turn spawn a "secondary" market for on-demand transportation using underutilized and personally owned capacity. It seems quite likely in this scenario that there will be lots of room for decentralized capital ownership. In contrast, if

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[42] A variety of studies have established that personal vehicles are put to use only a fairly small fraction of the time. For example, my analysis of data from the National Household Transportation Survey indicates that vehicles in California were utilized an average of 4.6% of the time. *See* Samuel Fraiberger & Arun Sundararajan, *Peer-to-Peer Rental Markets in the Sharing Economy*, (NYU Stern School of Bus. Research Paper, 2017) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2574337## [https://perma.cc/38DF-LHW9].

urbanization and other changes in residential living make an on-de-mand transportation solution economically viable for close to 100% of the population, the likelihood of capital centralization is higher. Clearly, the strength of the other consumer effects alluded to earlier—the identity effect and the value perceived in having transportation parked in one's driveway—will matter as well.

Regulatory history is another factor. Along with social/cultural ac-ceptance, regulatory issues rather than the technological capabilities of the vehicles remain the biggest hurdle to mass-market autonomous ve-hicle adoption. Although federal regulations may dictate standards for the "brain" of the car, each city, state and local government can dictate what is on its roads. Until we figure out all the "edge cases," train vehi-cles to deal with them, and grow citizen confidence, this regulatory path will be slow.

As a consequence, holding everything else constant, it is more likely that the first mass-market fully autonomous vehicles will emerge through platforms like Uber and Lyft rather than as owned Fords, not because of technological superiority, but because the code embedded in the on-demand platforms will be able to credibly enforce the complex mesh of different regulations and restrictions initially placed on fully autonomous cars. (Ironically, this may lead to a future in which regula-tion, rather than posing a barrier, creates an advantage for on-demand transportation.) This development may cause current automobile man-ufacturers makers to offer their own on-demand model as well (Ford has pre-announced one, and BMW and Daimler have on-demand busi-nesses already), biasing the likely long-term equilibrium towards a greater centralization of capital ownership.

V.   POLICY GUIDELINES

A.   Capital Ownership

A particularly attractive feature of crowd-based capitalism is its promise to redistribute and make less unequal the ownership of capital. But this promise is just a possibility, and not a certainty. My guidelines are in contrast with other proposed policy responses to digitally enabled automation which focus more heavily on the redistribution of income rather than of capital ownership, most radically through the increas-ingly popular proposal of a universal basic income,[43] although also in

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[43] *See*, *e.g.*, ANDY STERN & LEE KRAVITZ, RAISING THE FLOOR: HOW A UNIVERSAL BASIC INCOME CAN RENEW OUR ECONOMY AND REBUILD THE AMERICAN DREAM (2016). The extent of sup-port for this idea is reflected in a letter signed by a diverse array of executives, policy thinkers and academics. *See* ECON. SECURITY PROJECT, http://economicsecurityproject.org/ [https://perma.cc/9G

the form of progressive taxation and a capital tax.[44] As crowd-based platforms continue to proliferate and grow, and emerge in new industries like healthcare, energy, and professional services, the single most important broad policy guideline is to favor platform models that lead to genuine and decentralized capital ownership.

As some of the larger platforms become publicly traded corporations, such policy could take the form of government tax incentives that favor the issuing of "provider" stock ownership programs—under which providers are allocated shares in a platform.[45] Additionally, there may be a need to revise current U.S. antitrust laws that consider collective action by groups of non-employee providers anticompetitive. Collective bargaining power among providers will be important in shaping the future division of structural capital between providers and platforms. (For example, providers who wish to retain asset availability decision-making that a platform might want to centralize should not face onerous legal barriers to negotiating collectively.) Finally, since providers build "brand capital" through their online reputations, giving providers ownership over the associated data, perhaps through an extension of current intellectual property law would be good policy. This will allow the providers to credibly port not just the summary information but the details underlying their brand capital from one platform to another, increase the value of the associated intangible capital.

Beyond these prescriptions, policy makers need to tailor interventions that take into account specific industry characteristics. As reflected in Table 1, there is no optimal "one size fits all" split of capital ownership between providers and platforms. Some industries simply lend themselves more naturally to a greater level of decentralization. It seems natural for Airbnb hosts to choose differing prices for the diverse and differentiated accommodations they offer, and for consumers to compare alternatives when planning a vacation. In contrast, it seems less commercially viable to expect customers to choose between multiple drivers with differentiated offerings and prices when requesting a

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WV-WT5W].

  [44] *See* Jeffrey D. Sachs et al., *Robots: Curse or Blessing? A Basic Framework* (Nat'l. Bureau of Econ. Research, Working Paper No. 21091, 2015), http://www.nber.org/papers/w21091.pdf [https://perma.cc/6KXC-22BU].

     For a discussion of how a capital tax can help alleviate a rise in inequality following a robotic technology induced productivity shock, see Jeffrey D. Sachs & Laurence J. Kotlikoff, *Smart Machines and Long-Term Misery* (Nat'l Bureau of Economic Research, Working Paper 18629, 2012), http://www.nber.org/papers/w18629.pdf [https://perma.cc/UX9J-DWV4].

  [45] For further discussion, see OURS TO HACK AND TO OWN: THE RISE OF PLATFORM COOPERATIVISM, A NEW VISION FOR THE FUTURE OF WORK AND A FAIRER INTERNET (Trebor Scholz & Nathan Schneider eds., 2017).

short taxi ride. A standardized categorization of vehicle and fare by the platform seems more natural.

B.   New Approaches to Regulation

As crowd-based capitalism redefines the role of different institutions in the economy, society's approach to regulating business must evolve. This is natural. Regulation is often created to bridge gaps in trust that may otherwise lead to market failure. When institutions that create commercial trust evolve, new ones emerge, and the boundaries between these institutions shift, it seems natural to re-examine an economy's approach to regulation. Digital precursors to crowd-based capitalism may have, *de facto*, started to return us to a model of trust built on community consensus and gained reputation. Such community-generated trust has been digitized through peer reviews for real-world institutional businesses. User-generated reviews of restaurants can affect the establishment's bottom line or help city health departments trace food-borne illness; such crowd-based monitoring can complement traditional regulations, detecting deficiencies in and inducing enforcement of regulations already on the books.

However, the intensity of regulatory resistance to early crowd-based capitalism platforms like Airbnb, Uber, and Lyft suggest that the broader regulatory transition will not happen naturally. Often, crowd-based providers and the platforms that enable them emerge without formal government approval. It is critical that this "experimental" nature of innovation is preserved. Since such entry disrupts the stability and continuity of rules, regulators will often try to fit innovative services into existing frameworks rather than updating frameworks to accommodate innovation.[46] As the number of independent commercial providers scales well into the millions in many industries, rigid enforcement of existing regulation will slow the transition.

A few simple guidelines can help. First, because platforms represent a new generation of third-party institutions that mediate peer-to-peer transactions, they can be called on to define or enforce rules that govern these transactions. Twenty years ago, a taxicab regulatory body was essential to prevent market failure. Today, because Uber, Lyft and Didi Chuxing exist as intermediaries, they can take on many of the roles that the government was forced to play. The space of possible regulatory solutions is expanded.

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[46] This issue is discussed at length in Sofia Ranchordás, *Does Sharing Mean Caring? Regulating Innovation in the Sharing Economy*, 16 MINN. J. L. SCI. & TECH. 413 (2015).

Next, whether or not to delegate responsibility depends in part on who holds the data necessary for regulation,[47] as well as whether the interests of a crowd-based platform align well with those of society. For example, Airbnb's profit motive creates a natural incentive to ensure that hosts accurately represent the quality of their lodging; commercial and societal interests are well aligned. In ensuring that guests are not too noisy, however, Airbnb may not hold the best data, and may be faced with an additional conflict between commercial and social objectives.

Finally, decentralized capital ownership and an associated reduction in centrally mandated "standards" will naturally lead to greater variety in scale and quality. Thus, what might have been an easy "one size fits all" approach to, say, regulating taxicabs and limousines might be challenged when one has a range of different private cars, taxis, motorcycles, and other forms of shared transportation. Similarly, the sheer variety of options on Airbnb, relative to that of hotels, suggests that regulations that may be sufficient for, say, spare bedrooms may not be adequate for tree-houses or houseboats. Concurrently, there is a widespread expansion of the range of commercial scale. Micro-entrepreneurs making and selling handcrafted wooden toys on Etsy or renting out spare rooms on Airbnb may find onerous a body of regulations developed with major toy manufacturers like Mattel or a major hotel chain like Hilton in mind. New regulations must be designed so that they do not place insurmountable restrictions on micro-entrepreneurs.[48]

C.   Rethinking Education Policy

The shift in the production role of the typical individual earner in society, from provider of labor and talent in exchange for a salary to microbusiness owner necessitates a fundamental rethinking of post-secondary education. Countries around the world, most saliently the U.S., have invested heavily into creating universities and colleges that prepare, early in life, their workforces for a career of full-time employment. One change that will be essential is altering the mix of such education to be better suited for an economy of entrepreneurs, emphasizing design, creativity, and entrepreneurship education over deeper investments into cognitive skill-heavy professions with a higher probability of automation.

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[47] *See* Sundararajan, *supra* note 4, at 155–58 (discussing this idea of "data-driven delegation").

[48] *See, e.g., id.* at 131–158; *see also* ARUN SUNDARARAJAN, THE COLLABORATIVE ECONOMY: SOCIOECONOMIC, REGULATORY AND POLICY ISSUES 21–28 (2017), http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/595360/IPOL_IDA(2017)595360_EN.pdf [https://perma.cc/2S8G-C8KY].

More importantly, the focus of post-secondary education must shift away from one-time early life degrees and towards continuing education. Recent political outcomes in the U.S. and the U.K. reflect in part a significant underinvestment into creating new opportunities for a workforce displaced by automation and ill-equipped for a new world of work. We need new university-like institutions that can fill this gap, providing individuals in transition with structured and pedagogically sound education accompanied with a new professional network and access to new opportunities, facilitating relocation to pursue a new career more naturally, imbuing workers in flux with a new identity and sense of purpose, rebuilding self-worth to allow transition with dignity. Seeking this sort of mid-career intervention should be as natural as choosing to go to college after high school, a new rite of passage.

Creating such an ecosystem will necessitate the right government interventions. While the mix of post-high school education may naturally evolve over time in response to market forces, it is not realistic to expect a slew of robust new continuing education institutions to emerge naturally. The managerial revolution of the twentieth century in the United States was made possible in part by the universities that emerged from the federal subsidies given to states under the Morrill Land-Grant Act of 1862.[49] Although these institutions perhaps did not immediately fulfill their stated goal of teaching "agriculture and the mechanic arts," the Act laid the foundations for a nationwide and broadly accessible post-secondary university system.[50] A similar intervention aimed at continuing education is needed.

In parallel, the social contract must be refashioned to accommodate a different kind of workforce. During the second half of the twentieth century, a variety of labor laws have been developed to improve the quality of work life for full-time employees, including minimum wages, overtime, and insurance. A number of other incentives—fixed salaries, paid vacations, workplace training, and healthcare—that fulfill different human aspirations, are funded based on the assumption that the model of work is full-time employment and the employer will fund all or part of the incentive. The design and funding of this social safety net must be adapted for a workforce that is increasingly independent, while also creating substitutes for the career paths and community that a growing fraction of the workforce now gets from the company that they work for. Perhaps the role of the post-secondary university will evolve to include this kind of lifelong career planning.

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[49] 7 U.S.C. §§ 301–309 (2012).

[50] *Id.*

TAB 12

REWORKING THE REVOLUTION

Are you ready to compete as intelligent technology meets human ingenuity to create the future workforce?
#FutureWorkforce
#AppliedIntelligence

By Ellyn Shook and Mark Knickrehm

THE REVOLUTION

Intelligent machines are revolutionizing every aspect of our lives. Leading businesses are successfully using artificial intelligence (AI) to improve productivity. But to achieve superior rates of growth, and to create a new wave of employment, they must now apply AI in more innovative ways.

An alliance between humans and machines will usher in a new era of work and drive competitive advantage. The full promise of AI depends on humans and machines working together to develop differentiated customer experiences and to create entirely new products, services and markets. That is the real opportunity of AI.

Accenture estimates that this could boost business revenues by 38 percent in the next five years and generate higher levels of profitability and employment. To succeed, leaders must reimagine the nature of work today. Taking bold leaps means redefining the roles of people, shifting your workforce to new business models and scaling up "New Skilling" to harness intelligent technologies. It means doing things you never could before. Starting now.

Are you ready to take advantage of this opportunity in 2018? This paper aims to lay out the terrain and equip leaders to ask tough questions about your own organization's readiness to succeed in the era of AI.

38% REVENUE BOOST

estimated over the next five years for those fully committing to AI and investing in human–machine collaboration.

A FUTURE OF PROMISE

Business is on the brink of a brave new world wrought by artificial intelligence (AI).

A revolution in which intelligent technology meets human ingenuity to create the future workforce, one that promises previously unobtainable sources of growth and innovation.
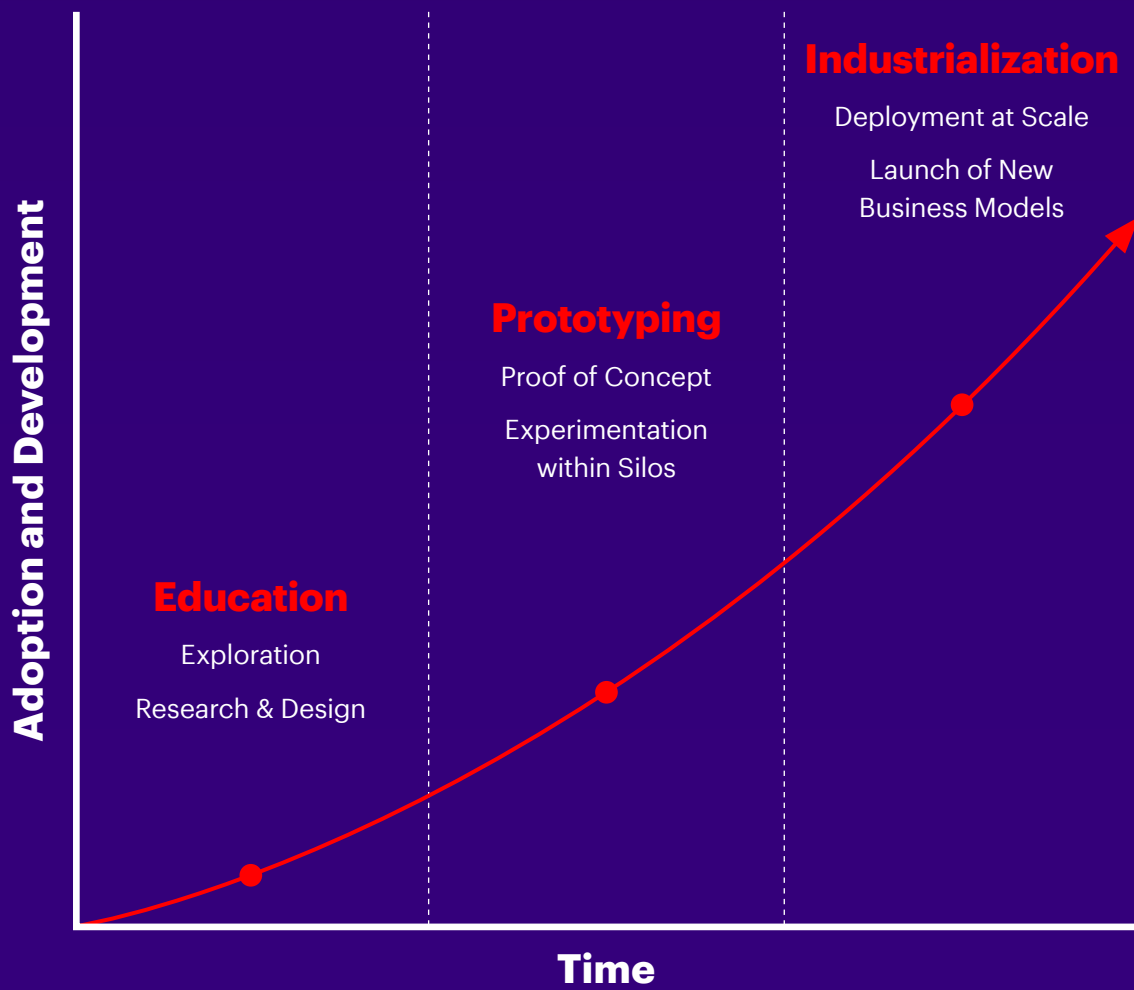
Until now, robots, big data analytics and other technologies have been used to work in parallel with people but in automated isolation. Their role: improve process efficiencies. Now, as companies invest in AI systems that can sense, communicate, interpret and learn, all that changes. AI can help businesses move beyond automation to elevate human capabilities that unlock new value.

Today, many businesses have yet to apply AI in this way to improve efficiencies or customer outcomes. They are at the first of three stages of adoption: education. In most cases, businesses have reached the second stage: prototyping and experimental initiatives. Only a few are embarking on the third stage: large-scale application. They are practicing what Accenture terms Applied Intelligence, the ability to implement technology and human ingenuity across all parts of their core business in order to solve complex challenges, break into new markets or generate entirely fresh revenue streams (see Figure 1). These include the online clothes retailer entering a crowded market to change the way consumers buy, the long-established sports shoemaker transforming the way manufacturers make and sell, or the pharma-tech company that fast-tracked initial phases of drug discovery to shortlist possible therapies for reducing rates of Ebola infection and multiple sclerosis.

The growth prospects of the AI revolution are not limited to such immediate outcomes. To take a lesson from history, the launch of the Ford Model T did not just replace horse-dependent labor with manufacturing employment. It ushered in an age of personal mobility that underpinned 20th century economic growth by opening the way to new industries and markets. Likewise, AI will have an exponential impact. But the speed of the digital revolution is unprecedented. According to Gartner, Deep Learning and Machine Learning, two key emerging AI technologies, will reach mainstream adoption within two to five years.[1] If businesses are to reap rewards from these developments, they need to take urgent action now.

Stages of adoption and development of new technologies.

Figure 1

Industrialization

Deployment at Scale

Launch of New
Business Models

Prototyping

Proof of Concept

Experimentation
within Silos

Education

Exploration

Research & Design

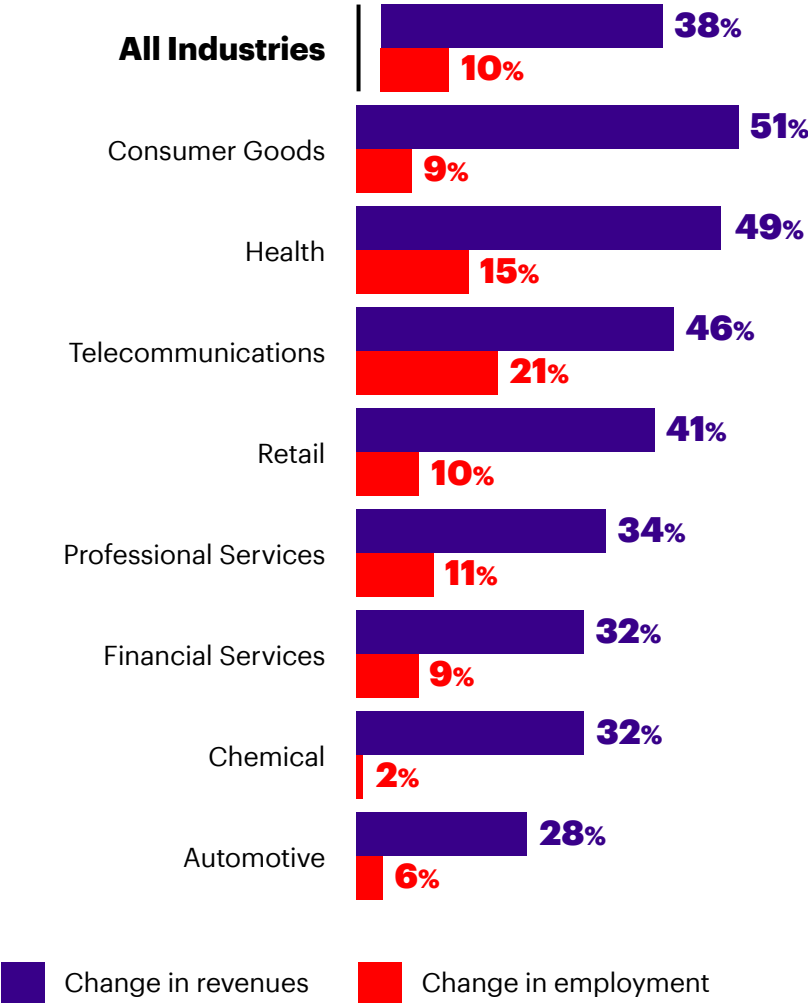**Adoption and Development**

Time

How higher AI investment can boost revenues and employment by industry, 2018 to 2022.

Accenture estimates that if companies invest in AI and in human–machine collaboration at the same rate as top-performing businesses, they could boost revenues by 38 percent between 2018 and 2022 (as much as 50 percent in the consumer goods and health sectors) and lift global profits by a total of US$4.8 trillion by 2022. For the average S&P 500 company, this equates to US$7.5 billion of revenues and a US$880 million lift to profitability. They could also increase employment by 10 percent (see Figure 2).

Figure 2

Industry	Change in revenues	Change in employment
All Industries	38%	10%
Consumer Goods	51%	9%
Health	49%	15%
Telecommunications	46%	21%
Retail	41%	10%
Professional Services	34%	11%
Financial Services	32%	9%
Chemical	32%	2%
Automotive	28%	6%

■ Change in revenues   ■ Change in employment

Source: Accenture Future Workforce Study 2017

AI offers insights that allow humans to make informed judgments.

The power of the new relationship between people and intelligent technology is becoming clear. For example, a Harvard-based team of pathologists recently created an AI-based technique to identify breast cancer cells with greater precision.

Pathologists beat the machines with 96 percent accuracy versus 92 percent. But the biggest surprise came when humans and AI combined forces. Together, they accurately identified 99.5 percent of cancerous biopsies.[2] With nearly 1.7 million new cases of breast cancer diagnosed globally each year,[3] this translates to 68,000 to 130,000 more women receiving accurate diagnoses than if we relied on humans or machines alone.
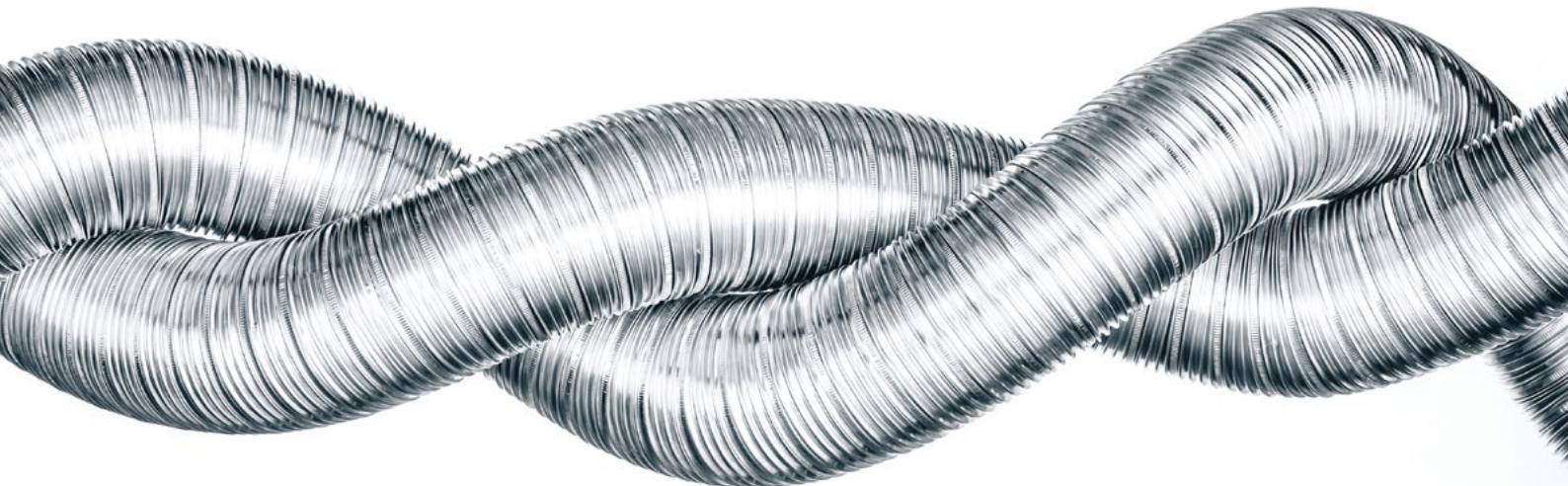
This kind of success depends on people continuously interacting with AI, in this case, training and retraining it to identify the right kind of cancer cell so that its performance improves. As systems such as this become more intelligent, they will proactively offer insights that enable doctors to make far more informed judgments and to offer more specific treatments.

> **"We want to take the use of artificial intelligence and data analytics to the next level in the automotive industry. I firmly believe this will help us to be more innovative and agile in the rapid introduction of new technologies, particularly for enhanced health and wellness and intuitive human–machine interfaces."**
>
> Patrick Koller, CEO, Faurecia

THE GLOBAL STUDY

Are business leaders and workers ready to take on human–machine collaboration of such sophistication and at a large scale?

To find out, Accenture Research spoke with more than 1,200 CEOs and top executives working with AI. We also surveyed more than 14,000 workers spanning four generations and representing all skill levels. The research covered 12 industries and 11 economies and included interviews with people working with AI in their daily work. Among the findings:

Three quarters (74 percent) of executives say they plan to use AI to automate tasks to a large or a very large extent in the next three years. But almost all (97 percent) note they intend to use AI to enhance worker capabilities.[4] Reflecting the intention to go beyond the prototype stage to the industrialized stage of AI application, they envision creating new sources of value by enabling their people to collaborate with intelligent machines. And investment in AI is growing strongly. Worldwide spending on cognitive and AI systems was forecast to have increased 59.1 percent in 2017 compared to 2016, reaching US$12 billion, according to IDC, and will rise to US$57.6 billion in 2021.[5]

These numbers paint a positive picture, but business leaders are struggling to match this commitment with action to transform the workforce: Even though almost half of business leaders in our survey identify skills shortages as a key workforce challenge, only three percent say their organization plans to increase investment in training programs significantly in the next three years. This low level of commitment will radically curtail their ability to deploy AI at scale.

> **"Often people only think of AI boosting growth by substituting humans. But actually huge value is going to come from the new goods, services and innovations AI will enable."**
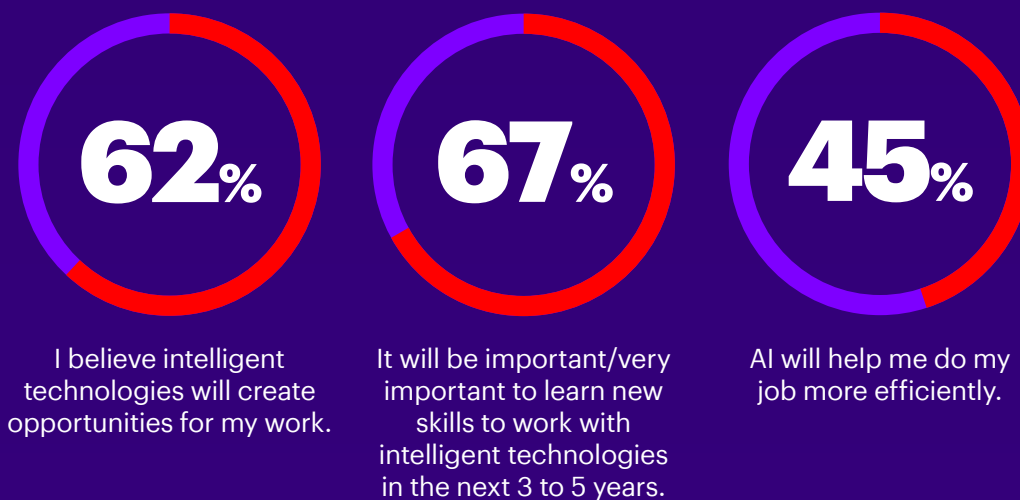>
> David Autor, Professor of Economics, MIT

ONE BARRIER

Employers underestimate the willingness of employees to acquire the relevant skills.

On average, they deem only about a quarter (26 percent) of their workforce as ready for AI adoption. Nearly one in four cite resistance by the workforce as a key obstacle. However, as our research revealed, 68 percent of highly skilled workers and nearly half (48 percent) of their lower skilled peers are positive about AI's impact on their work. Overall, 67 percent of workers consider it important to develop their own skills to work with intelligent machines. Millennials strongly support this view (75 percent) but even 56 percent of baby boomers do as well. Workers are impatient to embrace AI (see Figure 3).

Figure 3

62% — I believe intelligent technologies will create opportunities for my work.

67% — It will be important/very important to learn new skills to work with intelligent technologies in the next 3 to 5 years.

45% — AI will help me do my job more efficiently.

ONLY 3%

of executives say they intend to significantly increase investment in training and reskilling programs in the next three years.

Source: Accenture Future Workforce Worker and C-Suite Surveys 2017

WHAT'S OFTEN OVERLOOKED

Workers are also consumers. They already dictate grocery lists to Alexa and ask Siri for restaurant suggestions.

They expect personalized services delivered by AI. So at work, why wouldn't they anticipate that intelligent machines will continuously inform them and proactively uncover new insights that help them make their customers' lives better? Business leaders must seize this opportunity: Their people not only want new skills. They are impatient to thrive in an intelligent enterprise that can disrupt markets and improve their working experience.

How can business leaders elevate their workforce to create new value through human–machine collaboration? Our research points to three key actions.

1

REIMAGINE WORK

**from workforce planning
to work planning.**

2

PIVOT THE WORKFORCE

**to areas that create new
forms of value.**

3

SCALE UP "NEW SKILLING"

**to work with
intelligent machines.**

1

REIMAGINE WORK

REIMAGINE WORK

From workforce planning to work planning.

Forecasts of AI's impact on jobs vary. In January 2018, the World Economic Forum, in collaboration with Accenture, released analysis that reveals a smaller net loss of jobs than some studies have predicted. The study estimates that 16 percent of jobs are at risk of displacement in five production industries after accounting for potential job gains that would arise from the same trends. Even as automation continues, demand for labor will increase in parts of the value chain and in some locations.[6]

But a focus only on job gains and losses misses a crucial point: **The most significant impact of AI won't be on the number of jobs, but rather on job content.** Nearly half of the executives we surveyed (46 percent) said that traditional job descriptions are obsolete as machines take on routine tasks and as people move to project-based work. Twenty-nine percent of leaders report that they've extensively redesigned jobs.

Consider Fast Retailing, the Japanese retail holding company, which implemented an AI-enabled device for its shop assistants. The technology provides real-time data on inventory, orders and returns, freeing assistants to have more informed conversations with clients.[7] The company, which reported record sales and a profit increase of nearly 39 percent in its most recent financial year, plans to use AI to improve speed to market as part of its strategy to increase revenue by nearly 70 percent by 2021.[8]

46% of executives say job descriptions are obsolete.

How AI is elevating workers to add more value.

It should therefore come as no surprise that 61 percent of senior executives said that the proportion of roles requiring people to collaborate with AI will rise in the next three years. Figure 4 shows how work is transformed and how workers are elevated.

For example, Morgan Stanley is augmenting the work of its 16,000 financial advisors through the introduction of AI agents. By learning about their clients, the intelligent advisors continually interact with their human co-workers to proactively recommend a range of options that take into account their clients' changing financial situations. Financial advisors are consequently better placed to contact clients at the right time with more relevant advice.[9]

It's not just a case of AI enhancing human capabilities, but of humans improving the performance of intelligent technologies. It is perhaps for this reason that 63 percent of executives in our survey expect that AI will create net job gains in their organization in the next three years.

In previous research, Accenture explored the nature of some new roles and uncovered three new categories of AI-driven jobs: the "trainers," "explainers" and "sustainers."[10] Trainers, for example, will help computers learn to recognize faces. Explainers will interpret the results of algorithms to improve transparency and accountability for their decisions, helping to strengthen the confidence of both customers and workers in AI-powered processes. Sustainers will ensure intelligent systems stay true to their original goals without crossing ethical lines or reinforcing bias. For example, this could include an ethics compliance manager to ensure that an AI-powered credit approval system does not discriminate against certain categories of customers (see more on Responsible AI on page 35).

The evolution of work and the elevation of workers.

Figure 4

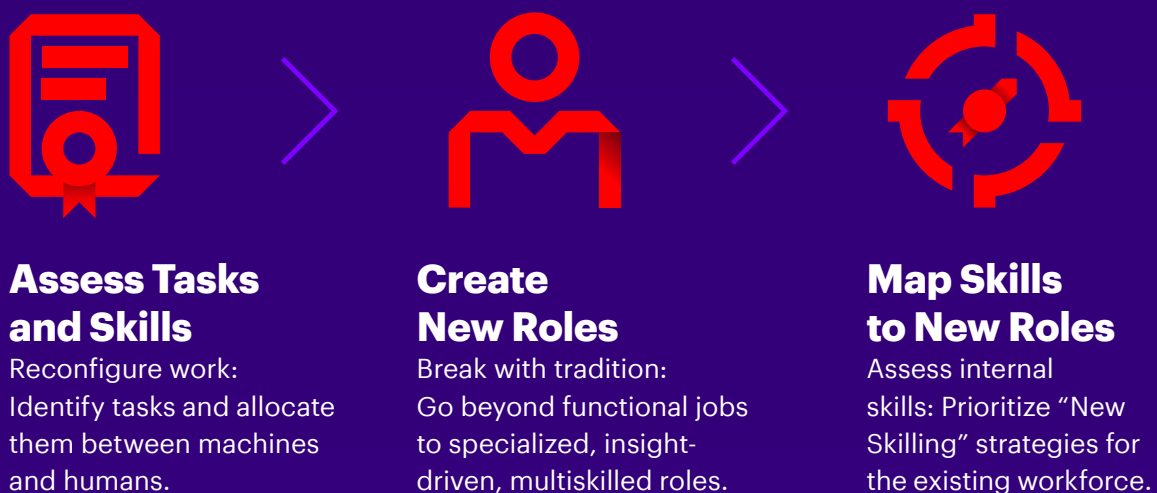A **drilling technician** drills multiple test holes, **manually preparing the drill, calculating and entering correct pressure and speed for the drill.**

AI tells the drilling technician which oil deposits to target and **intelligent drills** calculate speed, pressure and depth.

A **pharmacovigilance scientist combs through vast volumes of documents** in order to assess safety issues related to drugs.

AI, using **Natural Language Processing and Machine Learning,** helps free scientists to work on higher risk cases and cater to growth in Adverse Event cases.

A **software developer** spends time each week identifying new spam flags and **manually writing rules for spam detection.**

Machine intelligence identifies new spam keywords and updates detection rules, freeing the employee from work unrelated to new software development.

An **aerospace engineer** designs a new plane component making **manual calculations** to produce strong and light designs.

Generative Design mimics nature's evolutionary approach to consider millions of possible designs and tests for strength and lightness.

A **long-haul driver** controls the **vehicle** on the road, in charge of the speed, braking and steering.

The driver becomes an **"in-cab systems manager,"** performing high-level technical work, such as monitoring diagnostics systems and optimizing routing tasks as automation controls braking and speed.

Source: Accenture Future Workforce Ethnographic Study 2017

ACTIONS TO REIMAGINE WORK

While just over half of all employers acknowledge that getting human–machine collaboration right is critical to achieving their goals, few have adopted a systematic approach to unlock the value that lies at the intersection of people and intelligent machines.[11] The principle is to move the spotlight from jobs to the nature of the work itself before preparing workers with the necessary skills. When reconfiguring work, organizations need to take three steps (see Figure 5):

Figure 5

Assess Tasks and Skills
Reconfigure work: Identify tasks and allocate them between machines and humans.

Create New Roles
Break with tradition: Go beyond functional jobs to specialized, insight-driven, multiskilled roles.

Map Skills to New Roles
Assess internal skills: Prioritize "New Skilling" strategies for the existing workforce.

i) Assess tasks and skills, not jobs

First, companies need to identify the new kinds of tasks that must be performed. Assessing the range of technologies and teams at their disposal, they can then allocate those tasks to people or machines.

Dynamic Group, a US manufacturer, faced skills shortages in its injection molding production business. Using light robots that can work collaboratively side by side with workers, the company reallocated tasks accordingly. The investment quadrupled the efficiency of the process, reduced wastage from errors and saved existing workers repetitive and strenuous work.[12]

The process of allocating tasks between machines and robots is ongoing; it requires constant observation. Some companies are finding that they need to correct their initial allocation of work to machines. After all, many AI systems are not fully autonomous and require considerable input and adjustment from humans. In China, one vehicle technician we interviewed at an automaker found that a system analyzing massive amounts of customer data to help design cars with the right features was suggesting configurations that would be almost impossible to build. The company had to readjust roles so that people could train the AI to make more relevant recommendations.[13]

Designers' roles will change in sectors that can take advantage of generative AI software, such as that developed by Autodesk. This software mimics nature's evolutionary approach to design in order to develop creations that were not possible before. As the AI makes complex calculations to come up with designs, human co-workers set and reset aesthetic, engineering and material parameters that nudge the software through millions of concepts. This entirely collaborative process has been used by Airbus to design aircraft components that have to meet tough standards for strength and lightness. For example, the company produced a cabin partition 45 percent lighter than previous designs, which saved an estimated 3,180kg of fuel per partition per year,[14] more than twice the average annual fuel consumption of a car in the US.[15]

ii) Create new roles

Companies need to create new roles within a broader contextual shift as AI enables people to take on higher value work.

As Figure 6 shows, operational jobs will become more insight-driven and strategic, while mono-skilled roles will become multiskilled. For example, a trader at a Japanese investment firm explained how demand for people will change.

"We'll get workers to become familiar with AI or get workers who can make it smarter. They'll need experience as a trader and be strong in computers. They'll need to understand that deep learning works but that the data can't be perfect without a knowledge of trading."[16]

This evolution in work corresponds with the "trainer" and "sustainer" roles described earlier.

Jobs will also become more specialized as greater volumes of precise data allow more insights to be explored. For example, consumer brands will become increasingly dependent on AI chatbots to represent them in the mass market. Personality trainers will be required to develop the appropriate tone, humor and level of empathy needed for different situations. A health care AI agent must appreciate the sensitivity of patients in a different way than a supermarket AI agent would need to appreciate the mood and mindset of a groceries customer. Microsoft uses a team including a poet, a novelist and a playwright to develop Cortana's personality, without which this manifestation of the brand would be no different from any other.[17]

Reconfigured jobs are more strategic.

One of the greatest benefits of job reconfiguration: Employees take on higher value work, giving them a chance to be more strategic and to do more satisfying work.

Figure 6

Operational Roles	**Insight-Driven Roles**
Mono-Skilled Roles	**Multiskilled Roles**
Generalist Roles	**Specialized Roles**
Technology-Oriented Roles	**Creative Roles**
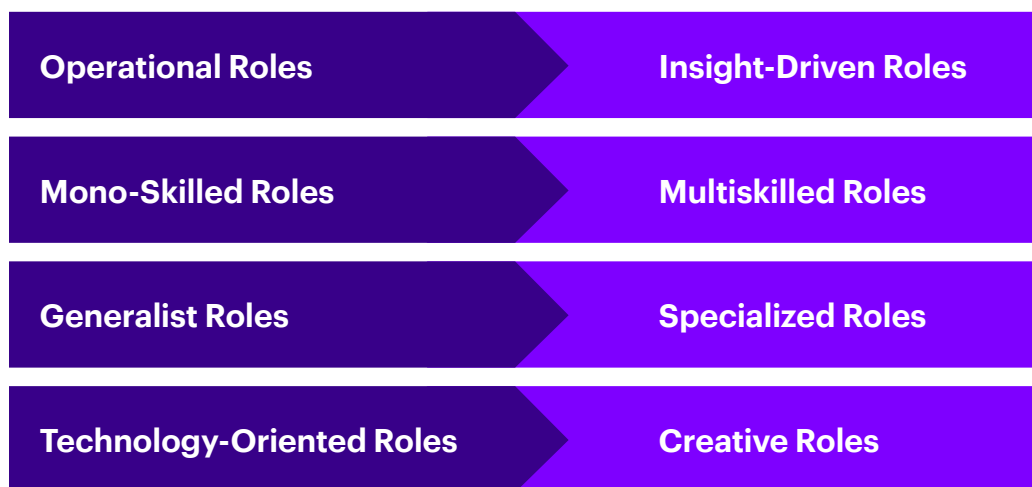
Source: Accenture Future Workforce Ethnographic Study 2017

Marriott checks out AI.

Marriott International puts AI at the heart of its pursuit of differentiation. Its TestBED is an accelerator for technology-driven customer experiences, giving startups a chance to trial products at the company's European hotels.[18]

One example: Mario, a robot at the reception desk of the Marriott Ghent, Belgium, speaks 19 languages and helps staff register guests.[19]

"Our AI council brings together subject matter experts from all disciplines within the company to consider new applications," said David Rodriguez, Chief Human Resources Officer, Marriott International. *"Ultimately, AI helps employees strengthen their relationship with guests by knowing them better. When we experiment with new technology, we implement it with a personal touch and ensure that we train our people in a localized way."*

Marriott's annual associate engagement survey reported its highest ever engagement scores in 2017.

iii) Map skills to new roles

Once a company has a full list of required tasks, skills and newly defined roles, it can map that list against the skills present in the workforce.

Where there are gaps in skills, companies must decide whether they can quickly train current employees or look for new sources of talent. In our research, we have found that some companies are addressing skills gaps with contract workers in the short term. Others have managed to align the skills of their existing workforce to the new requirements. One Indian telecoms company carefully analyzed changes in workflow to redefine roles when intelligent technologies were added.

Subsequently, the company's Chief Digital Officer told us, *"We then redesigned certain jobs, for example in customer support and logistics support, and provided training to our employees to operate these technologies in an efficient manner."* [20]

New intelligent platforms often result in changing roles. Consider Predix, a platform that can sense and predict faults in assets, such as aircraft engines. The company's technology assesses the performance of fleets of data in order to understand performance and the conditions that impact it. This allows maintenance workers to focus on fixing faults in place of making routine checks and gives engineers the data with which to pre-empt issues, resulting in more creative solutions down the line. The company has estimated it could save clients US$7 million in jet plane fuel annually through resulting engine efficiency. [21]

PIVOT THE WORKFORCE TO AREAS THAT CREATE NEW FORMS OF VALUE

AI is not simply the next in a line of new digital technologies. In the last century, perhaps only the motor car, the airplane and the internet have matched its potential to transform the way we work and live.

2 | PIVOT THE WORKFORCE

Today, AI and human–machine collaboration is beginning to have a significant impact on how enterprises conduct business.

But it has yet to transform what business enterprises choose to pursue. Just as Henry Ford could not have foreseen how the motor car would propel tourism, retail consumption, labor mobility or urbanization, we cannot know what opportunities await those who lead the AI revolution.

It is becoming clear, however, that as people and intelligent machines begin to collaborate in entirely new ways, business leaders will have to pivot their workforce not just once, but twice. The second and truly transformational shift may be less than a decade away in some sectors. In the meantime, business leaders must make a more immediate pivot to take full advantage of the opportunities human–machine collaboration presents today, which can create the springboard to entirely new future growth opportunities and market disruptions.

Executives seem to recognize the power of AI and humans to collaborate to create new customer experiences and business models. Seventy-two percent agree that adopting intelligent technologies will be critical to their organization's ability to differentiate in the market. Forty-two percent believe intelligent technologies will be behind every new innovation they implement in the next three years. This suggests that companies are positioning themselves to move from the prototype stage of development to larger scale applications, as suggested by Figure 1 (see page 5).

> **"Michelin solutions has used digital technologies, including IoT, to create innovative customer experiences that extend the value of our expertise. Part of the success is due to the way people collaborate with technology and data to offer new services. As businesses adopt artificial intelligence, human–machine collaboration to enhance human intelligence and capabilities will be a critical part of new business models."**
>
> Florent Menegaux, Senior Executive Vice President and Chief Operating Officer, Michelin Group
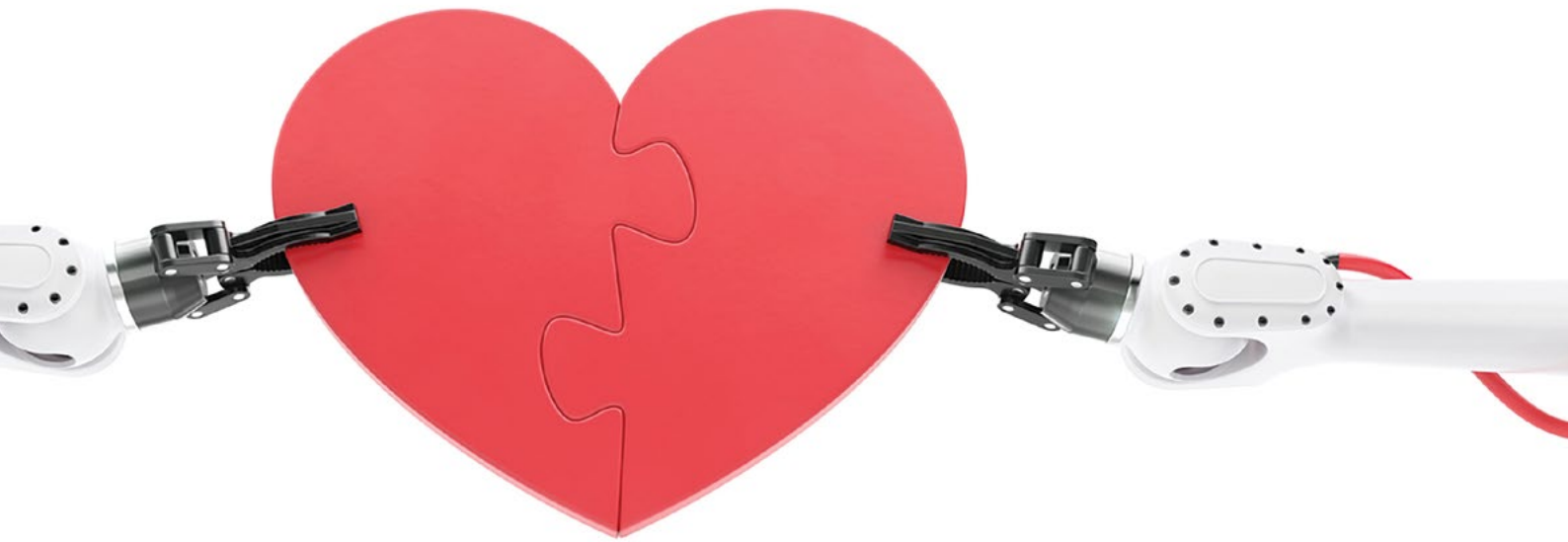
Marriott International is a pioneer in integrating its people with AI to create new value within its existing business. It is taking on the competition of both incumbents and digital players, such as Airbnb, with a growth model based on creating new technology-enabled experiences. Aside from its famous Relay and Botlr robots, which deliver towels and other items to guests' rooms, Marriott's new ChatBotlr uses Natural Language Processing to respond to guests' requests, relying on Machine Learning to get smarter each time it is used. At the heart of the company's successful drive for growth are innovations that reward loyalty and boost new revenue streams. It has launched recommendation engines to extend what it can sell to guests and new AI-powered chatbot apps that allow rewards customers to book direct on Facebook Messenger and Slack, saving on commission payments to travel agents.[22] The company reported a 20 percent year-on-year rise in adjusted net income in its latest financial results.[23] *See "Marriott checks out AI".*

2 PIVOT THE WORKFORCE

> **"Artificial Intelligence enables new services and revenue streams and is significantly changing how we deliver our telecom services now and in the future to our operator and vertical customers. AI has triggered a major shift in the skills of our engineers so they can deliver services faster and with higher quality."**
>
> Igor Leprince, President of Global Services, Nokia

Similarly, Carnival Corporation uses AI to create a competitive edge through enhanced customer experiences. AI helps crew members personalize engagement with its cruise ship guests. Using an Accenture-built solution, passengers wear Wi-Fi-enabled medallions holding information garnered by Machine Learning that collects and interprets their interests. The medallions alert nearby crew members who can anticipate passengers' needs and offer the bespoke kind of attention typically reserved for high-end guests.[24]

Driving growth opportunities with AI.

CenturyLink, a US-based telecommunications company, uses an AI agent called Angie that works with its sales managers. It saves them the virtually impossible task of cherry-picking the best of 30,000 sales leads per month. Angie sends emails to these leads, converses with them, interpreting responses in order to drop cases or to judge when to hand likely prospects to salespeople. The solution generates 40 hot leads a month and so far earns US$20 in new contracts for every dollar spent on the system.[25]

ACTIONS TO
PIVOT THE WORKFORCE

Executives should take immediate steps to pivot their workforce, but in doing so they must be sure that they are resisting the pressure to capture only short-term market advantage. They need to create the mindset, acumen and agility that will be required to seize longer term, transformational opportunities. This means ensuring that the workforce can adapt to new customer markets, that organizational processes can flex accordingly and that leadership is ready to champion a new culture. These four steps will help companies make that first, crucial pivot.

i) Align the workforce to new business models

Shift the purpose of your workforce to synchronize with your unique value proposition to customers.

Consider Stitch Fix, which stands out in clothes retail for its innovative use of human–machine collaboration. In place of salespeople, it has personal stylists who work with algorithms that interpret customers' preferences and learn more with every Pinterest post or returned item. Stylists use the information to improve the bespoke selections they make for customers.[26]

Adidas, the German sports apparel company, offers another example in the form of SPEEDFACTORY, its small but future-looking initiative to localize manufacturing in particular markets to meet demand for personalized products. Through SPEEDFACTORY, moving from design to production of a customized shoe can now happen in days. The initiative not only reduces time to market, but shifts the entire value proposition to satisfying demanding consumers with differentiated products. Importantly, it also requires a pivot to a highly specialized workforce of tailors, process engineers and others working closely with intelligent technology. The linchpin is the collaboration of people and robots in a series of overlapping production steps. Human hands are required, for example, to finally shape shoes that have been co-designed by computers and people.[27] Customization requires a level of adaptability that only people can provide, working hand in hand with intelligent machines.

42%

of executives say AI will be behind every new innovation in their organization in the next three years.

ii) Recognize the business case

Don't simply bank efficiencies to benefit the bottom line. Turn the savings into investments for the future workforce that will propel new business models.

Accenture puts 60 percent of the money it saves from investments from AI into its training programs. Over the past two years, it has retrained tens of thousands of people whose roles have been automated. These employees are now taking on higher value work, in some cases using AI and other technologies to provide more informed services to clients.

Take order processing and accounts payable collections. One Accenture client, a leader in the high-tech industry, has produced a human–AI hybrid workforce where algorithms predict which orders have issues, such as a risk of cancellation or payment disputes. Employees can therefore spend more time paying attention to high-risk situations and be more proactive in mitigating negative outcomes.

This approach has required training people to help them develop a range of expertise and capabilities — from industry sector knowledge to analytics and data interpretation, to the soft skills required to work with customers in new ways. But this investment in Applied Intelligence is paying off with a potential of delivering cash flow improvements of over US$50 million along with increased working capital and a bottom line profit of more than US$10 million in the first year of implementation.

> **"At ENGIE, we consider AI to be one of the key accelerators of harmonious progress, to create new and better ways of working for our people and to design brand new experiences for our clients."**
>
> Yves Le Gélard, Executive Vice President, Chief Digital Officer and in charge of Group Information Systems, ENGIE

2 PIVOT THE WORKFORCE

iii) Organize for agility

As people do less repetitive work and instead participate in a series of project teams, they must be given more autonomy and decision-making power.

An open culture is needed to encourage experimentation. That openness must extend to involving people in decisions that will change their working environment and the work they do. As the Chief Digital Officer of an Indian telecoms company told us:

"Being an employee-oriented organization, we don't only undertake initiatives based on market research. We also crowdsource ideas internally where our people get a chance to bring innovation to the organization by using their creativity."[28]

Organizations must also redesign the processes and organizational structures that enable the fluid assembly and disassembly of project teams, freeing people from traditional functional constraints.

"The opportunity for newly skilled individuals to collaborate with increasingly intelligent machines and software will accelerate the shift from an assembly line approach to a more fluid 'assemblage' of teams and technology, capable of higher levels of creativity and innovation," write Accenture's Paul Daugherty and Jim Wilson in *Human + Machine: Reimagining Work in the Age of AI.*[29]

iv) Foster a new leadership DNA

An agile workforce that leverages the best of intelligent technology and the best of human ingenuity ushers in a new set of expectations for today's leaders.

As hierarchies collapse and cross-function teams assemble and disassemble, leaders become co-creators and collaborators with their people. And, while AI enables individuals to take on higher value responsibilities, it also pushes decision-making closer to where the actual work occurs. Consider the shop floor worker whose tablet delivers real-time data, insights and training to make a decision on the spot. Ultimately leadership isn't a level — we need to build leaders at all levels.

Good leaders also recognize that the more digital we become, the more human connection matters. Angela Ahrendts, Senior Vice President of Retail at Apple, wisely suggests, *"The more technologically advanced our society becomes, the more we need to go back to the basic fundamentals of human communication."* [30] In an increasingly digital workplace, empathy, creativity, listening and inclusion — all uniquely human attributes — are needed now more than ever. Leaders' actions are a visible exemplar of these human attributes and a role model of the culture.

Circling back to the idea of the big pivot organizations eventually need to make to reap the full potential of intelligent technology, leadership is all about courage and innovation. Diving head first into uncharted territory. Good leadership seizes the opportunity to create that new reality — pivoting from existing core businesses to the new.

3

SCALE UP "NEW SKILLING" TO WORK WITH INTELLIGENT MACHINES

To fill the new and reconfigured jobs of the intelligent enterprise, companies will need new approaches to training. "New Skilling" programs must be rapid, flexible, tailored and large-scale to maximize the value humans and machines can create together.

In its efforts to rapidly pivot over 160,000 of its employees to be conversant in new IT skills and more than 100,000 to be job ready in less than two years, Accenture developed a "New Skilling" framework to guide its ambition based on a progression of skills from awareness to expert, while relying on a suite of innovative learning methods grounded in neuroscience research (see Figure 7).

Even though almost half of business leaders in our survey identify skills shortages as a key challenge, only three percent say their organization plans to increase investment in training programs significantly in the next three years. Companies can achieve more with less, but only if they are willing to innovate their training methods. Accenture has actually lowered its cost of training hours by more than 25 percent since it began aggressively expanding its digital learning channels while increasing the number of training hours its people spent by 40 percent.

Figure 7

Learning Framework: "New Skilling" at Accenture.

Awareness

Build awareness of new skills needed to make the pivot.

Conversant

Assess skills, using analytics, to customize learning based on individual needs to become conversant.

Job Ready

Foster job shadowing and test job readiness.

Expert

Monitor individuals and help them navigate the change as they continue to build deeper expertise.

Mentoring

Digital on Demand

Job Shadowing / Apprenticeship

Simulation / Augmented Reality

Hackathons / Experimentation

Coaching

Collaboration / Peer-to-Peer Learning

On-the-Job Learning

Teaching

Multichannel Approach Fosters Continuous Learning

ACTIONS TO SCALE UP "NEW SKILLING"

Three steps to expand the reach of skills programs.

i) Prioritize skills for development

Selecting skills training will depend on the type of AI being used and the size, sector and existing skills levels of an organization.

Creative skills will be important. However, in our survey, executives rank the following as the top five most important skills in the next three years: resource management, followed by leadership, communication, complex problem-solving and judgment/decision-making.[31]

Among the most valuable human skills required to collaborate with AI will be the judgment skills needed to intervene and make or correct decisions when machines struggle to make them. Also critical will be the ability to interrogate systems to gain maximum insight. This requires knowing how they categorize information and understanding the parameters of their algorithms. Teaching intelligent machines will be fundamental, both through explicit processes based on feeding them with quality inputs and through the implicit processes of learning on the job alongside people.

Sustained success will depend on practicing Responsible AI, ensuring that data and systems are managed to be fair, transparent and accountable. This will require training programs that extend from regulatory imperatives to the ethical behaviors of people and machines, and the business practices that follow.

ii) Account for willingness and skill

Target training to account for different levels of willingness and skill.

It is important to tailor programs to suit a range of employee "starting points." The training you offer must address both the differences in motivation levels and differences in skill levels.

Our research shows that confidence levels vary by age (see Figure 8), but that workers are willing to learn. We asked people to self-rate their skill and willingness levels (see Figure 9). A full 54 percent saw themselves as "high skill/high willingness" when it comes to learning new capabilities.

Figure 8

How confident are you in your skills and abilities to work with intelligent technologies?
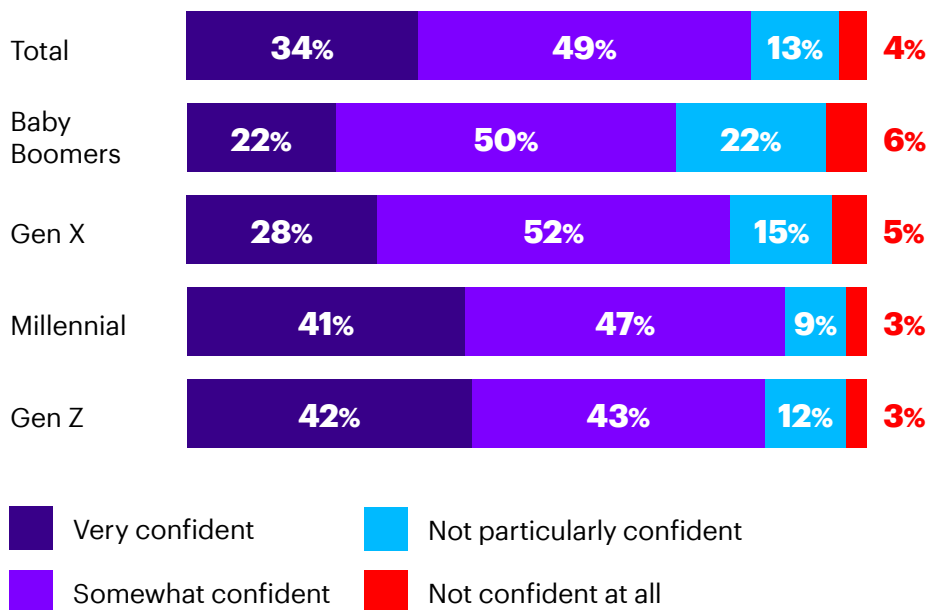
	Very confident	Somewhat confident	Not particularly confident	Not confident at all
Total	34%	49%	13%	4%
Baby Boomers	22%	50%	22%	6%
Gen X	28%	52%	15%	5%
Millennial	41%	47%	9%	3%
Gen Z	42%	43%	12%	3%

■ Very confident ■ Not particularly confident
■ Somewhat confident ■ Not confident at all

Source: Accenture Future Workforce Worker Survey 2017

Targeting "New Skilling."

Most employees fall into the high skill/high willingness category and have a positive attitude toward AI. Half are confident in their AI skills. Companies need to determine the levels of their own workforce and tailor "New Skilling" efforts accordingly.

Figure 9

	High Skill Low Willingness **16%**	High Skill High Willingness **54%**
Skills		
	Low Skill Low Willingness **9%**	Low Skill High Willingness **21%**

Willingness
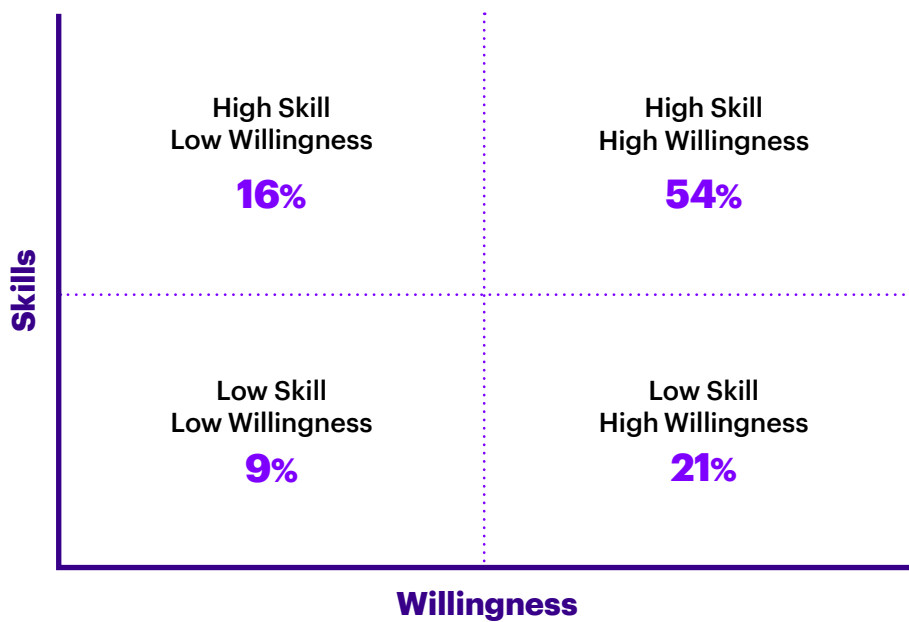
Source: Accenture Future Workforce Worker Survey 2017

While this number may be on the optimistic side, the approach illustrates the need to gauge the varying motivations of diverse workforces and to target programs at different generations and skill levels. Overall, the research revealed that 62 percent of workers think AI will have a positive impact on their work. When asked what factors would motivate them to develop new skills, almost half (49 percent) of baby boomers want time during the workday for training, but only 36 percent of Gen Z respondents feel that need. And while at least 46 percent of Gen X, Gen Z and millennials are looking to learn new skills to advance their careers, only 35 percent of baby boomers feel the same way.

iii) Go digital to create innovative learning experiences

Digital learning methods, such as virtual reality and augmented reality technologies, can provide realistic simulations to help workers master new manual tasks so they can work with smart machinery.

The same technologies can help reinforce correct procedures on the shop floor — monitoring how employees execute tasks and coaching them to do it the best way. Thyssenkrupp is overcoming skill mismatches through AI. The industrial services giant equips its elevator technicians to consult subject matter experts through Microsoft HoloLens, an augmented reality headset.[32]

3 | SCALE UP "NEW SKILLING"

Walmart's approach to "New Skilling."

At Walmart, US employees are being trained at the retailer's training academies using Oculus Rift virtual reality headsets, allowing trainees to experience and practice responding to real-world scenarios. Think a spill in aisle three with the instructor and trainee peer group able to provide performance feedback as they watch remotely through the employees' eyes. Following early success, Walmart has now rolled out the program to all 200 academies following the success of the pilot.[33]

Digital technology also helps to democratize learning. Accenture's 3,000 Pinterest-like digital learning boards are curated by approximately 900 experts and give 435,000 employees access to more than 300 content categories, with topics ranging from technical skills, such as blockchain, to softer skills such as coaching. Employees have completed more than 42 million learning activities via the digital boards since their inception, with over 29 million completed in the past year alone.

> **"Our customers are changing and so are their expectations. They expect simpler, faster, frictionless experiences both in our stores and online. To meet those needs, we are constantly evolving our use of technology to empower our associates and provide them with new skills at speed and scale to better serve our customers. Our academies combine classroom learning with hands-on experience delivered through technology, such as virtual reality, to create immersive and adaptive learning experiences. We have seen that department managers who complete academies have higher retention rates as do associates who report to them. These training investments are providing our associates with the skills they need to succeed today and in the future, driving positive business outcomes and keeping us competitive in our rapidly evolving retail environment."**
>
> Jacqui Canney, Executive Vice President, Global People Division, Walmart

HUMANS HELPING AI HELP HUMANS

Artificial intelligence is redefining the nature of value creation at unparalleled speed and scale. It is reshaping core business processes and has the potential to transform customer experiences and establish entirely new business models.

Companies in the future will achieve sustained growth by using AI to create better outcomes for customers and for wider communities. And yet, most businesses today are still focused on using intelligent technologies to improve efficiencies.

What's needed is an urgent shift in approach. Companies must help people learn to work closely with intelligent machines as collaborative partners. In other words: Humans need to help AI help humans. Combined with radical changes to organizational structures and processes, this allows them to make Applied Intelligence a reality.

The good news.

Workers are impatient to collaborate with AI and to learn the necessary skills for doing so. And they have a vision for how AI can improve the lives of customers.

The bad news.

Many business leaders don't recognize workers' enthusiasm and aren't funneling the necessary resources into "New Skilling."

> **"2017 was the year AI leapt to the forefront of CEO consciousness. 2018 may be the year that the hype starts to become reality."**[34]
>
> Alan Murray,
> President, Fortune

It's time for business leaders to reimagine the work their people do in partnership with AI and to ask themselves tough, uncomfortable questions about their organization's readiness to compete.

1 From "Workforce" Planning to "Work" Planning

Do we have a clear understanding today of how work in our organization will be reconfigured by intelligent machines, starting in 2018? Which of our core activities will be automated, which will see human–machine collaboration elevate our workers, and which will remain the preserve of workers only? What will this mean for our operating model? Are we prepared for the enormous changes ahead as the nature of work is reimagined, starting now?

2 "New Skilling" the Future Workforce

Do we have a clear view today of the knowledge, skills and mindsets required to work with intelligent machines in a way that creates real value? Where are our people against that benchmark? Is "New Skilling" already being integrated into our leadership development, learning and recruitment programs?

3 Positioning for the Full Value of AI

Do we have a clear understanding as a leadership team of how AI will be disruptive not just with efficiency and productivity gains in our existing business model, but in creating entirely new markets, products, services and customer experiences? What new jobs will this create in our organization? Are we organized, and do we have the talent to take advantage of both the top line and bottom line opportunity as human–machine collaboration reshapes the nature of competition in multiple industries?

These are some of the defining questions that will separate winners and losers in an era of intelligent machines. Not in three years or five years. Now. If you want to get ahead of the game in 2018, let's talk.

Contact the Authors

ELLYN J. SHOOK
Chief Leadership & Human Resources
Officer, Accenture
ellyn.j.shook@accenture.com
@EllynJShook1

MARK A. KNICKREHM
Group Chief Executive,
Accenture Strategy
mark.a.knickrehm@accenture.com
@Mark_Knickrehm

About the Research

The Accenture Research program was built on five proprietary research initiatives.

A worker survey of 14,078 workers across skill levels and generations. Executed by Market Knowledge Online.

A business leader survey of 1,201 C-level executives.

Both surveys covered 11 countries (Australia, Brazil, China, France, Germany, India, Italy, Japan, Spain, the UK and the USA) and the following industry sectors: Automotive, Consumer Goods & Services, Health & Life Sciences, Infrastructure & Transportation, Energy, Media & Entertainment, Software & Platforms, Banking (Retail & Investment), Insurance, Retail, Telecommunications and Utilities. Survey development and fieldwork undertaken with the assistance of Oxford Economics.

In-depth interviews with 48 C-level executives from a range of industries in Australia, Brazil, China, France, Germany, India, Italy, Japan, Spain and the USA. Interviews executed with the assistance of Oxford Economics.

Ethnographic interviews involving 30 in-depth qualitative in-work interviews with individuals who have been significantly impacted by the integration of new AI technologies into their workplace. Interviews covered Brazil, China, Germany, India, Japan, the UK and the USA, and eight industry sectors. Interviews executed by PSB.

Econometric modeling to determine the potential financial performance improvement resulting from investments in artificial intelligence. We adapted Acemoğlu & Autor (2014) to build a multivariate panel data econometric model that is able to account for the productivity impact of different sets of new technologies for both "leading" and "follower" companies. Leading companies are the top 20 percent according to both AI investment and financial performance. The company-level econometric model is the first to study the effect of investment in specific new technology clusters on companies' Profits (EBITDA), Productivity (EBITDA/Employees), Revenues and Employment with such level of granularity. The model runs on a unique and newly constructed data set that includes financial and technology investment data for 16,000+ companies across 14 industries and 10 new technologies for 2015 and 2016. Financial and technology investment data was sourced from IDC, Ovum and Capital IQ. The data set was enriched with companies' new technology investment forecasts through 2022.

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About Accenture

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TAB 13

Article

The evolution of work

New realities facing today's leaders

Heather Stockton , **Mariya Filipova** , **Kelly Monahan**

January 30, 2018

Technological and social forces are transforming how work gets done, who does it, and even what work looks like. In an effort to understand how organizations can rethink their approaches in the face of the evolution of work, this article tries to tap into the wisdom of crowds by asking leading thinkers to identify what they think are the most important driving forces shaping the work-related realities of tomorrow.

What could work look like tomorrow?

GETTING work done is a fundamental concern for any business. But today, paradigm-shifting forces seem to be driving significant changes in both work and the workforce. New digital and communications technologies are changing *how* work gets done. The growth of the gig economy and advances in artificial intelligence are changing *who* does the work. Even the question of *what* work looks like is coming under examination as a continually evolving marketplace drives organizations to explore new business models.

In the face of these technological and social forces, it could be imperative for businesses to rethink their approaches to the how, who, and what of work in fundamental, perhaps even transformative ways. And as usual, there seem to be no easy answers. While we anticipate that the future of work will be better in some respects than many of our present-day realities, we also anticipate much turbulence. The complexity of what lies ahead can make many business leaders feel as if they are navigating whitewater rapids rather than charting predictable courses of action.

The research this report describes aims to bring some degree of clarity to the pressures organizations can expect as they move forward in the future of work. Through an ongoing research collaboration with WikiStrat, we examine leading experts' views on the new realities that are emerging and ways in which individuals, organizational leaders, and public policy makers can take advantage of the opportunities that the future of work presents.

Understanding the future by engaging the crowd

The complexities and opportunities posed by the future of work may seem limitless, and they can present newfound realities to multiple stakeholders. And so, to better understand tomorrow's most pressing issues, we tapped into the potential power of leveraging the wisdom of crowds. Considering a wide range of perspectives on the future of work allows us to view the issue from a variety of viewpoints, yielding a fuller picture of the transformations underway.

To create this fuller picture, we used the WikiStrat crowdsourcing platform to ask leading thinkers across the globe to identify what they thought were the most important driving forces shaping the work-related realities of tomorrow. These were futurists and experts in law, business, society, health, and economics, representing 14 countries. We asked this crowd of experts to identify, not only what they thought were the most relevant forces driving the future of work, but also how likely they thought these new realities were to take shape over the next five to ten years. (See the sidebar *About the research* to learn more about the study methodology.)

As we gathered and unpacked the data during the study's first phase (conducted in April 2017), five "new realities" emerged that were considered both highly probable and likely to have a big impact on global public policy makers, organizational leaders, and employees seeking to navigate opportunities in the future of work. Each of these realities holds untapped potential for further developing the workforce, leveraging technology, and advancing economic and social growth in newfound ways.

The study's second phase (conducted in November 2017) validated the five original realities and identified two additional "emerging" realities on the horizon (figure 1).

Figure 1. Seven new realities in the future of work

Exponential organizations ①

Lifelong reinvention ②

The unleashed workforce ③

Technology, talent, and transformation ④

The ethics of work and society ⑤

The nimble enterprise ⑥

Regulated innovation ⑦

Source: Research conducted with WikiStrat for Heather Stockton, Mariya Filipova, and Kelly Monahan, *The evolution of work: New realities facing today's leaders*, Deloitte Insights, January 30, 2018.

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ABOUT THE RESEARCH

Deloitte Consulting LLP combined forces with Wikistrat, a crowdsourced consultancy with a global network of over 2,200 subject matter experts, to research what possibilities the future of work could hold.

We chose to ~~min~~ creating

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Reality No. 1: Exponential organizations

The driving forces of big data, the Internet of Things, and the growing number of Generation X individuals in leadership positions have led to the rise of exponential technologies and data-driven organizations. Organizations that can capture the potential value unlocked by technology and data's unprecedented availability are

anticipated to outpace their peers. We often refer to these organizations as "exponential organizations" (ExOs). We define an ExO as one that has a disproportionately large impact (or output) compared to its peers, and that enjoys an exponential return on assets (such as talent, capital, or intellectual property). An ExO's exponential return on assets may be largely due to the use of new organizational techniques that employ the right mix of exponential technologies, business models, and, most importantly, human talent.

To successfully operate as an ExO, an organization should find the right mix between people and technology to scale impact and accelerate growth. ExOs seem to have mastered artful augmentation—leveraging the power of technology while further developing the enduring human skill sets needed to capture value in the market. They generally see technology, not simply as a way to create efficiencies and cut costs, but as a way to unleash exponential growth in abundant markets. They can redefine their markets and use data to create new industries (for example, the sharing economy and crowdfunding).

A concrete example of the kind of action an ExO may take to achieve these ends is the steps that a large hedge fund organization is taking to use artificial intelligence to augment the firm's management decision-making. This allows its investment managers to spend more time engaged in higher-value tasks. [2] Another example is that of a leading medical practice that is using cloud technology and data science to provide more precise health care and value to patients. [3]

One challenge to operating as an ExO is the pragmatic difficulty of getting one's arms around the vast volume of data and information

being generated. This volume is only growing; some estimate that 90 percent of the world's data has been created in the past few years. We also often hear about the increased flow of information: 2.5 exabytes of data are produced every day, while 140 million emails are sent every minute. **4** How then can organizational leaders prepare to harness data and information in the quest for exponential performance?

A good starting point is to create a data-driven business model that focuses on customer value creation by relying on new data streams, technologies, and human talent to inform decision-making and redefine the competitive market. Harnessing a mix of data, technology, and people allows ExOs to create opportunities in untapped markets. It is also necessary to develop core business competencies like statistical reasoning, data manipulation, and data visualization. And, while ExOs focus heavily on science and data, they also place a premium on technical workers who can *also* leverage soft skills such as social interaction, creative thinking, and complex problem-solving.

Key insights: Public policy makers should keep a close eye on data privacy and intellectual property protection as organizations continue to compete based on intangible assets. Organizational leaders should develop a technology-fluent workforce to capture value from technology investments. From the individual's point of view, people who can apply both "hard" technical and "soft" interpersonal skill sets can thrive and potentially find much opportunity in an ExO.

Read more: Every year, Deloitte works with the Massachusetts Institute of Technology to understand how organizations are adapting

to exponential technologies. Our latest report examined how the most **mature digital organizations** are thriving in this new reality. [5]

Reality No. 2: The unleashed workforce

Factors such as the growth of freelancing, 24-hour everything, mobility, crowdsourcing, and gamification have unleashed the workforce, freeing it from many traditional bounds and constraints. Indeed, one of the fastest-growing workforce segments is the "alternative" worker—one who works off-campus and outside of an organization's official talent balance sheet. [6] In addition, the rise of platform technologies has made it easier for organizations to use crowdsourcing to tackle tough challenges. And technologies such as artificial intelligence, augmented reality, and robotic process automation allow work to be outsourced to robots.

This broadening of the talent continuum gives employers an opportunity to engage in a multi-channel workforce strategy that leverages a mix of traditional full-time employees, joint ventures, contractors, freelancers, crowds, and robots (figure 3).

Figure 3. The continuum of talent in the future of work

Employees
Joint ventures
Contractors
Freelancers
Crowds
Robots

DISRUPTED
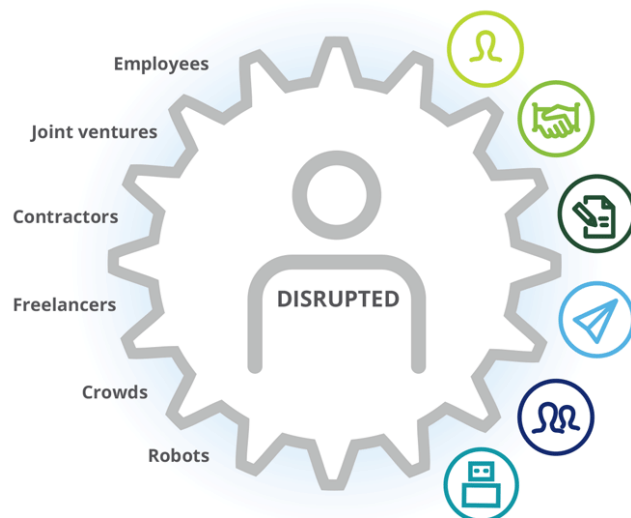
Source: Deloitte analysis.

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To reap benefits from this new reality, successful organizations can leverage team-based models and decision-making protocols rather than building traditional hierarchical business models. Agile companies can draw upon all points of the talent continuum to rapidly shape new business models, improve output quality, generate ideas, and manage costs. At the same time, effective organizations also recognize the different needs and specific attributes of different worker types along the continuum. They do not take a one-size-fits-all approach to the employee experience.

These new alternative talent models lend themselves to new management styles that can allow organizational leaders to take better advantage of team-based decision-making. One large global banking organization, for instance, began experimenting with a new agile human resources model that formed nine-person groups loosely

organized into 13 teams. These teams were free to operate and make decisions at the team level rather than going through the traditional hierarchical decision-making process. This approach was so successful in improving time to market, boosting employee engagement, and increasing productivity that the bank is now rolling it out throughout the organization. [7]

In our most recent refresh of the WikiStrat research, we saw a powerful trend emerge within the larger growth of the continuum of talent: namely, that today's workforce encompasses more diversity—in terms of gender, age, background, experience, viewpoint, and overall workforce composition—than in the past. As society's perceptions evolve to become more inclusive of women and minorities in leadership positions, companies will experience increasing pressure to continue to diversify their workforce and diligently avoid the many scandals that have recently been brought to light regarding discriminatory practices and harassment in the workplace. Especially with HR selection and management processes changing to accommodate the use of data and technology in recruitment, organizations have the ability to make more fact-based choices [8] to reduce some of the many inherent biases against women and minorities in the workplace (as is evident from numerous behavioral science studies.) [9]

Key insights: Public policy makers should consider new labor categories to account for the rise of alternative work arrangements, paying particular attention to social safety nets and tax incentives that could offset the impact of income uncertainty among an increasingly transitory and ephemeral workforce. Organizational leaders may

consider moving away from traditional hierarchical structures toward project-based teams composed of a variety of workers, which can allow them to respond faster to marketplace needs and opportunities. Individual workers should plan for and adapt to perhaps greater uncertainty about where and when their next job will be, as well as embrace lifelong learning with an increasing emphasis on essentially human, enduring skillsets.

Read more: Deloitte's *2017 Global Human Capital Trends* report discusses the **augmented workforce** in greater depth. [10] We also consider the opportunities organizational leaders have in extending their culture **beyond office walls and balance sheets** . [11]

Reality No. 3: Lifelong reinvention

The lengthening of the productive years (figure 4) and the need for lifelong learning have led to the new reality of lifelong reinvention. Longer lifespans seem to be challenging traditional ideas about careers, retirement, and work-life balance, and these changes in mind-set are starting to affect the way people work. Lengthening worker careers could complicate operational and resource management. The effectiveness with which organizations can manage quadri-generational workforces may affect business efficiency and productivity, investment decisions, and resource retention. Extended careers might redefine worker and management attitudes toward aging, alter the pace at which organizations are renewed by younger talent and new ideas, and increase intergenerational competition for jobs.

Figure 4. Five generations at work

Projected US civilian labor force participation rate by age
1994, 2004, 2014, and projected 2024 (by percent)
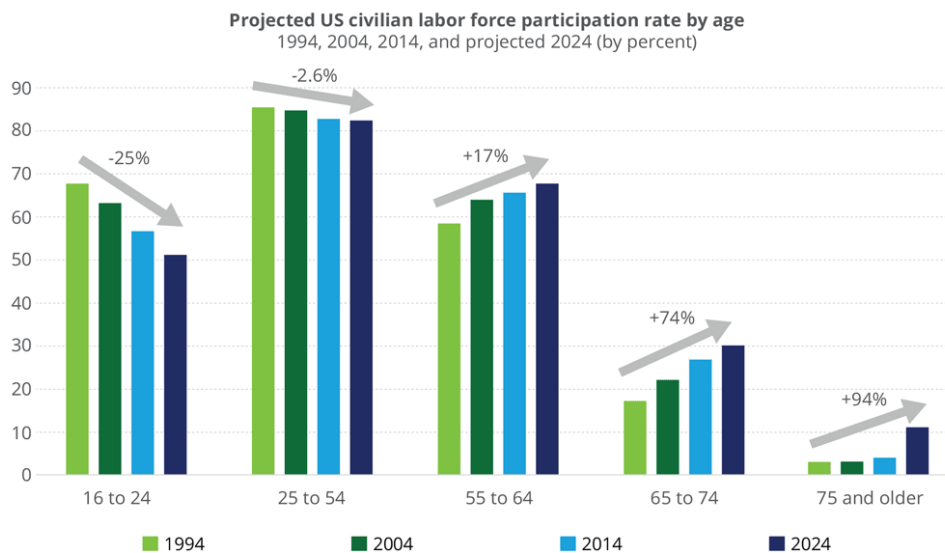
Source: US Bureau of Labor Statistics.

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Lifelong reinvention can be enhanced by leveraging the strengths of each generation. St. John's university professor Nicos Scordis has remarked, "There is an implied assumption that all future young workers would bring to the workplace superb skills. The reality might be different. It might be that the value of older workers might actually improve, not for their productivity, but rather as role models for their work ethics." [12]　The use of mentoring models is likely to rise in this new reality, with older workers teaching early career workers interpersonal and leadership skills, which often develop with experience.

The need for lifelong reinvention is presenting itself in a few different ways in the workplace. For example, one finance organization unveiled plans to increase its over-50 employee population by 12 percent by 2022. [13]　Another financial services firm is giving its bankers more

flexible hours throughout the work week to engage in personal learning. [14] A telecommunications company is encouraging all of its employees to learn a new digital skill, giving them both the time and resources to do so. [15]

Key insights: Individual workers should make education part of their careers, including engaging in both traditional and on-the-job training opportunities. Organizational leaders will likely want to consider implementing flexibility policies that are suitable for and inclusive of workers of all ages. Public policy makers should try to ensure the adoption of and adherence to anti-discrimination and anti-ageism laws across industries and sectors.

Read more: **Josh Bersin's latest article**

<https://www2.deloitte.com/insights/us/en/deloitte-review/issue-21/changing-nature-of-careers-in-21st-century.html> discusses the evolution of the 21st-century career and how organizations can encourage continuous learning. [16]

Reality No. 4: Technology, talent, and transformation

The falling cost of automation, an increase in the use of artificial intelligence, and the rise of human-machine collaboration have created a new reality of talent trade-offs and transitions. This reality presents the opportunity to reimagine the economic value of work through the increased productivity that human-machine collaboration can bring to the workplace. While the impact of automation currently remains largely concentrated in a few industries and countries, it is nevertheless spreading across industries, including services industries and the public sector. (Figure 5 highlights how different countries are using robotics in response to rising labor rates.) Automation is also gaining ground in

developing countries, although one challenge to its widespread adoption is that many emerging economies are long on labor and short on technology. In addition, the establishment of automated factories in more-developed areas of an emerging nation may create social and political tensions within the country as well as with other countries.

Agile organizations assess and reassess the mix of human and machine talent at all levels as an essential element of their business and strategic planning. Getting it right could significantly affect an organization's productivity, competitiveness, and positioning. Organizations should prepare for a multiyear, complex transition period as jobs and careers are assessed and reassessed, technologies become more capable, and legal and social safety nets evolve.

Figure 5. Labor cost savings

Labor-cost savings from adoption of advanced industrial robots (%, 2025)

Average global labor-cost savings ~ 16%
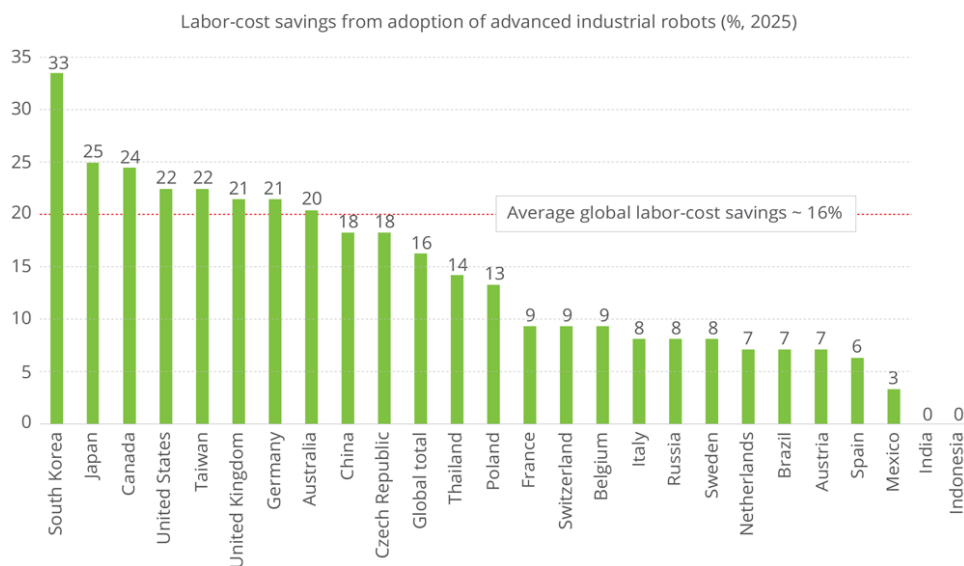
Source: BCG, *The shifting economics of global manufacturing*, February 2015.

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Contrary to what some may fear, robots are not taking over human jobs. In the context of technological enablement and automation, there is an ongoing need for essentially human and enduring skillsets that robots currently do not possess. One global manufacturer plans to replace nearly 30 percent of its current workforce capacity with robots—but to reallocate its human workers to more complex tasks rather than eliminating them. [17]   A global car company with a production facility in Germany announced it will reduce the number of robots on its production line and replace them with human labor, as customization, which is in high demand, is not cost-efficient using robots. [18]   In a different industry, one social media company is planning to hire more human workers to provide oversight over what is published on their platforms. [19]

As these examples illustrate, organizations will have to continue to make talent trade-off decisions as automation becomes ever more prevalent and available. Most—thanks to the broader talent continuum the future of work is making available—will have a variety of talent models to choose from. Automation technologies become more likely to be leveraged when the cost of labor for routine tasks rises. In parallel, the marketplace value of human labor to perform highly complex, customized, and unpredictable tasks is also likely to rise.

Key insights: Public policy makers should consider increasing incentives for lifelong learning and skills development while developing safety nets for workers disenfranchised by new technologies. Organizational leaders should brace themselves for potential rapid disruption caused by technological advances that could require

substantial talent restructuring. Individual workers should seek to identify and target employment opportunities in areas where the demand for human workers is likely to increase, while also understanding and learning technology skills for sustainable employability.

Read more: Earlier this year, our CEO, Cathy Engelbert, **talked with Tom Friedman** <https://www2.deloitte.com/insights/us/en/deloitte-review/issue-21/tom-friedman-interview-jobs-learning-future-of-work.html> and explored the talent trade-off decisions that organizations in the future will have to make. [20]

Reality No. 5: The ethics of work and society

The driving forces behind our fifth new reality seem to be the economy of good deeds and a rise in discussions around the need for universal basic income.

The evolving clash between traditional conceptions of work, societal values, and public policy may define the limits and conditions placed on the future organization. Developments such as artificial intelligence and job market fragmentation could produce large-scale shifts, changing how we think about work, what is valued at the workplace, and what is valued by society. In particular, worker demands appear to be pushing organizations to focus on worker interests—such as the effect of some technology applications on workers' well-being—along with broader social benefits. New policies and programs might eventually be needed to balance organizational interests with the need to protect workers from the new working environment's uncertainties.

The reality that organizations seem to be held to an increasingly high ethical standard is manifesting itself in a variety of ways, as organizations strive to balance shareholder needs with those of their broader constituents such as employees and their local communities. For example, one banking organization recently raised its workers' minimum wage; another, smaller regional bank rolled out companywide benefits to better accommodate autistic individuals. [21]

Key insights: Both individual workers and organizational leaders may need to develop a deep understanding of changing laws and employment regulations, especially as they relate to the alternative workforce. Organizational leaders should also reinforce ethical behavior and responsible conduct as a core management principle. Public policy makers will likely continue to develop regulations to protect workers. They may, for instance, establish watchdogs for artificial intelligence algorithms that could have a greater influence on hiring and firing decisions.

Read more: *Reimagining measurement: Enhancing social impact through better monitoring, evaluation, and learning* explores ways organizations can more productively measure social impact. [22] Cathy Engelbert and John Hagel's latest *Harvard Business Review* <https://hbr.org/2017/12/fulfilling-the-promise-of-ai-requires-rethinking-the-nature-of-work-itself> article discusses ways that artificial intelligence is causing people to rethink the nature of work.

EMERGING REALITIES   Adapting to the new realities

During our most recent refresh of the data, we found two additional emerging trends that cast the future of work in an optimistic light. One of these realities deals with the growing use of advancing

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The new realities we've discussed here can present a host of opportunities. But to capitalize on them, we will need to find new ways to align institutions, organizations, and individuals with each other amid rapid market shifts. Public policy makers, organizational leaders, and individual workers will likely need to invest time and effort to figure out how to work together, or at least avoid working at cross-purposes, in the current and future world of work. Yet doing so could ensure that the future of work is both productive and rewarding for all parties.

Capturing the inherent value within each of these new realities could require many changes. It could involve reengineering work to take advantage of technological advances. It may require transforming workplaces to welcome and accommodate a continuum of talent needs. Almost inevitably, today's organizational leaders will need much courage to upend their existing models of work to usher in a more nimble and diverse enterprise.

Our recommendations for leaders seeking to capture value for tomorrow's realities include:

- Start to explore ways to tap into different parts of today's talent continuum to accomplish work that is currently more expensive and less productive than you would like it to be. Emphasize human-machine collaboration, not competition—utilizing the strengths that each brings to the workplace. Try, test, and learn.

- Place strategic longer-term bets. Identify the most important value chains in your business, and invest in transforming work in these specific areas. Start small, experiment, and scale quickly.

- Consider ways in which your business can engage in a broader societal narrative. Younger generations, especially, generally expect businesses to play a positive role in shaping society and heling to address some of its most pressing issues.

> **Join the conversation:** *To dive deeper into the issues surrounding the future of work, visit our* **extensive collection of Future of Work articles** *on Deloitte Insights (* **www.deloitte.com/insights** *).*

Authors

Heather Stockton , based in Toronto, Canada, is a member of Deloitte's Global Human Capital Executive and leads the organization's Future of Work program.

Mariya Filipova leads the Future of Work global program office. She is based in Boston, MA.

Dr. Kelly Monahan is a subject matter specialist at Deloitte's Center for Integrated Research. She is based in Philadelphia, PA.

Acknowledgements

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Emerging technologies , **Future of Work** , **Human Capital** , **HR Strategy**

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TAB 14

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BETTER POLICIES FOR BETTER LIVES   DES POLITIQUES MEILLEURES POUR UNE VIE MEILLEURE

Promoting Technological Innovation to Address Climate Change

Technological change is undoubtedly one of the keys to ensuring that climate change can be addressed without compromising economic growth. In order for this to be the case it is vitally important that climate and innovation policies provide the right incentives for the development and diffusion of 'climate-friendly' technologies. The OECD is assisting countries in their efforts to improve the design, implementation and evaluation of their policies in this area.

Key Messages

- Provide predictable and long-term policy signals in order to give potential innovators and adopters of climate-friendly technologies the confidence to undertake the necessary investments.

- Use flexible policy measures to give potential innovators incentives to identify the best way to meet climate objectives, and to avoid locking-in technologies that may become inefficient in future.

- Put a price on GHG emissions, for example through taxes or tradable permits, in order to provide incentives across all stages of the innovation cycle.

- Provide an appropriate mix and sequencing of complementary policy measures in order to overcome barriers to development and diffusion of breakthrough technologies.

- Balance the benefits of technology-neutral policies with the need to direct technological change toward climate-saving trajectories, by diversifying the portfolio of technologies for which support is provided and identifying general purpose technologies with environmental benefits.

- Since the sources of innovation are widely-dispersed, support research and development in a broad portfolio of complementary fields, and not just energy, 'climate-friendly' or 'environmental' R&D.

- Ensure that international policy efforts maximise the potential for sharing of knowledge and technologies of mutual benefit, for example through international research-sharing agreements.

- Support international technology-oriented agreements as an important complement to other international efforts (*e.g.* emissions-based agreements).

Government Policy Aimed at Promoting Innovation

Provide Predictable and Flexible Signals

In addition to commercial and technological uncertainty, investors in climate-related sectors face an additional source of uncertainty – that which is associated with climate policy. There can be uncertainty about the future stringency, timing, nature or durability of the policy framework. Irrespective of the nature of the uncertainty, an uncertain policy framework will result in less innovation in environmental and climate mitigation technologies. For instance, recent empirical analysis by the OECD supports the hypothesis that increased volatility of public R&D spending has a negative impact on innovation, undermining the benefits of a given level of support by one-half to two-thirds (see Figure 1).

Why is this the case? Policy signals that are difficult to predict encourage investors to postpone investments, including the risky investments that lead to innovation. In the face of unpredictability there is an advantage to waiting until the 'policy dust settles'. As such, adding to the risk that investors already face in the market, an unpredictable or unstable policy regime can serve as a 'brake' on innovation, both in terms of technology invention and adoption.

However, it is important to note that changing the policy parameters does not necessarily provide more uncertainty to investors, as long as this is done in a predictable manner. For instance, periodic adjustments made in response to market developments are likely to be predictable to market participants.

Figure 1. Effect of Environmental Policy Characteristics on Innovation

Source: OECD (2011) *Invention and Transfer of Environmental Technologies.*

Note: The Figure shows the estimated coefficient of different combinations of characteristics of environmental policy framework in encouraging inventive activity in environmental technologies.
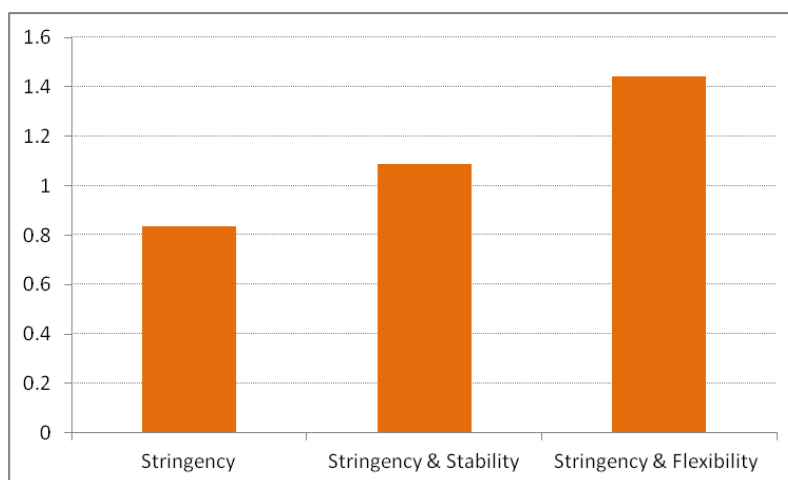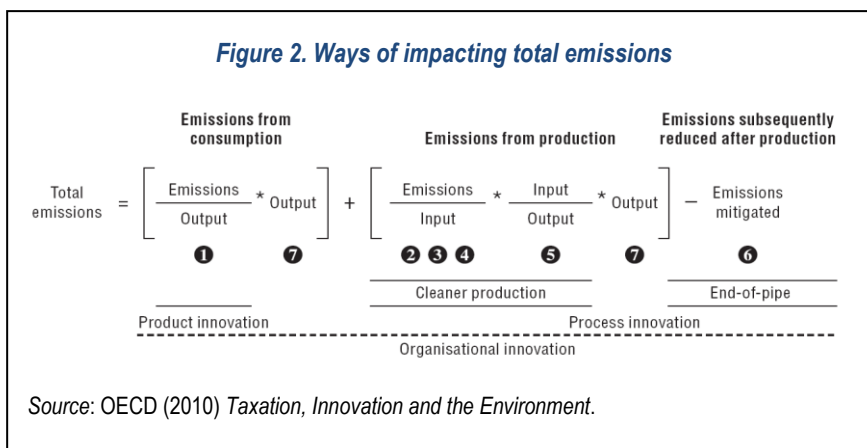
More generally, as new information becomes available, whether environmental or economic in nature, then adjustments in policies are likely to be necessary and desirable.

In addition, the more 'flexible' a policy regime, the more innovation takes place since this gives innovators the incentive to seek out the best means of meeting given environmental objectives (see Figure 1). This implies that rather than prescribing certain abatement strategies, wherever possible governments should give firms stronger incentives to engage in search for new innovations. Flexibility of policy regimes also ensures that markets are not fragmented across different countries. Given the risks associated with expenditures on research and development it is important that markets for innovation not be chopped up into different regulatory silos.

The Importance of Prices

Predictability and flexibility is partly a consequence of policy choice, and market-based instruments can be designed in such a way as to give potential innovators a degree of foresight, as well as space for innovation. However, this depends upon the details of policy design. For instance, the precise characteristics of the tax instrument can have a large impact on the resulting innovation (and environmental impacts). Tax instruments applied at different points in the chain of production and on consumption provide differing levels of incentive for both the development of innovations and their adoption.

When both the production and consumption of a product result in pollution, the total direct and indirect emissions of the producing firm can be thought of as being composed of the components illustrated in Figure 2. Three factors determine the firm's direct and indirect emissions: how much its outputs pollute when used, how much the firm itself pollutes when making the outputs, and what the firm does to negate its emissions from production after the pollution has been created.

Figure 2 also outlines the various types of innovations that can be used to reduce emissions for each component. The numbers represent specific actions that can be taken to reduce emissions:

1. Create new products for consumers that generate fewer emissions when used.

2. Use less emission-intensive inputs (of the same type).

3. Use less emission-intensive inputs (of a different type).

4. Reduce pollution intensity per unit of input (without modifying inputs).

5. Reduce input use per unit of output.

Figure 2. Ways of impacting total emissions

Source: OECD (2010) *Taxation, Innovation and the Environment*.

6. Undertake remedial, "end-of-pipe" measures.

7. Of course, the firm (and the consumer) could simply produce (and consume) less.

Each of these alternatives is a way in which emission levels can be reduced in the economy. The choice of environmental policy instrument has a direct bearing on which actions are stimulated. Figure 3 outlines each of the five main tax measures and the strength of the innovation creation and adoption incentive that they have on each emission reduction possibility, assuming they are used in isolation.

It is clear that some tax instruments encourage a wider range of actions (and therefore provide greater incentives for innovation) than others. Taxes on pollution provide incentives for all of the potential abatement measures, as levying the tax directly on the pollutant does not exclude any potential abatement measure and provides the greatest range of incentives for invention and technological change. As the incidence of the tax moves further

Figure 3. Innovation impacts of different tax instruments

	Invention propensity	Adoption propensity
Taxes on pollution	❶ ❷ ❸ ❹ ❺ ❻	❶ ❷ ❸ ❹ ❺ ❻
Taxes on proxies to pollution	❶ ❷ ❹ ❺	❶ ❷ ❹ ❺
Accelerated depreciation allowances	③ ⑤	❸ ❺
R&D tax credits	① ③ ⑤	① ③ ⑤
Reductions in VAT rate	①	❶

Note: White numbers on black background indicate strong inducement effect; black numbers on white background indicate weak inducement effect; absence of number indicates no inducement effect.

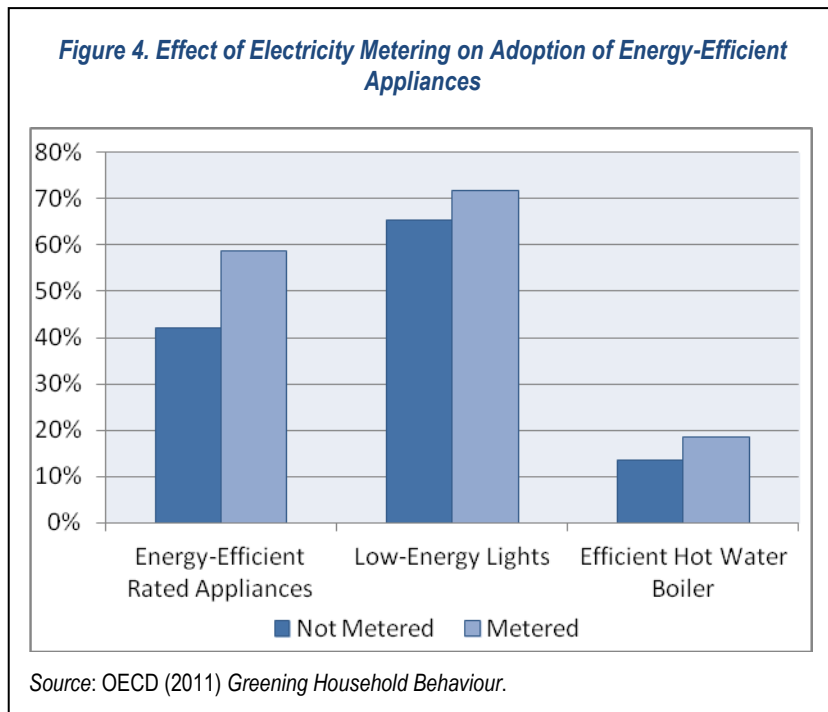*Source*: OECD (2010) *Taxation, Innovation and the Environment*.

from the actual pollutant, the range of potential measures for abatement decreases. Taxes on proxies to pollution provide much the same incentives, except where the abatement actions become disconnected from input use. Accelerated depreciation allowances encourage greater investment in physical capital. Such an instrument does not affect mitigation measures that are generally not capital intensive, such as actions one, two and four. Even for capital-intensive measures, an accelerated depreciation allowance as the sole policy instrument provides no incentive for abatement unless it is through the greater rationalisation of other inputs (such as fuel).

Similarly, generally available or environmentally targeted R&D tax credits do not provide incentives for mitigation, unless they help reduce the cost of existing processes or create new products. Without a price on carbon, R&D that significantly reduces the cost of carbon capture and storage, for example, would still have no economic rationale to be adopted. As such, only actions one, three and five are stimulated for invention and adoption. Finally, reductions in value added taxes for "green" purchases provide direct incentives for consumers to adopt new innovations, as they lead to a direct and identifiable price reduction versus non-reduced goods and services. The incentives for firms to invest in innovation activities are less strong, as the firm receives no direct benefit from the consumption tax reduction (although it will benefit from increased demand and can increase its prices somewhat) and these measures are frequently temporary.

The ideal policy instrument is, therefore, one which targets the environmental 'bad' directly and gives innovators flexibility to identify the best means of meeting given environmental objectives. For these reasons, price signals arising out of the implementation of emissions taxes and tradable permit systems are likely to be an efficient means of inducing innovation (OECD 2010).

Figure 4. Effect of Electricity Metering on Adoption of Energy-Efficient Appliances

Source: OECD (2011) *Greening Household Behaviour.*

Indeed, they may be a necessary condition for innovation since in the absence of clear price signals which penalise environmentally-damaging behaviour, other policy measures may be 'pushing on a string', with little impact. This is likely to be particularly true for the adoption of technologies. For instance, Figure 4 presents data on the adoption of energy-efficient appliances depending upon whether or not the household pays for electricity per unit consumed.

### *Policy Mixes and Breakthrough Technologies*

However, price signals may not always be sufficient, particularly if breakthrough technologies are to be induced. For instance, recent work undertaken in the area of alternative-fuel vehicles assessed the relative importance of fleet-level fuel-efficiency standards, after-tax fuel prices, and state support for R&D on innovation in electric and hybrid vehicles. It was found that relatively minor changes in a performance standard or automotive fuel prices would yield a much greater increase in patented inventions than a similar proportional increase in R&D budgets for some technologies (see Figure 5.)

Figure 5. Relative Effect of Technology Standards, Fuel Prices and Public R&D on Innovation in Electric and Hybrid Vehicles

Source: OECD (2011) *Invention and Transfer of Environmental Technologies.* Note: For ease of interpretation. Elasticities have been normalised such that effect of R&D=1. Unfilled bars indicate no statistical significance.
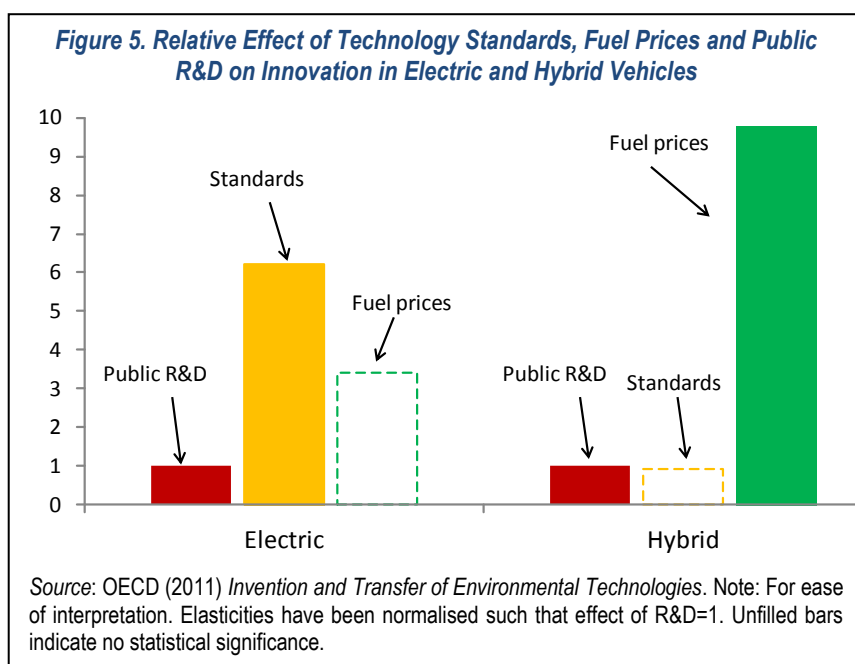
However, the results also suggest that there are significant differences between the effects of different policy measures depending on the type of technology, whether electric or hybrid vehicles. While the latter technologies are nearing the situation where they are competitive with interenal combustion engine vehicles, this is not the case for electric vehicles. This indicates the importance of the appropriate mix of policy measures. Relative prices may have a lesser role to play than ambitious performance standards or significant public support for research the further a technology is from being directly competitive with the incumbent technology (petrol- and diesel-driven technologies). While in theory a price sufficient to induce an equal level of innovation for such technologies could be introduced, such a measure would likely be politically infeasible in practice. Moreover, even if introduced, potential innovators may not perceive it as credible over the longer-term.

The importance of inducing investment in breakthrough technologies has been examined recently at the macroeconomic level. More specifically, the effects of the emergence of backstop technologies through dedicated R&D spending was modelled, making it possible to compare the economic costs of reaching a 550 ppm GHG concentration target with and without such technologies. The analysis finds that, although there is an initial GDP loss due to the large increase in R&D, in the longer run – especially beyond mid-century – the costs of meeting the stabilisation target are significantly reduced by the availability of backstop technologies (see Figure 6).

Figure 6. Projected world GDP costs under 550 ppm GHG concentration stabilisation scenario, with and without backstop technologies
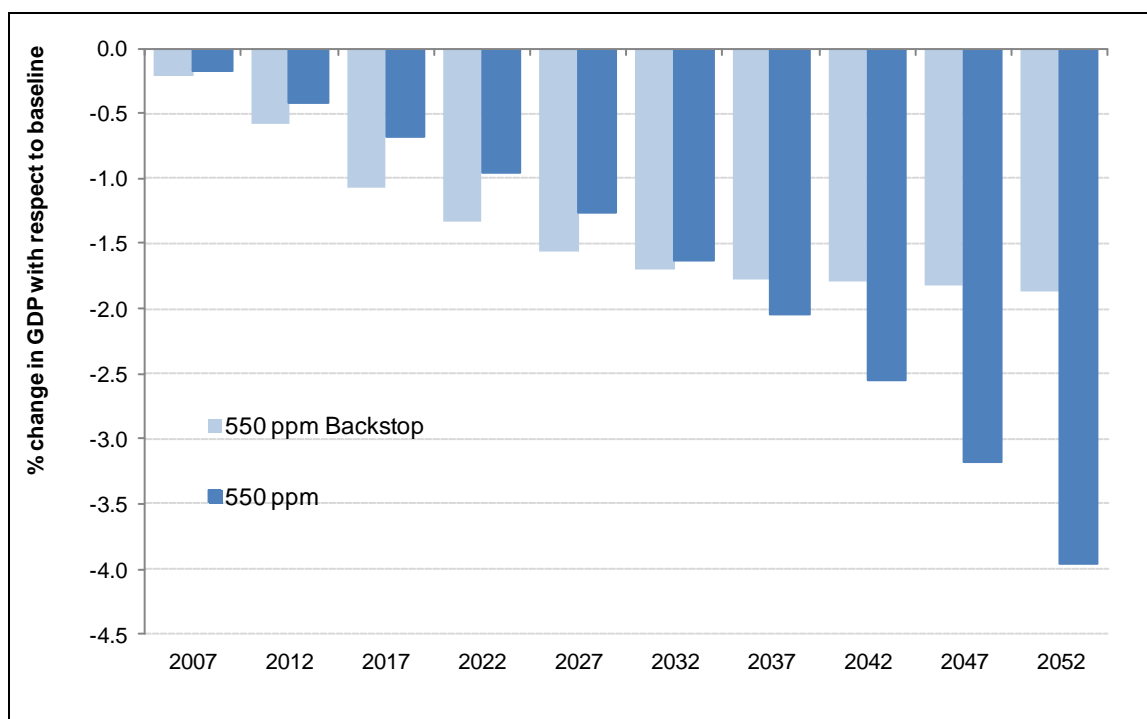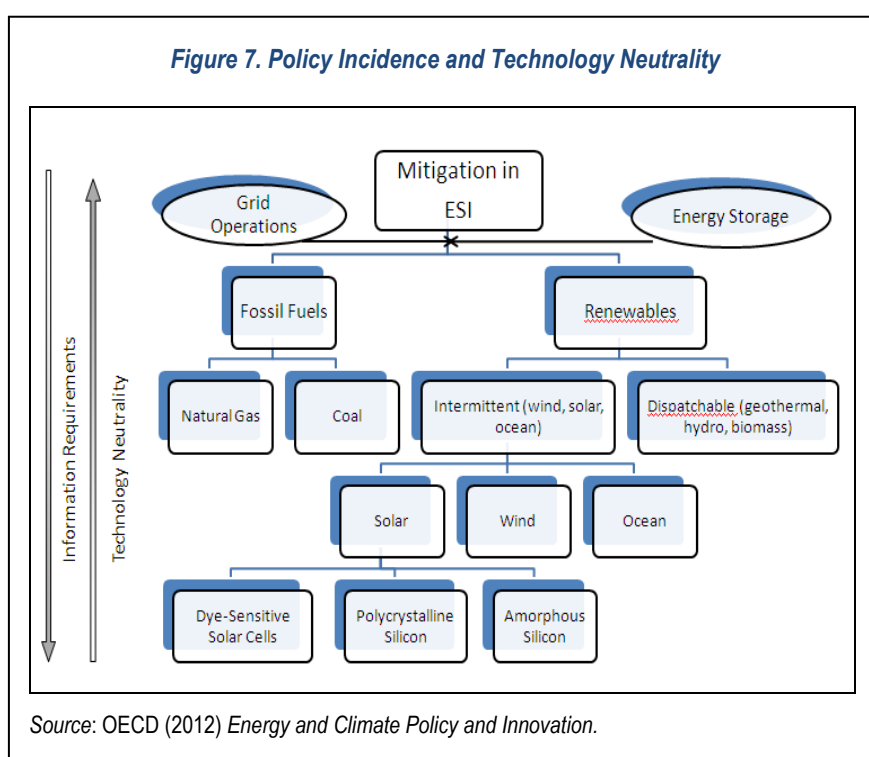
Source: OECD (2009) *The Economics of Climate Change Mitigation* Note: Emissions of non-CO_2 gases are not covered by the model used in this analysis and are therefore excluded from these simulations. The 550 ppm greenhouse gas concentration stabilisation scenario run here is in fact a 450 ppm CO_2 only scenario and greenhouse gas prices are CO_2 prices. Stabilisation of CO_2 concentration at 450 ppm corresponds to stabilisation of overall greenhouse gas concentration at about 550 ppm.

Public Support for Directed Innovation

In practice, market-based instruments such as environmental taxes and tradable permits are often complemented with other policies, which target specific technologies. While the case for the role of the government in supporting basic and long-term research has been made and serves as an important source of future technological change, the issue of supporting specific technologies is less straightforward. Basic and long-term research has a public good character and is therefore unlikely to be undertaken by the private sector. Public support helps address fundamental scientific challenges and fosters technologies that are considered too risky, uncertain or long-gestating for the private sector. However, at the level of applied research the issue is more complicated. Should governments seek to minimise risks and support those technologies that are closest to the market, or should they seek to maximise returns and support technologies with the greatest mitigation potential? The OECD has started to examine these issues. For example, in recent years many governments have intervened directly in energy markets in order to promote increased investment in low emission technologies, such as renewable energy power plants. Increasing the penetration of intermittent renewable energy sources (wind, solar, ocean) presents significant challenges to electricity grid management. Improved energy storage and grid management can overcome this constraint by increasing system flexibility.

The benefits of targeting public R&D expenditures at system flexibility (energy storage and grid management technologies) may be greater than directly at intermittent generating technologies. Preliminary empirical evidence suggests that focussing policy incentives on innovation in system flexibility may obviate some of the problems associated with trying to "pick winners" amongst a portfolio of generating technologies of unknown potential (see Figure 7). The reasoning is simple - improved grid management and energy storage will yield benefits, irrespective of which intermittent renewable energy technologies ultimately prove to be 'winners'.

Figure 7. Policy Incidence and Technology Neutrality

Source: OECD (2012) *Energy and Climate Policy and Innovation.*

Where governments do provide targeted support, the design of policy mechanisms is of great importance. Good policy designs need to ensure competitive selection processes, focus on performance rather than specific technologies, avoid favouring incumbents or providing opportunities for lobbying, ensure a rigorous evaluation of policy impact, and contain costs. Proven ways to meet these design considerations include multi-year appropriations, independence of the agencies making funding decisions, use of peer review and other competitive procedures with clear criteria for project selection, and payments based on progress and outcomes rather than cost recovery or choice of technologies. Support for commercialisation should be temporary and accompanied by clear sunset clauses and transparent phase-out schedules, which requires a good understanding of the state of development of alternative technologies and the market structure in which they are being developed. Government support policies also need to be aligned with existing international commitments, notably under the WTO, and with competition policy.

OECD analysis shows that innovation in clean energy technologies depends on a wide range of research, notably material sciences, chemistry and physics, and not just on energy or environmental research. (See Figure 8). Investing in research to foster environmental technologies will therefore require a broad portfolio of investments, and not just

energy or environmental R&D. Moreover, such investments will increasingly need to be undertaken through approaches that involve multi-disciplinary funding, rather than funding along scientific disciplines.

Figure 8: The innovation-science link in "clean" energy technologies, 2000-2009 (Share of scientific fields cited in total non-patent literature cited in patents for "clean" energy technologies)
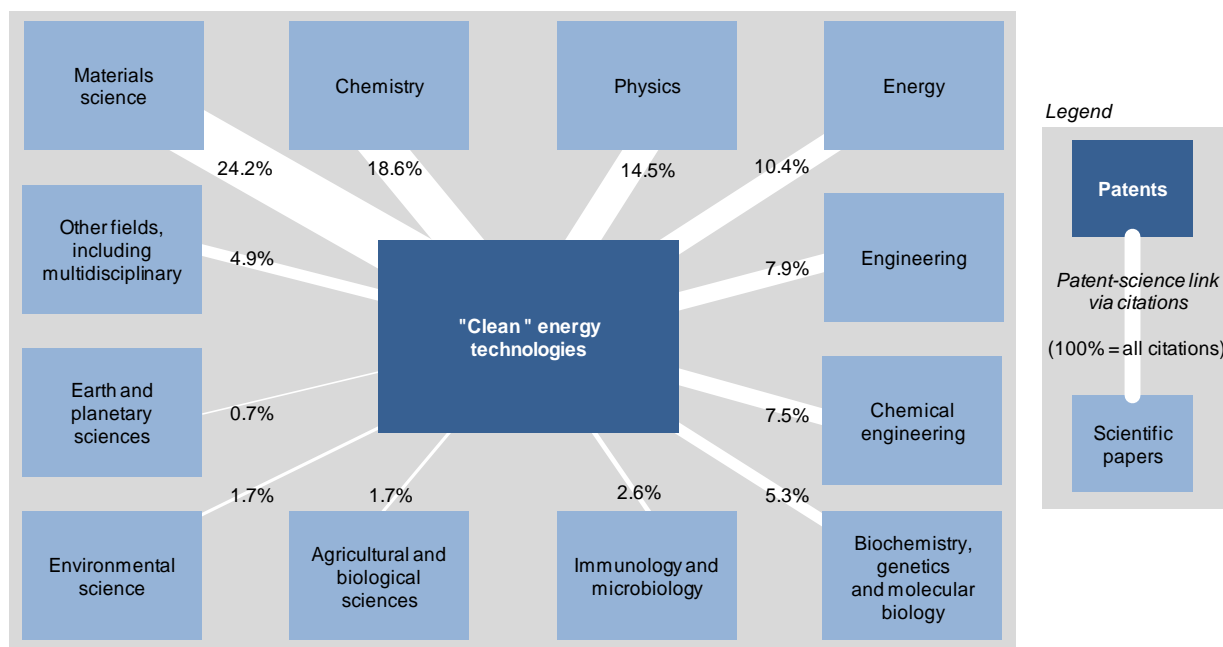
Source: OECD calculations, based on Scopus Custom Data, Elsevier, December 2010 and EPO, Worldwide Patent Statistical Database, April 2011.

Public investments in research will need to be well designed to complement private investments in research and should aim for scientific excellence and areas in which social returns and spill-over effects are potentially the greatest. Exploratory research focused on potentially radical innovations - characterised by high risk and uncertainty - should be included in the funding mix. Given the significant potential for research to reduce the costs of meeting environmental goals, greater public investment in research at the global level is needed.

However, governments can also provide greater direction to the existing research effort, *e.g.* in prioritising thematic and mission-oriented research programmes aimed at addressing specific challenges such as climate mitigation, without necessarily specifying the nature of the research required. Moreover, governments can take action to improve the process of translating research into innovation, *e.g.* in strengthening the links between science and business. To enable research efforts to materialise the policy commitment to such research should be stable over a long period.

International Environmental Governance

For environmental concerns of international concern, there are benefits to be gained from international policy coordination which extend beyond joint commitment to emission reductions. Recent OECD work has examined the role multilateral environmental agreements (MEAs) play in encouraging the international diffusion of abatement technologies. More specifically, the role that adherence to a series of international agreements on reducing SO_X and NO_X emissions - the Long-Range Transboundary Air Pollution Protocols - has played in inducing the transfer of technologies between signatories has been assessed. The major finding is that there is a positive effect on technology transfer between pairs of countries which have both joined the LRTAP Protocols (see Figure 9). Conversely, the effect is less pronounced when only either country joined or when neither one joined.

Figure 9. Protocol Signature and International Transfer of Air Pollution (SOx and NOx) Abatement Technologies: 1980-2008
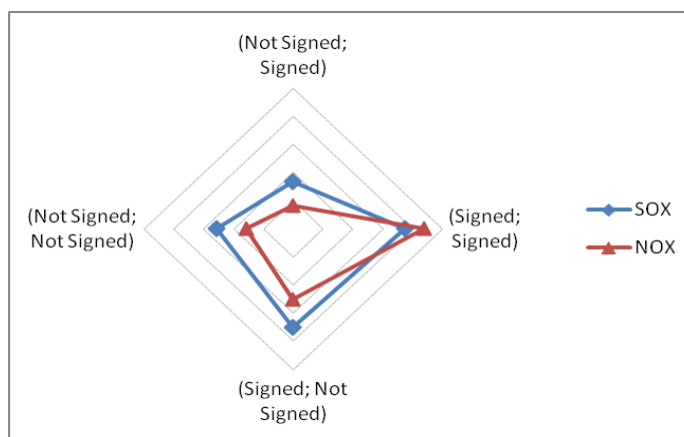
Source: OECD (2011) *Invention and Transfer of Environmental Technologies.* Note: The relative importance of cross-border transfer of emissions abatement technologies, measured as the number of duplicate patent applications. The corners indicate whether one, neither or both countries have signed the Protocol.

International research collaboration can be an important vehicle through which countries can share costs and increase knowledge spillovers. While this has often occurred international research collaboration has been common amongst OECD economies, it is interesting to note that for 'environmental' technologies inventors in many emerging countries are collaborating with partners in the OECD. Table 1 shows the most active co-invention pairs for four environmental technologies (wind power, solar photovoltaic, energy storage and carbon capture and storage), as well as for all technologies combined. While major OECD economies dominate the latter the situation is much more mixed in the environmental fields, with emerging economies and small OECD economies in greater evidence. Indeed, geographical patterns of research collaboration are increasingly diverse (see Figure 10 for the case of wind power).

Table 1. The Top Co-Inventing Country Pairs for Environmental and General Technologies
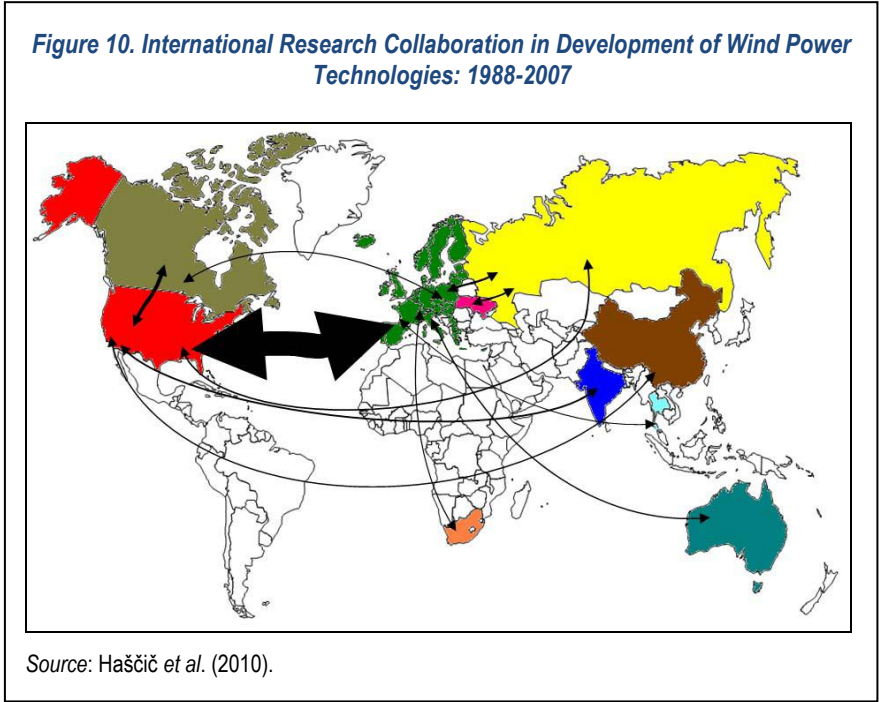
Sector	1	2	3	4	5	6	7	8	9	10
All Technologies	GB-US	DE-US	CA-US	CH-DE	JP-US	FR-US	NL-US	DE-FR	CH-FR	CH-US
Wind	DK-GB	DE-US	CA-US	DE-NL	NL-US	DE-DK	IN-US	BE-**ZA**	**RU**-US	DK-ES
Solar PV	JP-US	DE-US	GB-US	CH-DE	AT-DE	CA-US	**CN**-US	DE-FR	DE-NL	GB-IT
Energy Storage	GB-US	CA-US	DE-US	JP-US	JP-KR	FR-US	CH-DE	CA-FR	**CN**-US	KR-US
CCS	CA-US	NL-US	GB-US	FR-US	DE-US	AU-NL	DE-GB	GB-NL	NO-US	**CN**-US

Note: Co-invention is measured as country of residence for patented inventions. Emerging economies in bold.

Given the potential benefits from international research collaboration it has been suggested that technology-oriented agreements may be a potentially useful means to complement emissions-based agreements at the international level. Measures that support international collaborative research activities across countries can be a helpful mechanism to encourage the development and diffusion of climate mitigation technologies internationally.

In order to gain an improved understanding of why international research collaboration occurs, recent work has investigated the relationship between the International Energy Agency's "Implementing Agreements" (IA) and co-inventive activities between participating countries. The evidence suggests that co-invention is significantly affected by membership of a country in the Implementing Agreement, although the magnitude of this effect varies across the different IAs (indicating that institutional arrangements and the substance of collaborative efforts play an important role (Kahrobaie *et al*. 2011). It is interesting that countries such as India, China, Brazil and South Africa have started to play increasingly important roles in different IAs with implications for the development of climate mitigation technologies. Moreover, they have become important research partners (see Figure 10). Given the urgency to develop effective international mechanisms to mitigate climate change, these results are encouraging.

Figure 10. International Research Collaboration in Development of Wind Power Technologies: 1988-2007

Source: Haščič *et al.* (2010).

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

ORGANISATION DE COOPÉRATION ET
DE DÉVELOPPEMENT ÉCONOMIQUES

BETTER POLICIES FOR BETTER LIVES   DES POLITIQUES MEILLEURES POUR UNE VIE MEILLEURE

Further Reading

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Further Information

- **Environmental Policy and Technological Innovation**
  http://www.oecd.org/environment/innovation
  Ivan Haščič (ivan.hascic@oecd.org)
  Nick Johnstone (nick.johnstone@oecd.org)

- **Environment and Innovation Policy Roadmaps**
  Xavier Leflaive (Xavier.Leflaive@oecd.org)

- **Taxation, Innovation and the Environment**
  Nils Axel Braathen (Nils-Axel.Braathen@oecd.org)
  James Greene (James.Greene@oecd.org)

- **Science and Technology Policy**
  http://www.oecd.org/sti/
  Dirk Pilat (dirk.pilat@oecd.org)

- **Environmental-Economic Modelling**
  http://www.oecd.org/environment/modelling
  Rob Dellink (rob.dellink@oecd.org)
  Elisa Lanzi (elisa.lanzi@oecd.org)

www.oecd.org/environment/innovation
Updated November 2011

TAB 15

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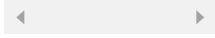
News (/)

ARTICLE / 22 JAN, 2018

UN Supports Blockchain Technology for Climate Action

New Climate Chain Coalition Launched, Seeking Members

UN Climate Change News, 22 January 2018 – Suppose information important to tackling climate change – such as an industry sector's greenhouse emissions – were continually updated from a multitude of sources and shared in an open and transparent way. Crucial

information would be readily available, up-to-date, transparently displayed and reviewed for accuracy.

This is the promise of so-called distributed ledger technology (DLT), the benefits of which seem limited only by the imagination of people familiar with the technology. The most well-known application of DLT and blockchain technology has been for creation of e-currencies, such as Bitcoin.
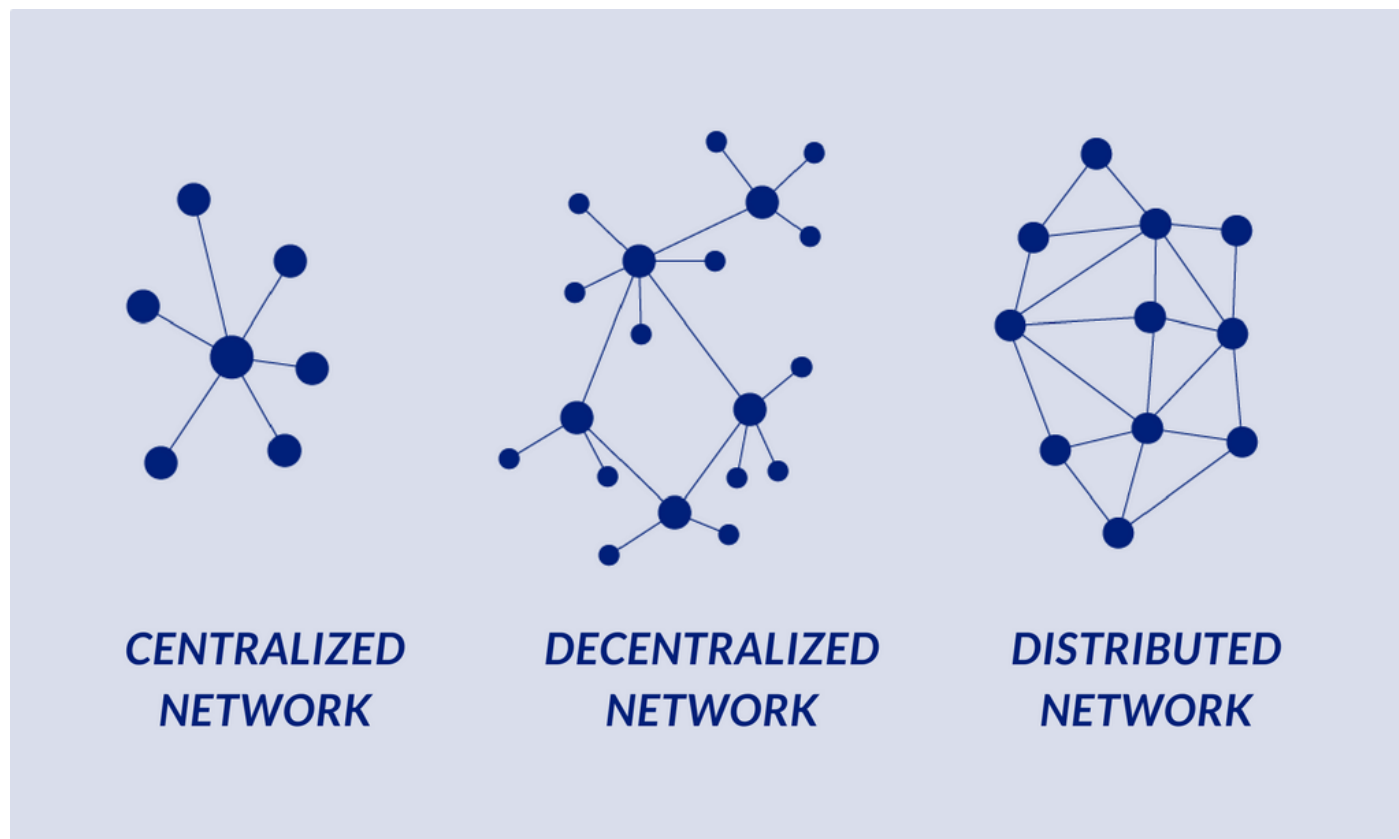
(/media/48293)

Blockchain technology is based on a mutual distributed network, which allows for high-level trust among users and better monitoring over the stored data.

To encourage exploration and eventual use of this technology in support of climate action, the UN Climate Change secretariat initiated and facilitated the creation of the Climate Chain Coalition and contributed to the writing of its charter of principles and values (below).

"The UN Climate Change secretariat recognizes the potential of blockchain technology to contribute to enhanced climate action and sustainability," said Massamba Thioye, who is leading UN Climate Change's work exploring DLT and blockchain.
DLT and blockchain could:

- strengthen monitoring, reporting and verification of the impacts of climate action
- improve transparency, traceability and cost-effectiveness of climate action
- build trust among climate actors

- make incentive mechanisms for climate action accessible to the poorest
- support mobilization of green finance.

"To fully and promptly mobilize this potential, broad collaboration among stakeholders is needed to direct resources to priority areas, avoid duplication of effort, and help avoid the pitfalls of working on a new technology with countless unknowns," said Mr. Thioye.

There are currently about 32 members signed up to the coalition, and membership is open. (See below.) For more information on DLT and blockchain, see <u>How Blockchain Technology Could Boost Climate Action (https://cop23.unfccc.int/news/how-blockchain-technology-could-boost-climate-action)</u>.

+ + + + +

Announcing the Climate Chain Coalition and its Membership Charter

During the One Planet Summit on 12 December 2017 in Paris, France (on the second anniversary of the Paris Climate Change Agreement), a multi-stakeholder group of 25 organizations working on distributed ledger technology (DLT, i.e. blockchain) held a meeting to agree to collaborate and establish an open global initiative called the Climate Chain Coalition (CCC).

DLT and related digital solutions (e.g. Internet of Things, big data) can enhance monitoring, reporting and verification and help mobilize climate finance to scale climate actions for mitigation and adaptation.

The CCC mission is to advance collaboration among members working on issues of common interest, and to help enhance the environmental integrity and results of DLT applications for climate. The CCC membership agreed on shared principles and values to facilitate and guide activities for capacity building, networking, research, governance, demonstrations, and pilot projects.

New members are welcome to join this open initiative and contribute to the transition to a climate-resilient economy aligned with the Paris Agreement. Contact Tom Bauman of ClimateCHECK at tb(at)climate-check.com

Climate Chain Coalition
Members Charter

As a member of the Climate Chain Coalition, our organization agrees to cooperatively support the application of distributed ledger technology ('DLT', including 'the blockchain') and related digital solutions to addressing climate change by adhering to the following shared principles and values:

1. Alignment with the long-term goals of the Paris Agreement

We recognize the massive challenge and urgency of global transition to a low-carbon and climate-resilient economy and; align with the goals of the Paris Agreement. We will cooperate to support immediate actions by and for blockchain and related digital solutions that contribute to the achievement of this transition;

2. Advancement of DLT for Better Climate Change Solutions

We will cooperate to support the rapid advancement of DLT solutions to address climate change across mitigation and adaptation through enhanced climate actions, including but not limited to the measurement, reporting and verification (MRV) of the impact of all sorts of intervention, and the mobilization of climate finance from diversified sources;

3. Collaboration within the Scope of the Coalition

On the basis of these shared principles and values, we will collaborate on concerted activities and in the dissemination of outputs in relation to DLT solutions and support stakeholder capacity building with regard to the deployment of shared tools and systems to advance climate change governance, especially in developing countries;

4. Technology Neutrality

We recognize that DLT evolves constantly and therefore, maintain a neutral position regarding the applicability of DLT;

5. Commitment to Standardization

We will collaborate to establish basic standards in the development of related tools in support of the efficacy of DLT applications for climate change governance;

6. Dissemination of DLT Benefits

We will collaborate on DLT-related solutions to be developed in the interest of cost-effectiveness, integrity, transparency, and empowering stakeholders in socio-economic systems;

7. Fraud Mitigation

We will collaborate on a proactive strategy to identify and seek to mitigate fraudulent activities associated with the application of DLT in climate change and sustainability governance in general, as appropriate;

8. Responsibility for addressing challenges attributable to DLT applications

As organizations concerned about environmental integrity generally and climate change specifically, we recognize some negative effects and current challenges of many DLT applications (in particular those using the blockchain with proof of work consensus) regarding their levels of energy consumption and GHG emissions. We are transparent and forthcoming while we actively seek appropriate solutions to address these challenges;

9. Sustainable Development Goals

We recognize that climate change is one of the Sustainable Development Goals (SDGs) and will encourage the development of DLT-based innovations for climate change which can simultaneously contribute to the achievement of SDGs.

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Related News

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ARTICLE

Implementing Paris Agreement Could Save Governments USD 54 Trillion in Health Care – Report

UN Climate Change News, 5 March 2018 - Meeting the objectives of the Paris Climate Change Agreement by investing in low emissions technology would save governments around USD 54 trillion in health care costs by mid-century, leading medical experts say in a new report. Investing in the reduction of...

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2018 United Nations Framework Convention on Climate Change

TAB 16

Task Force on Climate-related Financial Disclosures

Public Consultation Summary

April 18, 2017

BACKGROUND

The Financial Stability Board (FSB) established the Task Force on Climate-related Financial Disclosures (TCFD) in 2015 to develop recommendations for more effective climate-related disclosures that:

- could "**promote more informed investment, credit, and insurance underwriting decisions**" and,

- in turn, "would enable stakeholders to **understand better** the concentrations of **carbon-related assets in the financial sector** and the financial system's **exposures to climate-related risks**."

Industry Led and Geographically Diverse Task Force

The Task Force's 32 international members, led by Michael Bloomberg, include providers of capital, insurers, large non-financial companies, accounting and consulting firms, and credit rating agencies.

| 16 Experts from the Financial Sector | 8 Experts from Non-Financial Sectors | 8 Other Experts |

PUBLIC CONSULTATION APPROACH

The Task Force on Climate-related Financial Disclosures released its report for a 60-day public consultation on December 14, 2016. The consultation period closed on February 12, 2017.

- The public consultation was conducted through an **online questionnaire** designed to gather feedback on the report, guidance, and key issues identified by the Task Force.

- The Task Force received **306 responses to the online consultation** questionnaire and **59 comment letters on the report and guidance from a variety of organizations**.

- 14 of the 59 respondents that submitted comment letters did not also complete the online questionnaire, resulting in a total of **320 unique responses**.

Recommendations
of the Task Force
on Climate-related
Financial Disclosures

December 14, 2016

TCFD | TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES
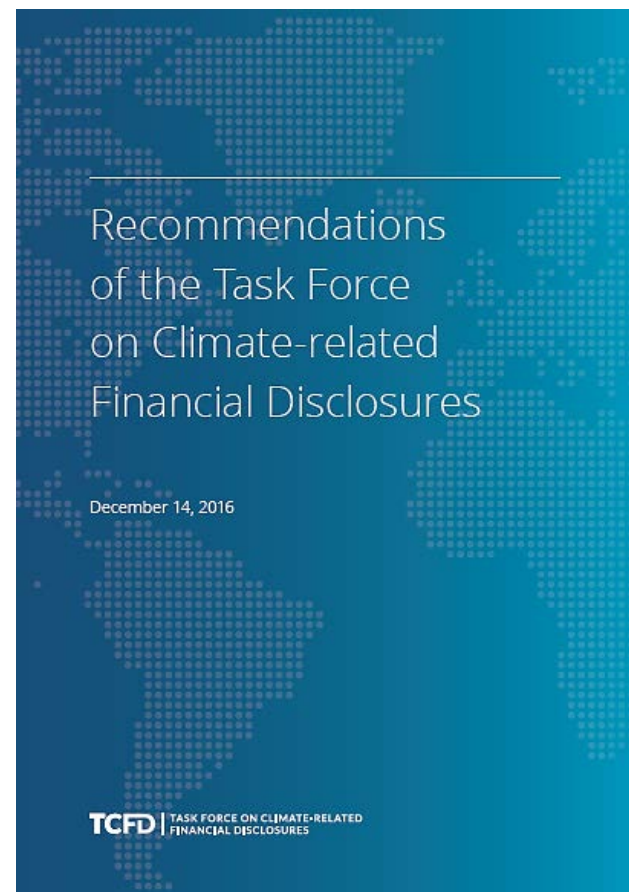
Please note that due to rounding the numbers in certain charts throughout the presentation may not add to 100%

GEOGRAPHICAL DISTRIBUTION

The Task Force received online responses and comment letters from respondents in 30 countries, including 15 of the G20 jurisdictions.

Organizations that provided both online submissions and comment letters are counted in the "Online Consultation Responses Received" totals.

ONLINE CONSULTATION RESPONSES RECEIVED

Country	Responses	Country	Responses
Australia	15	Italy	5
Austria	2	Japan	25
Belgium	10	Luxembourg	1
Belize	1	Mauritius	1
Brazil	8	Mexico	1
Canada	19	Netherlands	11
Colombia	1	Norway	5
Denmark	1	Peru	1
Finland	1	Singapore	4
France	27	Sweden	6
Germany	16	Switzerland	8
Greece	1	Turkey	2
Hong Kong	6	United Kingdom	78
India	7	United States	42
Indonesia	1		

COMMENT LETTERS FROM UNIQUE RESPONDENTS

Country	Responses	Country	Responses
United Kingdom	4	France	1
Canada	2	Germany	1
Switzerland	2	India	1
United States	2	Saudi Arabia	1

ONLINE RESPONSES BY REGION

- Europe — 56.9%
- North America — 20.3%
- Asia Pacific — 19.0%
- Middle East/Africa — 0.3%
- South America — 3.6%
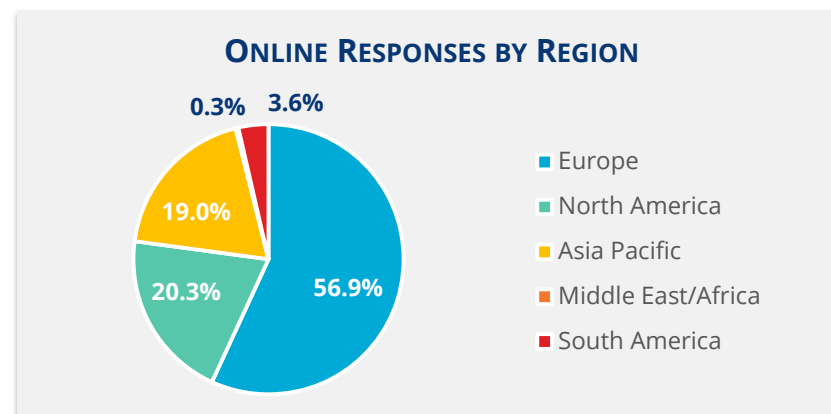
Types of Respondents

Respondents were asked to provide information on their industry and their perspective on the recommendations as a user, preparer, or user and preparer of disclosures, or other. In addition, respondents noted their area of responsibility.
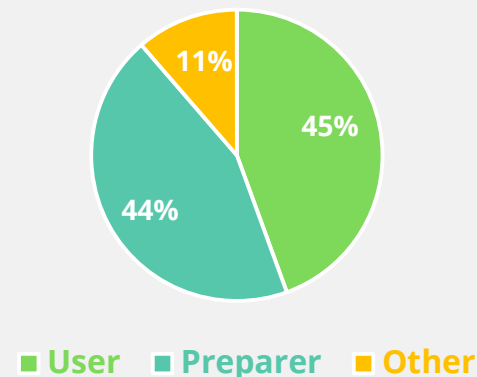
Percentage of Respondents by Sector

- **Financial** — 43%
- **Non-Financial** — 18%
- **NGOs and Others** — 39%
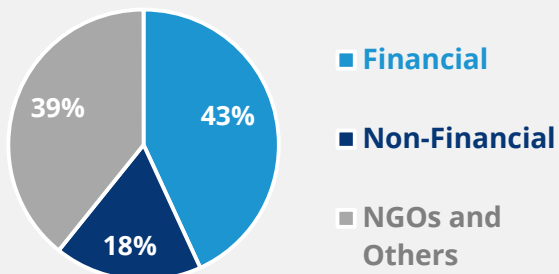
132 respondents work in the **financial** sector, 54 in **non-financial** sectors, and 120 in "Academia," "NGO", or "Other" categories ("**NGOs and Others**").

192 respondents identified themselves as **users** of disclosure, 191 as **preparers** of disclosure, and 49 as "**other**."*

Percentage of Respondent Type

- **User** — 45%
- **Preparer** — 44%
- **Other** — 11%

Percentage of Respondents by Role

- Sustainability — 21%
- Other — 14%
- Investment/Asset Management — 22%
- Academic/Industry Expert — 8%
- Government/Regulatory Affairs — 12%
- Finance/Corporate Reporting/Strategy — 9%
- Admin/General Management — 7%
- Legal/Risk/Compliance — 4%
- Board Member — 3%

Respondents represented a variety of roles, most commonly sustainability and investment/asset management.
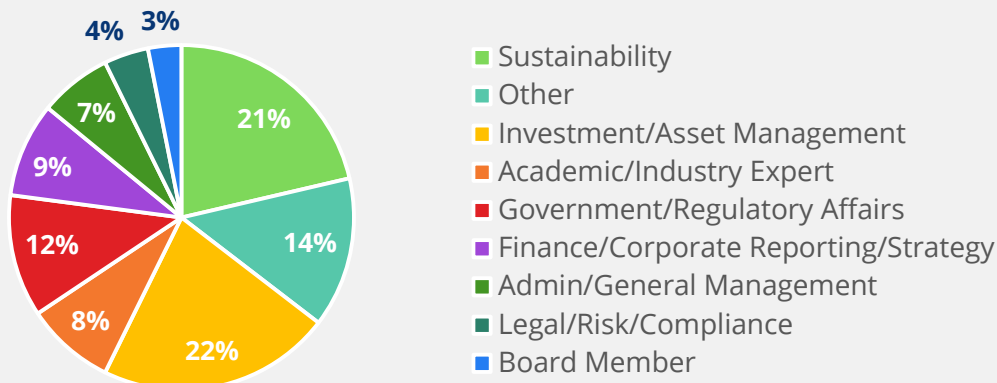
RESPONSES AT A GLANCE

The Task Force asked respondents whether certain aspects of its recommendations and guidance were useful. The table below lists the questions asked and summarizes the responses.

QUESTION	RESPONDENTS	USEFUL	NOT USEFUL	NEITHER	DON'T KNOW
How useful are the recommendations and guidance for all sectors in preparing disclosures?	**Preparers**	**75%**	12%	11%	2%
How useful is the supplemental guidance in preparing disclosures?	**Preparers**	**66%**	14%	18%	2%
If organizations disclose the recommended information, how useful would it be for decision making?	**Users** and **Others**	**77%**	3%	10%	10%
How useful is a description of potential performance across a range of scenarios to understanding climate-related impacts on an organization's businesses, strategy, and financial planning?	**Financial**	**74%**	7%	9%	10%
	Non-Financial	17%	**50%**	26%	7%
	NGOs and **Others**	**86%**	7%	6%	2%
How useful are the illustrative examples of metrics and targets?	**Financial**	**74%**	4%	5%	17%
	Non-Financial	**33%**	**33%**	30%	4%
	NGOs and **Others**	**72%**	3%	15%	11%
How useful would the disclosure of GHG emissions associated with investments be for economic decision-making purposes (e.g., investing decisions)?	**Financial**	**68%**	11%	14%	8%
	NGOs and **Others**	**74%**	7%	13%	7%

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KEY THEMES

Overall, commenters were generally supportive of the Task Force's recommendations; however, several provided specific and constructive feedback on the report.

The key themes from this feedback are included below. The Task Force will address these themes in the final version of the report.

Materiality and Location of Disclosures

Clarifying which recommended disclosures **depend on materiality assessment** and providing flexibility for organizations to provide some or all disclosures in reports other than financial filings.

Metrics for Non-Financial Sectors

Improving comparability and consistency of the **illustrative metrics** for non-financial sectors, clarifying the links to financial impact and climate-related risks and opportunities.

Scenario Analysis

Improving ease of implementation, and comparability of **scenario analysis** by specifying standard scenario(s) and providing additional guidance and tools.

Metrics for the Financial Sector

Encouraging **further development and standardization of metrics for the financial sector**.

Implementation

Providing **disclosure examples** to support preparers in developing relevant climate-related disclosures.

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USEFULNESS OF RECOMMENDATIONS AND GUIDANCE

Preparers were asked how useful Task Force's recommendations and guidance for all sectors are in preparing disclosures.

75% responded that the recommendations and guidance for all sectors would be **quite useful or very useful.**

RESPONDENTS	USEFUL	NOT USEFUL	NEITHER	DON'T KNOW
Preparers	**75%**	12%	11%	2%

PERCENTAGE OF RESPONDENT TYPE
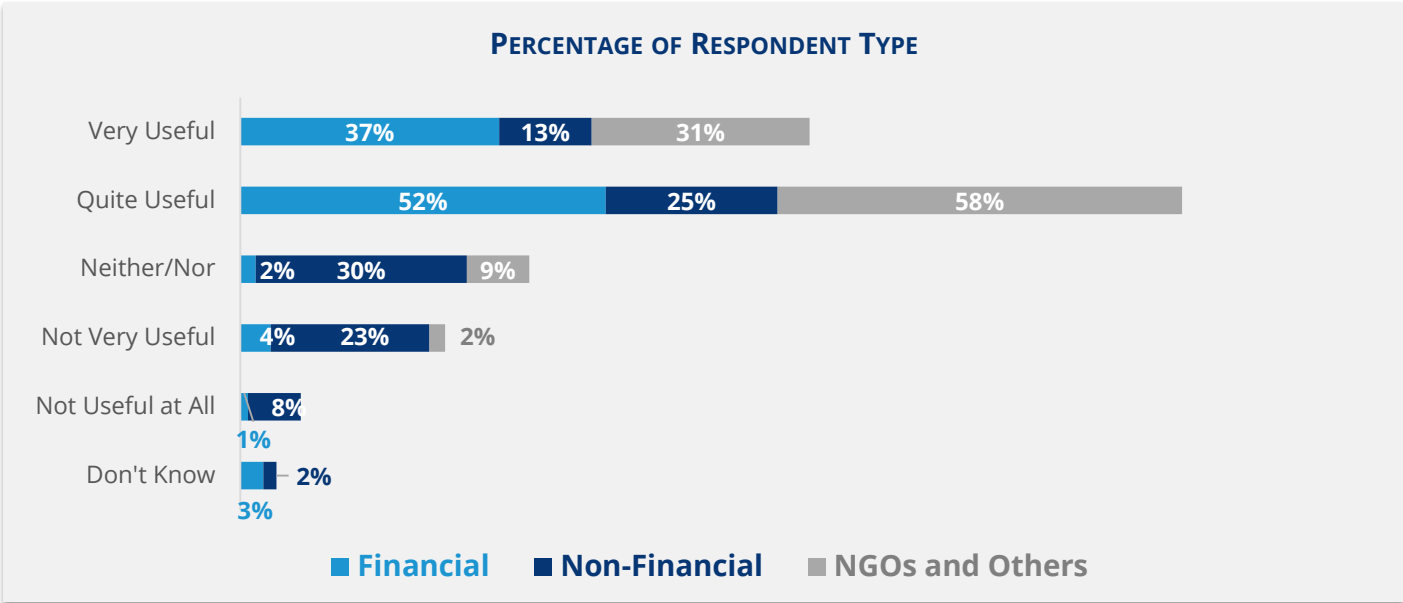
Base size (asked of **Preparers**): **191**

USEFULNESS OF RECOMMENDATIONS AND GUIDANCE *(CONTINUED)*

Preparers were asked how useful Task Force's supplemental guidance is or would be for preparing disclosures.

66% responded that the supplemental guidance would be **quite useful or very useful.**

RESPONDENTS	USEFUL	NOT USEFUL	NEITHER	DON'T KNOW
Preparers	**66%**	14%	18%	2%

Base size (asked of **Preparers**): 191

PERCENTAGE OF RESPONDENT TYPE

- Very Useful: 26% 8% 16%
- Quite Useful: 53% 25% 64%
- Neither/Nor: 12% 34% 11%
- Not Very Useful: 4% 21% 9%
- Not Useful at All: 11% 1%
- Don't Know: 2% 3%

■ **Financial** ■ **Non-Financial** ■ NGOs and Others

Users and others were asked if organizations disclose the recommended information, how useful would it be for decision making purposes (e.g., investment, underwriting, and lending).

77% responded that the disclosures would be **quite useful or very useful.**

RESPONDENTS	USEFUL	NOT USEFUL	NEITHER	DON'T KNOW
Users and Others	**77%**	3%	10%	10%

Base size (asked of **Users** and **Others**): 241

PERCENTAGE OF RESPONDENT TYPE

- Very Useful: 33% 31%
- Quite Useful: 47% 44%
- Neither/Nor: 10% 9%
- Not Very Useful: 2% 3%
- Not Useful at All: 1%
- Don't Know: 8% 14%

■ **Financial** ■ NGOs and Others

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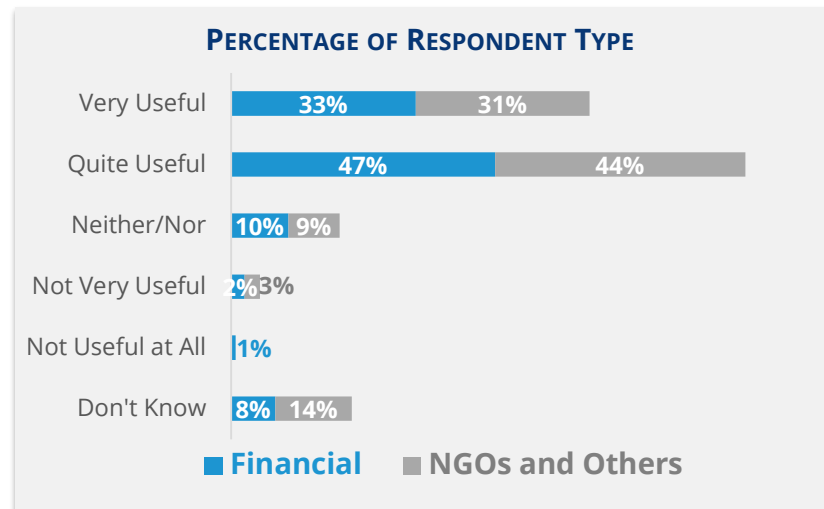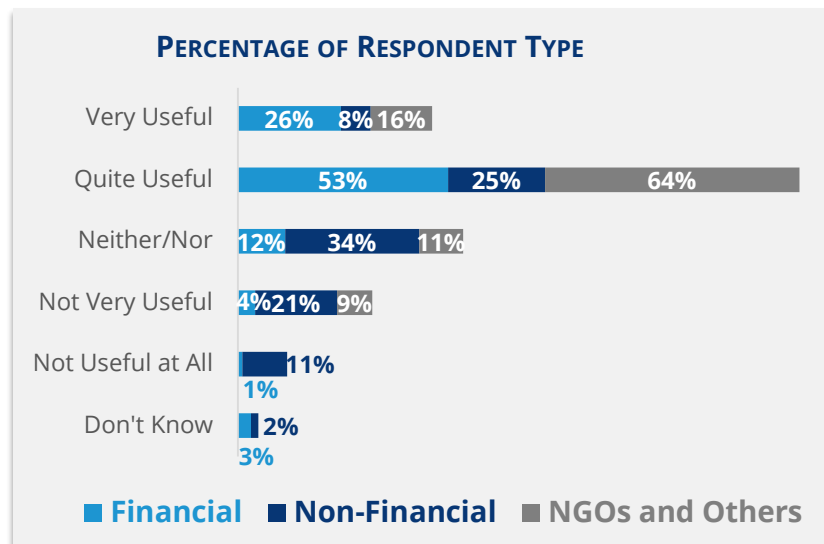
USEFULNESS OF SCENARIO ANALYSIS

All respondents were asked about the usefulness of a **description of potential performance across a range of scenarios** to understanding climate-related impacts on an organization's businesses, strategy, and financial planning.

All respondents were asked about the most **effective measures to address potential challenges around conducting scenario analysis** and disclosing the recommended information.

RESPONDENTS	USEFUL	NOT USEFUL	NEITHER	DON'T KNOW
All	**69%**	14%	11%	6%

PERCENTAGE OF RESPONDENT TYPE

- Very Useful: Financial 36%, Non-Financial 7%, NGOs and Others 47%
- Quite Useful: Financial 39%, Non-Financial 9%, NGOs and Others 39%
- Neither/Nor: Financial 9%, Non-Financial 26%, NGOs and Others 6%
- Not Very Useful: Financial 5%, Non-Financial 39%, NGOs and Others 6%
- Not Useful at All: Financial 11%, Non-Financial 1%, 2%
- Don't Know: Financial 10%, Non-Financial 7%, NGOs and Others 2%

■ **Financial** ■ **Non-Financial** ■ **NGOs and Others**

PERCENTAGE OF RESPONSES

- Better practice standards around conducting and disclosing scenario analyses — 29%
- Development of additional methodologies and tools — 26%
- Further work by industry trade groups and disclosure users on critical elements to be… — 22%
- Reduce the cost of conducting and disclosing scenario analysis — 8%
- Allow a year or two to phase-in scenario analysis and related disclosures — 7%
- Other — 7%

Base size (asked of **All**): **306**

Base size (asked of **All**): **306**

METRICS AND TARGETS

All respondents were asked about the usefulness of the **illustrative examples of metrics and targets** provided for non-financial groups.

RESPONDENTS	USEFUL	NOT USEFUL	NEITHER	DON'T KNOW
All	**66%**	9%	13%	12%

PERCENTAGE OF RESPONDENT TYPE

Very Useful	30% / 4% / 27%	
Quite Useful	44% / 30% / 45%	
Neither/Nor	5% / 30% / 15%	
Not Very Useful	20% / 3%	
Not Useful at All	3... / 13% / 1%	
Don't Know	17% / 4% / 11%	

■ **Financial**   ■ **Non-Financial**   ■ **NGOs and Others**
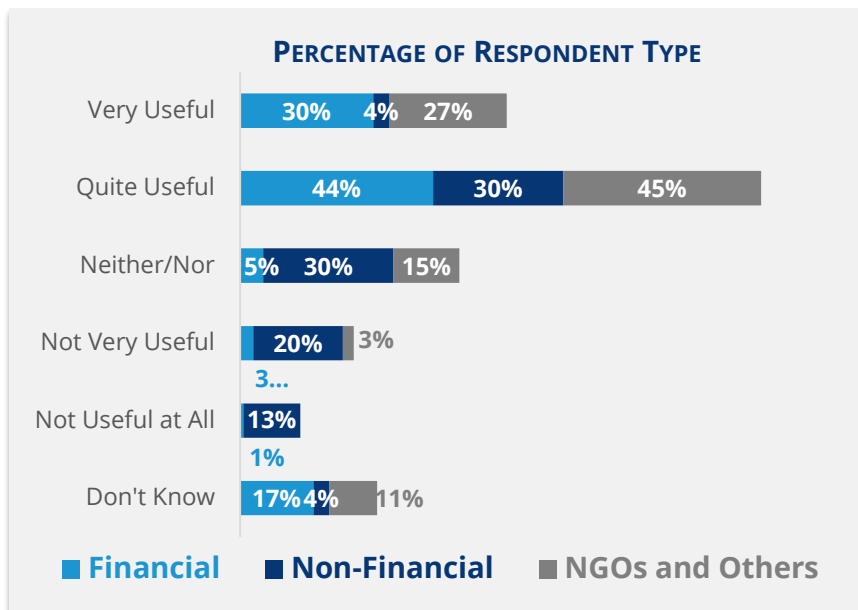
Users were asked **how useful disclosure of GHG emissions associated with investments** would be for economic decision-making (e.g., investing decisions).

RESPONDENTS	USEFUL	NOT USEFUL	NEITHER	DON'T KNOW
Users	**70%**	10%	13%	7%

PERCENTAGE OF RESPONDENT TYPE

Very Useful	22% / 35%
Quite Useful	45% / 39%
Neither/Nor	14% / 13%
Not Very Useful	9% / 4%
Not Useful at All	3% / 3%
Don't Know	8% / 7%

■ **Financial**   ■ **NGOs and Others**

Base size (asked of **All**): 306
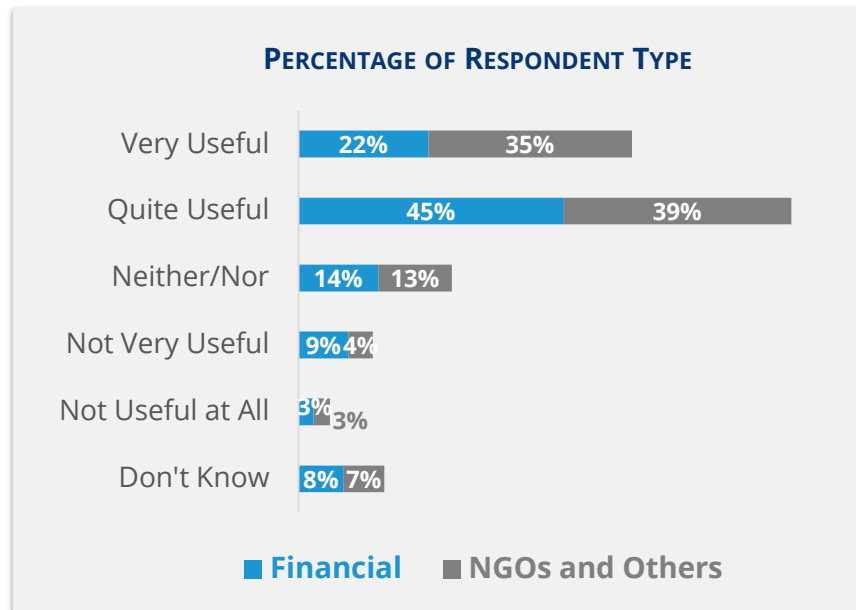
Base size (asked of **Users**): 192

IMPLEMENTATION TIMEFRAME

Preparers were asked about the timeframe in which they would be willing to implement the recommendations in financial filings.

Over 40% of **financial** and **non-financial preparers** indicated that they do not know whether or when they would implement the recommendations. The most often cited reasons include:

- the organization has not yet decided whether to implement the recommendations
- the organization will report outside of financial filings
- the organization will likely implement the recommendations, but could not commit at this time

PERCENTAGE OF RESPONSES

- In the next one to two years — 21%
- In three to five years — 16%
- We do not intend to implement the recommendations — 10%
- We already report these disclosures in financial filings — 6%
- Do not know — 47%
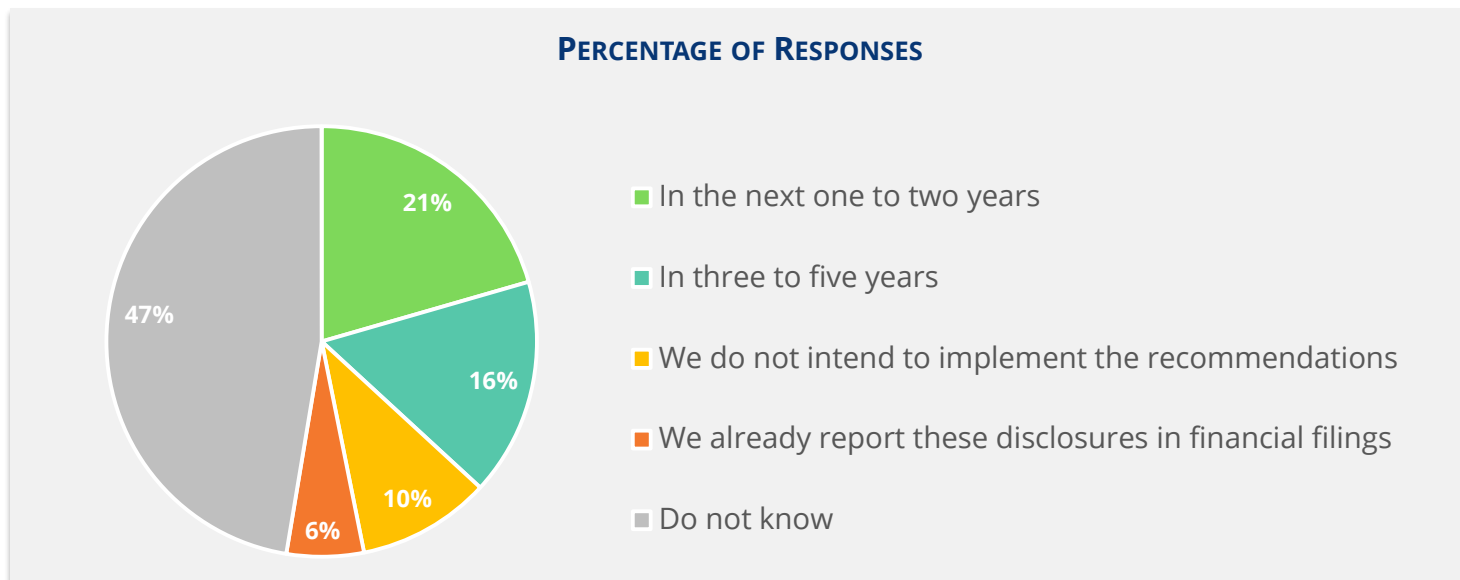
Base size (asked of **Preparers**): **191**

DRIVERS FOR IMPLEMENTATION - PREPARERS

Preparers were asked what drivers, if any, would encourage them to adopt the recommendations.

"**Request from investors**" was the most cited driver in focus groups and by the non-financial respondents. Financial respondents said that "**adoption by peers**" would be their primary driver.

NUMBER OF RESPONSES

	Financial	Non-Financial	Other
Adoption by industry peers	66	22	32
Requests from investors to disclose	54	26	34
Requests from clients or beneficiaries	64	21	28
Inquiries or requests from debt or equity analysts	42	21	27
Reputational benefits and goodwill from adoption	53	11	23
Other	30	12	20
None of the above	6	16	1

■ **Financial** ■ **Non-Financial** ■ **Other**

Base size (asked of **Preparers**): **191**

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NEXT STEPS

The Task Force is in the process of evaluating feedback and potential changes to the report, which is scheduled to be finalized and released in June 2017.

The FSB has extended the Task Force through mid-2018 to support and monitor adoption.

TIMELINE

Second Quarter 2017	Third Quarter 2017	Fourth Quarter 2017	First Quarter 2018	Second Quarter 2018

Apr 20-21: Meeting of G20 Finance Ministers and Governors

Jul 7-8: FSB report presentation at G20 Summit

Q2 2018: Submission of implementation monitoring report

Q2: Update report per consultation feedback

Q4 2017-Q2 2018: Implementation monitoring

Q2 2017-Q2 2018: Outreach and engagement

Jun: Issuance of final report to FSB

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TAB 17

Final Report

Recommendations of the Task Force on Climate-related Financial Disclosures

TCFD | TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

June 2017

Mr. Mark Carney
Chairman
Financial Stability Board
Bank for International Settlements
Centralbahnplatz 2
CH-4002 Basel
Switzerland

Dear Chairman Carney,

On behalf of the Task Force on Climate-related Financial Disclosures, I am pleased to present this final report setting out our recommendations for helping businesses disclose climate-related financial information.

As you know, warming of the planet caused by greenhouse gas emissions poses serious risks to the global economy and will have an impact across many economic sectors. It is difficult for investors to know which companies are most at risk from climate change, which are best prepared, and which are taking action.

The Task Force's report establishes recommendations for disclosing clear, comparable and consistent information about the risks and opportunities presented by climate change. Their widespread adoption will ensure that the effects of climate change become routinely considered in business and investment decisions. Adoption of these recommendations will also help companies better demonstrate responsibility and foresight in their consideration of climate issues. That will lead to smarter, more efficient allocation of capital, and help smooth the transition to a more sustainable, low-carbon economy.

The industry Task Force spent 18 months consulting with a wide range of business and financial leaders to hone its recommendations and consider how to help companies better communicate key climate-related information. The feedback we received in response to the Task Force's draft report confirmed broad support from industry and others, and involved productive dialogue among companies and banks, insurers, and investors. This was and remains a collaborative process, and as these recommendations are implemented, we hope that this dialogue and feedback continues.

Since the Task Force began its work, we have also seen a significant increase in demand from investors for improved climate-related financial disclosures. This comes amid unprecedented support among companies for action to tackle climate change.

I want to thank the Financial Stability Board for its leadership in promoting better disclosure of climate-related financial risks, and for its support of the Task Force's work. I am also grateful to the Task Force members and Secretariat for their extensive contributions and dedication to this effort.

The risk climate change poses to businesses and financial markets is real and already present. It is more important than ever that businesses lead in understanding and responding to these risks—and seizing the opportunities—to build a stronger, more resilient, and sustainable global economy.

Sincerely,

Michael R. Bloomberg

Executive Summary

Financial Markets and Transparency

One of the essential functions of financial markets is to price risk to support informed, efficient capital-allocation decisions. Accurate and timely disclosure of current and past operating and financial results is fundamental to this function, but it is increasingly important to understand the governance and risk management context in which financial results are achieved. The financial crisis of 2007-2008 was an important reminder of the repercussions that weak corporate governance and risk management practices can have on asset values. This has resulted in increased demand for transparency from organizations on their governance structures, strategies, and risk management practices. Without the right information, investors and others may incorrectly price or value assets, leading to a misallocation of capital.

> Increasing transparency makes markets more efficient and economies more stable and resilient.
> —Michael R. Bloomberg

Financial Implications of Climate Change

One of the most significant, and perhaps most misunderstood, risks that organizations face today relates to climate change. While it is widely recognized that continued emission of greenhouse gases will cause further warming of the planet and this warming could lead to damaging economic and social consequences, the exact timing and severity of physical effects are difficult to estimate. The large-scale and long-term nature of the problem makes it uniquely challenging, especially in the context of economic decision making. Accordingly, many organizations incorrectly perceive the implications of climate change to be long term and, therefore, not necessarily relevant to decisions made today.

The potential impacts of climate change on organizations, however, are not only physical and do not manifest only in the long term. To stem the disastrous effects of climate change within this century, nearly 200 countries agreed in December 2015 to reduce greenhouse gas emissions and accelerate the transition to a lower-carbon economy. The reduction in greenhouse gas emissions implies movement away from fossil fuel energy and related physical assets. This coupled with rapidly declining costs and increased deployment of clean and energy-efficient technologies could have significant, near-term financial implications for organizations dependent on extracting, producing, and using coal, oil, and natural gas. While such organizations may face significant climate-related risks, they are not alone. In fact, climate-related risks and the expected transition to a lower-carbon economy affect most economic sectors and industries. While changes associated with a transition to a lower-carbon economy present significant risk, they also create significant opportunities for organizations focused on climate change mitigation and adaptation solutions.

For many investors, climate change poses significant financial challenges and opportunities, now and in the future. The expected transition to a lower-carbon economy is estimated to require around $1 trillion of investments a year for the foreseeable future, generating new investment opportunities.[1] At the same time, the risk-return profile of organizations exposed to climate-related risks may change significantly as such organizations may be more affected by physical impacts of climate change, climate policy, and new technologies. In fact, a 2015 study estimated the value at risk, as a result of climate change, to the total global stock of manageable assets as

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[1] International Energy Agency, *World Energy Outlook Special Briefing for COP21*, 2015.

ranging from $4.2 trillion to $43 trillion between now and the end of the century.[2] The study highlights that "much of the impact on future assets will come through weaker growth and lower asset returns across the board." This suggests investors may not be able to avoid climate-related risks by moving out of certain asset classes as a wide range of asset types could be affected. Both investors and the organizations in which they invest, therefore, should consider their longer-term strategies and most efficient allocation of capital. Organizations that invest in activities that may not be viable in the longer term may be less resilient to the transition to a lower-carbon economy; and their investors will likely experience lower returns. Compounding the effect on longer-term returns is the risk that present valuations do not adequately factor in climate-related risks because of insufficient information. As such, long-term investors need adequate information on how organizations are preparing for a lower-carbon economy.

Furthermore, because the transition to a lower-carbon economy requires significant and, in some cases, disruptive changes across economic sectors and industries in the near term, financial policymakers are interested in the implications for the global financial system, especially in terms of avoiding financial dislocations and sudden losses in asset values. Given such concerns and the potential impact on financial intermediaries and investors, the G20 Finance Ministers and Central Bank Governors asked the Financial Stability Board to review how the financial sector can take account of climate-related issues. As part of its review, the Financial Stability Board identified the need for better information to support informed investment, lending, and insurance underwriting decisions and improve understanding and analysis of climate-related risks and opportunities. Better information will also help investors engage with companies on the resilience of their strategies and capital spending, which should help promote a smooth rather than an abrupt transition to a lower-carbon economy.

Task Force on Climate-related Financial Disclosures

To help identify the information needed by investors, lenders, and insurance underwriters to appropriately assess and price climate-related risks and opportunities, the Financial Stability Board established an industry-led task force: the Task Force on Climate-related Financial Disclosures (Task Force). The Task Force was asked to develop voluntary, consistent climate-related financial disclosures that would be useful to investors, lenders, and insurance underwriters in understanding material risks. The 32-member Task Force is global; its members were selected by the Financial Stability Board and come from various organizations, including large banks, insurance companies, asset managers, pension funds, large non-financial companies, accounting and consulting firms, and credit rating agencies. In its work, the Task Force drew on member expertise, stakeholder engagement, and existing climate-related disclosure regimes to develop a singular, accessible framework for climate-related financial disclosure.

The Task Force developed four widely adoptable recommendations on climate-related financial disclosures that are applicable to organizations across sectors and jurisdictions (Figure 1). Importantly, the Task Force's recommendations apply to financial-sector organizations, including banks, insurance companies, asset managers, and asset owners. Large asset owners and asset managers sit at the top of the investment chain and, therefore, have an

Figure 1
Key Features of Recommendations

– Adoptable by all organizations

– Included in financial filings

– Designed to solicit decision-useful, forward-looking information on financial impacts

– Strong focus on risks and opportunities related to transition to lower-carbon economy

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[2] The Economist Intelligence Unit, "The Cost of Inaction: Recognising the Value at Risk from Climate Change," 2015. Value at risk measures the loss a portfolio may experience, within a given time horizon, at a particular probability, and the stock of manageable assets is defined as the total stock of assets held by non-bank financial institutions. Bank assets were excluded as they are largely managed by banks themselves.

important role to play in influencing the organizations in which they invest to provide better climate-related financial disclosures.

In developing and finalizing its recommendations, the Task Force solicited input throughout the process.[3] First, in April 2016, the Task Force sought public comment on the scope and high-level objectives of its work. As the Task Force developed its disclosure recommendations, it continued to solicit feedback through hundreds of industry interviews, meetings, and other touchpoints. Then, in December 2016, the Task Force issued its draft recommendations and sought public comment on the recommendations as well as certain key issues, receiving over 300 responses. This final report reflects the Task Force's consideration of industry and other public feedback received throughout 2016 and 2017. Section E contains a summary of key issues raised by the industry as well as substantive changes to the report since December.

Disclosure in Mainstream Financial Filings
The Task Force recommends that preparers of climate-related financial disclosures provide such disclosures in their mainstream (i.e., public) annual financial filings. In most G20 jurisdictions, companies with public debt or equity have a legal obligation to disclose material information in their financial filings—including material climate-related information. The Task Force believes climate-related issues are or could be material for many organizations, and its recommendations should be useful to organizations in complying more effectively with existing disclosure obligations.[4] In addition, disclosure in mainstream financial filings should foster shareholder engagement and broader use of climate-related financial disclosures, thus promoting a more informed understanding of climate-related risks and opportunities by investors and others. The Task Force also believes that publication of climate-related financial information in mainstream annual financial filings will help ensure that appropriate controls govern the production and disclosure of the required information. More specifically, the Task Force expects the governance processes for these disclosures would be similar to those used for existing public financial disclosures and would likely involve review by the chief financial officer and audit committee, as appropriate.

Importantly, organizations should make financial disclosures in accordance with their national disclosure requirements. If certain elements of the recommendations are incompatible with national disclosure requirements for financial filings, the Task Force encourages organizations to disclose those elements in other official company reports that are issued at least annually, widely distributed and available to investors and others, and subject to internal governance processes that are the same or substantially similar to those used for financial reporting.

Core Elements of Climate-Related Financial Disclosures
The Task Force structured its recommendations around four thematic areas that represent core elements of how organizations operate: governance, strategy, risk management, and metrics and targets (Figure 2, p. v). The four overarching recommendations are supported by recommended disclosures that build out the framework with information that will help investors and others understand how reporting organizations assess climate-related risks and opportunities.[5] In addition, there is guidance to support all organizations in developing climate-related financial disclosures consistent with the recommendations and recommended disclosures. The guidance assists preparers by providing context and suggestions for implementing the recommended disclosures. For the financial sector and certain non-financial sectors, *supplemental* guidance was developed to highlight important sector-specific considerations and provide a fuller picture of potential climate-related financial impacts in those sectors.

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[3] See Appendix 2: Task Force Objectives and Approach for more information.

[4] The Task Force encourages organizations where climate-related issues could be material in the future to begin disclosing climate-related financial information outside financial filings to facilitate the incorporation of such information into financial filings once climate-related issues are determined to be material.

[5] See Figure 4 on p. 14 for the Task Force's recommendations and recommended disclosures.

Core Elements of Recommended Climate-Related Financial Disclosures

Governance
The organization's governance around climate-related risks and opportunities

Strategy
The actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning

Risk Management
The processes used by the organization to identify, assess, and manage climate-related risks

Metrics and Targets
The metrics and targets used to assess and manage relevant climate-related risks and opportunities

Climate-Related Scenarios

One of the Task Force's key recommended disclosures focuses on the resilience of an organization's strategy, taking into consideration different climate-related scenarios, including a 2° Celsius or lower scenario.[6] An organization's disclosure of how its strategies might change to address potential climate-related risks and opportunities is a key step to better understanding the potential implications of climate change on the organization. The Task Force recognizes the use of scenarios in assessing climate-related issues and their potential financial implications is relatively recent and practices will evolve over time, but believes such analysis is important for improving the disclosure of decision-useful, climate-related financial information.

Conclusion

Recognizing that climate-related financial reporting is still evolving, the Task Force's recommendations provide a foundation to improve investors' and others' ability to appropriately assess and price climate-related risk and opportunities. The Task Force's recommendations aim to be ambitious, but also practical for near-term adoption. The Task Force expects to advance the quality of mainstream financial disclosures related to the potential effects of climate change on organizations today and in the future and to increase investor engagement with boards and senior management on climate-related issues.

Improving the quality of climate-related financial disclosures begins with organizations' willingness to adopt the Task Force's recommendations. Organizations already reporting climate-related information under other frameworks may be able to disclose under this framework immediately and are strongly encouraged to do so. Those organizations in early stages of evaluating the impact of climate change on their businesses and strategies can begin by disclosing climate-related issues as they relate to governance, strategy, and risk management practices. The Task Force recognizes the challenges associated with measuring the impact of climate change, but believes that by moving climate-related issues into mainstream annual financial filings, practices and techniques will evolve more rapidly. Improved practices and techniques, including data analytics, should further improve the quality of climate-related financial disclosures and, ultimately, support more appropriate pricing of risks and allocation of capital in the global economy.

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[6] A 2° Celsius (2°C) scenario lays out an energy system deployment pathway and an emissions trajectory consistent with limiting the global average temperature increase to 2°C above the pre-industrial average. The Task Force is not recommending organizations use a specific 2°C scenario.

Contents

A Introduction

A Introduction

1. Background

It is widely recognized that continued emission of greenhouse gases will cause further warming of the Earth and that warming above 2° Celsius (2°C), relative to the pre-industrial period, could lead to catastrophic economic and social consequences.[7] As evidence of the growing recognition of the risks posed by climate change, in December 2015, nearly 200 governments agreed to strengthen the global response to the threat of climate change by "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels," referred to as the Paris Agreement.[8] The large-scale and long-term nature of the problem makes it uniquely challenging, especially in the context of economic decision making. Moreover, the current understanding of the potential financial risks posed by climate change—to companies, investors, and the financial system as a whole—is still at an early stage.

There is a growing demand for decision-useful, climate-related information by a range of participants in the financial markets.[9] Creditors and investors are increasingly demanding access to risk information that is consistent, comparable, reliable, and clear. There has also been increased focus, especially since the financial crisis of 2007-2008, on the negative impact that weak corporate governance can have on shareholder value, resulting in increased demand for transparency from organizations on their risks and risk management practices, including those related to climate change.

The growing demand for decision-useful, climate-related information has resulted in the development of several climate-related disclosure standards. Many of the existing standards, however, focus on disclosure of climate-related information, such as greenhouse gas (GHG) emissions and other sustainability metrics. Users of such climate-related disclosures commonly cite the lack of information on the financial implications around the climate-related aspects of an organization's business as a key gap. Users also cite inconsistencies in disclosure practices, a lack of context for information, use of boilerplate, and non-comparable reporting as major obstacles to incorporating climate-related risks and opportunities (collectively referred to as climate-related issues) as considerations in their investment, lending, and insurance underwriting decisions over the medium and long term.[10] In addition, evidence suggests that the lack of consistent information hinders investors and others from considering climate-related issues in their asset valuation and allocation processes.[11]

In general, inadequate information about risks can lead to a mispricing of assets and misallocation of capital and can potentially give rise to concerns about financial stability since markets can be vulnerable to abrupt corrections.[12] Recognizing these concerns, the G20 (Group of 20) Finance Ministers and Central Bank Governors requested that the Financial Stability Board (FSB) "convene public- and private-sector participants to review how the financial sector can take account of climate-related issues."[13] In response to the G20's request, the FSB held a meeting of public- and private-sector representatives in September 2015 to consider the implications of climate-related issues for the financial sector. "Participants exchanged views on the existing work of the financial sector, authorities, and standard setters in this area and the challenges they face,

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[7] Intergovernmental Panel on Climate Change, *Fifth Assessment Report,* Cambridge University Press, 2014.
[8] United Nations Framework Convention on Climate Change, "The Paris Agreement," December 2015.
[9] Avery Fellow, "Investors Demand Climate Risk Disclosure," Bloomberg, February 2013.
[10] Sustainability Accounting Standards Board (SASB), *SASB Climate Risk Technical Bulletin#: TB001-10182016,* October 2016.
[11] Mercer LLC, *Investing in a Time of Climate Change,* 2015.
[12] Mark Carney, "Breaking the tragedy of the horizon—climate change and financial stability," September 29, 2015.
[13] "Communiqué from the G20 Finance Ministers and Central Bank Governors Meeting in Washington, D.C. April 16-17, 2015," April 2015.

areas for possible further work, and the possible roles the FSB and others could play in taking that work forward. The discussions continually returned to a common theme: the need for better information."[14]

In most G20 jurisdictions, companies with public debt or equity have a legal obligation to disclose material risks in their financial reports—including material climate-related risks. However, the absence of a standardized framework for disclosing climate-related financial risks makes it difficult for organizations to determine what information should be included in their filings and how it should be presented. Even when reporting similar climate-related information, disclosures are often difficult to compare due to variances in mandatory and voluntary frameworks. The resulting fragmentation in reporting practices and lack of focus on financial impacts have prevented investors, lenders, insurance underwriters, and other users of disclosures from accessing complete information that can inform their economic decisions. Furthermore, because financial-sector organizations' disclosures depend, in part, on those from the companies in which they invest or lend, regulators face challenges in using financial-sector organizations' existing disclosures to determine system-wide exposures to climate-related risks.

In response, the FSB established the industry-led Task Force on Climate-related Financial Disclosures (TCFD or Task Force) in December 2015 to design a set of recommendations for consistent "disclosures that will help financial market participants understand their climate-related risks."[15] See Box 1 (p. 3) for more information on the Task Force.

2. The Task Force's Remit

The FSB called on the Task Force to develop climate-related disclosures that "could promote more informed investment, credit [or lending], and insurance underwriting decisions" and, in turn, "would enable stakeholders to understand better the concentrations of carbon-related assets in the financial sector and the financial system's exposures to climate-related risks."[16,17] The FSB noted that disclosures by the financial sector in particular would "foster an early assessment of these risks" and "facilitate market discipline." Such disclosures would also "provide a source of data that can be analyzed at a systemic level, to facilitate authorities' assessments of the materiality of any risks posed by climate change to the financial sector, and the channels through which this is most likely to be transmitted."[18]

The FSB also emphasized that "any disclosure recommendations by the Task Force would be voluntary, would need to incorporate the principle of materiality and would need to weigh the balance of costs and benefits."[19] As a result, in devising a principle-based framework for voluntary disclosure, the Task Force sought to balance the needs of the users of disclosures with the challenges faced by the preparers. The FSB further stated that the Task Force's climate-related financial disclosure recommendations should not "add to the already well developed body of existing disclosure schemes."[20] In response, the Task Force drew from existing disclosure frameworks where possible and appropriate.

The FSB also noted the Task Force should determine whether the target audience of users of climate-related financial disclosures should extend beyond investors, lenders, and insurance underwriters. Investors, lenders, and insurance underwriters ("primary users") are the appropriate target audience. These primary users assume the financial risk and reward of the

[14] FSB, "FSB to establish Task Force on Climate-related Financial Disclosures," December 4, 2015.
[15] Ibid.
[16] FSB, "Proposal for a Disclosure Task Force on Climate-Related Risks," November 9, 2015.
[17] The term carbon-related assets is not well defined, but is generally considered to refer to assets or organizations with relatively high direct or indirect GHG emissions. The Task Force believes further work is needed on defining carbon-related assets and potential financial impacts.
[18] FSB, "Proposal for a Disclosure Task Force on Climate-Related Risks," November 9, 2015.
[19] Ibid.
[20] Ibid.

decisions they make. The Task Force recognizes that many other organizations, including credit rating agencies, equity analysts, stock exchanges, investment consultants, and proxy advisors also use climate-related financial disclosures, allowing them to push information through the credit and investment chain and contribute to the better pricing of risks by investors, lenders, and insurance underwriters. These organizations, in principle, depend on the same types of information as primary users.

This report presents the Task Force's recommendations for climate-related financial disclosures and includes supporting information on climate-related risks and opportunities, scenario analysis, and industry feedback that the Task Force considered in developing and then finalizing its recommendations. In addition, the Task Force developed a "stand-alone" document—*Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures* (Annex)—for organizations to use when preparing disclosures consistent with the recommendations. The Annex provides supplemental guidance for the financial sector as well as for non-financial groups potentially most affected by climate change and the transition to a lower-carbon economy. The supplemental guidance assists preparers by providing additional context and suggestions for implementing the recommended disclosures.

The Task Force's recommendations provide a foundation for climate-related financial disclosures and aim to be ambitious, but also practical for near-term adoption. The Task Force expects that reporting of climate-related risks and opportunities will evolve over time as organizations, investors, and others contribute to the quality and consistency of the information disclosed.

Box 1
Task Force on Climate-related Financial Disclosures

The Task Force membership, first announced on January 21, 2016, has international representation and spans various types of organizations, including banks, insurance companies, asset managers, pension funds, large non-financial companies, accounting and consulting firms, and credit rating agencies—a unique collaborative partnership between the users and preparers of financial reports.

In its work, the Task Force drew on its members' expertise, stakeholder engagement, and existing climate-related disclosure regimes to develop a singular, accessible framework for climate-related financial disclosure. See Appendix 1 for a list of the Task Force members and Appendix 2 for more information on the Task Force's approach.

The Task Force is comprised of 32 global members representing a broad range of economic sectors and financial markets and a careful balance of users and preparers of climate-related financial disclosures.

16	8	8
Experts from the Financial Sector	Experts from Non-Financial Sectors	Other Experts
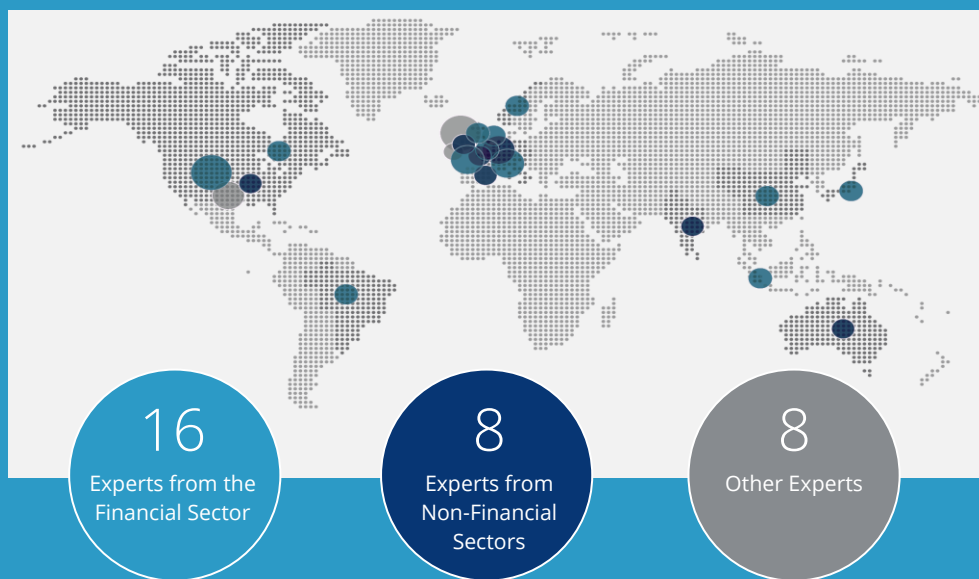
B Climate-Related Risks, Opportunities, and Financial Impacts

B Climate-Related Risks, Opportunities, and Financial Impacts

Through its work, the Task Force identified a growing demand by investors, lenders, insurance underwriters, and other stakeholders for decision-useful, climate-related financial information. Improved disclosure of climate-related risks and opportunities will provide investors, lenders, insurance underwriters, and other stakeholders with the metrics and information needed to undertake robust and consistent analyses of the potential financial impacts of climate change.

The Task Force found that while several climate-related disclosure frameworks have emerged across different jurisdictions in an effort to meet the growing demand for such information, there is a need for a standardized framework to promote alignment across existing regimes and G20 jurisdictions and to provide a common framework for climate-related financial disclosures. An important element of such a framework is the consistent categorization of climate-related risks and opportunities. As a result, the Task Force defined categories for climate-related risks and climate-related opportunities. The Task Force's recommendations serve to encourage organizations to evaluate and disclose, as part of their annual financial filing preparation and reporting processes, the climate-related risks and opportunities that are most pertinent to their business activities. The main climate-related risks and opportunities that organizations should consider are described below and in Tables 1 and 2 (pp. 10-11).

1. Climate-Related Risks

The Task Force divided climate-related risks into two major categories: (1) risks related to the *transition* to a lower-carbon economy and (2) risks related to the *physical* impacts of climate change.

a. Transition Risks

Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organizations.

Policy and Legal Risks

Policy actions around climate change continue to evolve. Their objectives generally fall into two categories—policy actions that attempt to constrain actions that contribute to the adverse effects of climate change or policy actions that seek to promote adaptation to climate change. Some examples include implementing carbon-pricing mechanisms to reduce GHG emissions, shifting energy use toward lower emission sources, adopting energy-efficiency solutions, encouraging greater water efficiency measures, and promoting more sustainable land-use practices. The risk associated with and financial impact of policy changes depend on the nature and timing of the policy change.[21]

Another important risk is litigation or legal risk. Recent years have seen an increase in climate-related litigation claims being brought before the courts by property owners, municipalities, states, insurers, shareholders, and public interest organizations.[22] Reasons for such litigation include the failure of organizations to mitigate impacts of climate change, failure to adapt to climate change, and the insufficiency of disclosure around material financial risks. As the value of loss and damage arising from climate change grows, litigation risk is also likely to increase.

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[21] Organizations should assess not only the potential direct effects of policy actions on their operations, but also the potential second and third order effects on their supply and distribution chains.

[22] Peter Seley, "Emerging Trends in Climate Change Litigation," *Law 360,* March 7, 2016.

Technology Risk

Technological improvements or innovations that support the transition to a lower-carbon, energy-efficient economic system can have a significant impact on organizations. For example, the development and use of emerging technologies such as renewable energy, battery storage, energy efficiency, and carbon capture and storage will affect the competitiveness of certain organizations, their production and distribution costs, and ultimately the demand for their products and services from end users. To the extent that new technology displaces old systems and disrupts some parts of the existing economic system, winners and losers will emerge from this "creative destruction" process. The timing of technology development and deployment, however, is a key uncertainty in assessing technology risk.

Market Risk

While the ways in which markets could be affected by climate change are varied and complex, one of the major ways is through shifts in supply and demand for certain commodities, products, and services as climate-related risks and opportunities are increasingly taken into account.

Reputation Risk

Climate change has been identified as a potential source of reputational risk tied to changing customer or community perceptions of an organization's contribution to or detraction from the transition to a lower-carbon economy.

b. Physical Risks

Physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for organizations, such as direct damage to assets and indirect impacts from supply chain disruption. Organizations' financial performance may also be affected by changes in water availability, sourcing, and quality; food security; and extreme temperature changes affecting organizations' premises, operations, supply chain, transport needs, and employee safety.

Acute Risk

Acute physical risks refer to those that are event-driven, including increased severity of extreme weather events, such as cyclones, hurricanes, or floods.

Chronic Risk

Chronic physical risks refer to longer-term shifts in climate patterns (e.g., sustained higher temperatures) that may cause sea level rise or chronic heat waves.

2. Climate-Related Opportunities

Efforts to mitigate and adapt to climate change also produce opportunities for organizations, for example, through resource efficiency and cost savings, the adoption of low-emission energy sources, the development of new products and services, access to new markets, and building resilience along the supply chain. Climate-related opportunities will vary depending on the region, market, and industry in which an organization operates. The Task Force identified several areas of opportunity as described below.

a. Resource Efficiency

There is growing evidence and examples of organizations that have successfully reduced operating costs by improving efficiency across their production and distribution processes, buildings, machinery/appliances, and transport/mobility—in particular in relation to energy efficiency but also including broader materials, water, and waste management.[23] Such actions can

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[23] UNEP and Copenhagen Centre for Energy Efficiency, *Best Practices and Case Studies for Industrial Energy Efficiency Improvement*, February 16, 2016.

result in direct cost savings to organizations' operations over the medium to long term and contribute to the global efforts to curb emissions.[24] Innovation in technology is assisting this transition; such innovation includes developing efficient heating solutions and circular economy solutions, making advances in LED lighting technology and industrial motor technology, retrofitting buildings, employing geothermal power, offering water usage and treatment solutions, and developing electric vehicles.[25]

b. Energy Source

According to the International Energy Agency (IEA), to meet global emission-reduction goals, countries will need to transition a major percentage of their energy generation to low emission alternatives such as wind, solar, wave, tidal, hydro, geothermal, nuclear, biofuels, and carbon capture and storage.[26] For the fifth year in a row, investments in renewable energy capacity have exceeded investments in fossil fuel generation.[27] The trend toward decentralized clean energy sources, rapidly declining costs, improved storage capabilities, and subsequent global adoption of these technologies are significant. Organizations that shift their energy usage toward low emission energy sources could potentially save on annual energy costs.[28]

c. Products and Services

Organizations that innovate and develop new low-emission products and services may improve their competitive position and capitalize on shifting consumer and producer preferences. Some examples include consumer goods and services that place greater emphasis on a product's carbon footprint in its marketing and labeling (e.g., travel, food, beverage and consumer staples, mobility, printing, fashion, and recycling services) and producer goods that place emphasis on reducing emissions (e.g., adoption of energy-efficiency measures along the supply chain).

d. Markets

Organizations that pro-actively seek opportunities in new markets or types of assets may be able to diversify their activities and better position themselves for the transition to a lower-carbon economy. In particular, opportunities exist for organizations to access new markets through collaborating with governments, development banks, small-scale local entrepreneurs, and community groups in developed and developing countries as they work to shift to a lower-carbon economy.[29] New opportunities can also be captured through underwriting or financing green bonds and infrastructure (e.g., low-emission energy production, energy efficiency, grid connectivity, or transport networks).

e. Resilience

The concept of climate resilience involves organizations developing adaptive capacity to respond to climate change to better manage the associated risks and seize opportunities, including the ability to respond to transition risks and physical risks. Opportunities include improving efficiency, designing new production processes, and developing new products. Opportunities related to resilience may be especially relevant for organizations with long-lived fixed assets or extensive supply or distribution networks; those that depend critically on utility and infrastructure networks or natural resources in their value chain; and those that may require longer-term financing and investment.

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[24] Environmental Protection Agency Victoria (EPA Victoria), "Resource Efficiency Case Studies: Lower your Impact."

[25] As described by Pearce and Turner, circular economy refers to a system in which resource input and waste, emission, and energy leakage are minimized. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. This is in contrast to a linear economy which is a "take, make, dispose" model of production.

[26] IEA, "Global energy investment down 8% in 2015 with flows signaling move towards cleaner energy," September 14, 2016.

[27] Frankfurt School-United Nations Environmental Programme Centre and Bloomberg New Energy Finance, "Global Trends in Renewable Energy Investment 2017," 2017.

[28] Ceres, "Power Forward 3.0: How the largest US companies are capturing business value while addressing climate change," 2017.

[29] G20 Green Finance Study Group. *G20 Green Finance Synthesis Report*. 2016. The proposal to launch the Green Finance Study Group was adopted by the G20 Finance Ministers and Central Bank Deputies in December 2015.

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3. Financial Impacts

Better disclosure of the financial impacts of climate-related risks and opportunities on an organization is a key goal of the Task Force's work. In order to make more informed financial decisions, investors, lenders, and insurance underwriters need to understand how climate-related risks and opportunities are likely to impact an organization's future financial position as reflected in its income statement, cash flow statement, and balance sheet as outlined in Figure 1. While climate change affects nearly all economic sectors, the level and type of exposure and the impact of climate-related risks differs by sector, industry, geography, and organization.[30]

Figure 1

Climate-Related Risks, Opportunities, and Financial Impact
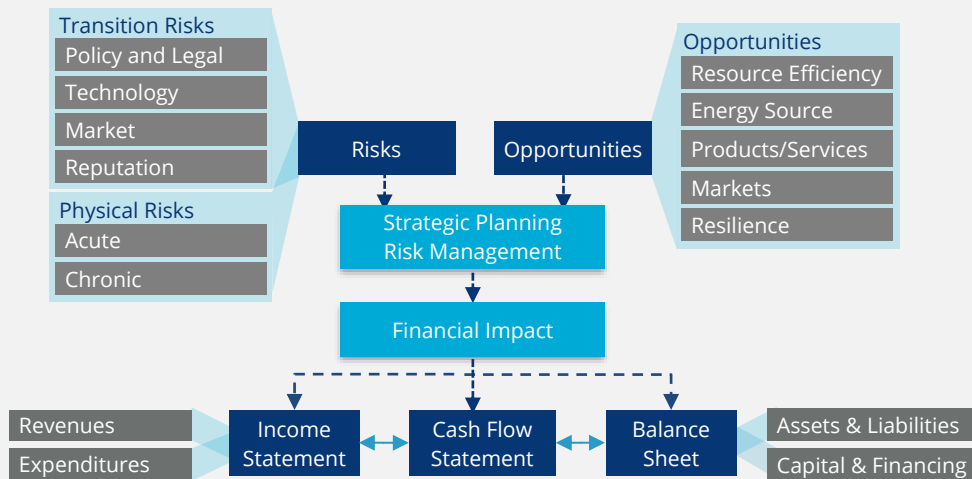
Fundamentally, the financial impacts of climate-related issues on an organization are driven by the specific climate-related risks and opportunities to which the organization is exposed and its strategic and risk management decisions on managing those risks (i.e., mitigate, transfer, accept, or control) and seizing those opportunities. The Task Force has identified four major categories, described in Figure 2 (p. 9), through which climate-related risks and opportunities may affect an organization's current and future financial positions.

The financial impacts of climate-related issues on organizations are not always clear or direct, and, for many organizations, identifying the issues, assessing potential impacts, and ensuring material issues are reflected in financial filings may be challenging. Key reasons for this are likely because of (1) limited knowledge of climate-related issues within organizations; (2) the tendency to focus mainly on near-term risks without paying adequate attention to risks that may arise in the longer term; and (3) the difficulty in quantifying the financial effects of climate-related issues.[31] To assist organizations in identifying climate-related issues and their impacts, the Task Force developed Table 1 (p. 10), which provides examples of climate-related risks and their potential financial impacts, and Table 2 (p. 11), which provides examples of climate-related opportunities and their potential financial impacts. In addition, Section A.4 in the Annex provides more information on the major categories of financial impacts—revenues, expenditures, assets and liabilities, and capital and financing—that are likely to be most relevant for specific industries.

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[30] SASB research demonstrates that 72 out of 79 Sustainable Industry Classification System (SICS™) industries are significantly affected in some way by climate-related risk.

[31] World Business Council for Sustainable Development, "Sustainability and enterprise risk management: The first step towards integration." January 18, 2017.

Figure 2
Major Categories of Financial Impact

Income Statement	Balance Sheet
Revenues. Transition and physical risks may affect demand for products and services. Organizations should consider the potential impact on revenues and identify potential opportunities for enhancing or developing new revenues. In particular, given the emergence and likely growth of carbon pricing as a mechanism to regulate emissions, it is important for affected industries to consider the potential impacts of such pricing on business revenues.	**Assets and Liabilities.** Supply and demand changes from changes in policies, technology, and market dynamics related to climate change could affect the valuation of organizations' assets and liabilities. Use of long-lived assets and, where relevant, reserves may be particularly affected by climate-related issues. It is important for organizations to provide an indication of the potential climate-related impact on their assets and liabilities, particularly long-lived assets. This should focus on existing and committed future activities and decisions requiring new investment, restructuring, write-downs, or impairment.
Expenditures. An organization's response to climate-related risks and opportunities may depend, in part, on the organization's cost structure. Lower-cost suppliers may be more resilient to changes in cost resulting from climate-related issues and more flexible in their ability to address such issues. By providing an indication of their cost structure and flexibility to adapt, organizations can better inform investors about their investment potential. It is also helpful for investors to understand capital expenditure plans and the level of debt or equity needed to fund these plans. The resilience of such plans should be considered bearing in mind organizations' flexibility to shift capital and the willingness of capital markets to fund organizations exposed to significant levels of climate-related risks. Transparency of these plans may provide greater access to capital markets or improved financing terms.	**Capital and Financing.** Climate-related risks and opportunities may change the profile of an organization's debt and equity structure, either by increasing debt levels to compensate for reduced operating cash flows or for new capital expenditures or R&D. It may also affect the ability to raise new debt or refinance existing debt, or reduce the tenor of borrowing available to the organization. There could also be changes to capital and reserves from operating losses, asset write-downs, or the need to raise new equity to meet investment.

The Task Force encourages organizations to undertake both historical and forward-looking analyses when considering the potential financial impacts of climate change, with greater focus on forward-looking analyses as the efforts to mitigate and adapt to climate change are without historical precedent. This is one of the reasons the Task Force believes scenario analysis is important for organizations to consider incorporating into their strategic planning or risk management practices.

Table 1

Examples of Climate-Related Risks and Potential Financial Impacts

Type	Climate-Related Risks[32]	Potential Financial Impacts
Transition Risks	**Policy and Legal**	
	– Increased pricing of GHG emissions – Enhanced emissions-reporting obligations – Mandates on and regulation of existing products and services – Exposure to litigation	– Increased operating costs (e.g., higher compliance costs, increased insurance premiums) – Write-offs, asset impairment, and early retirement of existing assets due to policy changes – Increased costs and/or reduced demand for products and services resulting from fines and judgments
	Technology	
	– Substitution of existing products and services with lower emissions options – Unsuccessful investment in new technologies – Costs to transition to lower emissions technology	– Write-offs and early retirement of existing assets – Reduced demand for products and services – Research and development (R&D) expenditures in new and alternative technologies – Capital investments in technology development – Costs to adopt/deploy new practices and processes
	Market	
	– Changing customer behavior – Uncertainty in market signals – Increased cost of raw materials	– Reduced demand for goods and services due to shift in consumer preferences – Increased production costs due to changing input prices (e.g., energy, water) and output requirements (e.g., waste treatment) – Abrupt and unexpected shifts in energy costs – Change in revenue mix and sources, resulting in decreased revenues – Re-pricing of assets (e.g., fossil fuel reserves, land valuations, securities valuations)
	Reputation	
	– Shifts in consumer preferences – Stigmatization of sector – Increased stakeholder concern or negative stakeholder feedback	– Reduced revenue from decreased demand for goods/services – Reduced revenue from decreased production capacity (e.g., delayed planning approvals, supply chain interruptions) – Reduced revenue from negative impacts on workforce management and planning (e.g., employee attraction and retention) – Reduction in capital availability
Physical Risks	**Acute**	
	– Increased severity of extreme weather events such as cyclones and floods	– Reduced revenue from decreased production capacity (e.g., transport difficulties, supply chain interruptions) – Reduced revenue and higher costs from negative impacts on workforce (e.g., health, safety, absenteeism) – Write-offs and early retirement of existing assets (e.g., damage to property and assets in "high-risk" locations)
	Chronic	
	– Changes in precipitation patterns and extreme variability in weather patterns – Rising mean temperatures – Rising sea levels	– Increased operating costs (e.g., inadequate water supply for hydroelectric plants or to cool nuclear and fossil fuel plants) – Increased capital costs (e.g., damage to facilities) – Reduced revenues from lower sales/output – Increased insurance premiums and potential for reduced availability of insurance on assets in "high-risk" locations

[32] The sub-category risks described under each major category are not mutually exclusive, and some overlap exists.

Table 2

Examples of Climate-Related Opportunities and Potential Financial Impacts

Type	Climate-Related Opportunities[33]	Potential Financial Impacts
Resource Efficiency	– Use of more efficient modes of transport – Use of more efficient production and distribution processes – Use of recycling – Move to more efficient buildings – Reduced water usage and consumption	– Reduced operating costs (e.g., through efficiency gains and cost reductions) – Increased production capacity, resulting in increased revenues – Increased value of fixed assets (e.g., highly rated energy-efficient buildings) – Benefits to workforce management and planning (e.g., improved health and safety, employee satisfaction) resulting in lower costs
Energy Source	– Use of lower-emission sources of energy – Use of supportive policy incentives – Use of new technologies – Participation in carbon market – Shift toward decentralized energy generation	– Reduced operational costs (e.g., through use of lowest cost abatement) – Reduced exposure to future fossil fuel price increases – Reduced exposure to GHG emissions and therefore less sensitivity to changes in cost of carbon – Returns on investment in low-emission technology – Increased capital availability (e.g., as more investors favor lower-emissions producers) – Reputational benefits resulting in increased demand for goods/services
Products and Services	– Development and/or expansion of low emission goods and services – Development of climate adaptation and insurance risk solutions – Development of new products or services through R&D and innovation – Ability to diversify business activities – Shift in consumer preferences	– Increased revenue through demand for lower emissions products and services – Increased revenue through new solutions to adaptation needs (e.g., insurance risk transfer products and services) – Better competitive position to reflect shifting consumer preferences, resulting in increased revenues
Markets	– Access to new markets – Use of public-sector incentives – Access to new assets and locations needing insurance coverage	– Increased revenues through access to new and emerging markets (e.g., partnerships with governments, development banks) – Increased diversification of financial assets (e.g., green bonds and infrastructure)
Resilience	– Participation in renewable energy programs and adoption of energy-efficiency measures – Resource substitutes/diversification	– Increased market valuation through resilience planning (e.g., infrastructure, land, buildings) – Increased reliability of supply chain and ability to operate under various conditions – Increased revenue through new products and services related to ensuring resiliency

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[33] The opportunity categories are not mutually exclusive, and some overlap exists.

C Recommendations and Guidance

C Recommendations and Guidance

1. Overview of Recommendations and Guidance

To fulfill its remit, the Task Force developed four widely adoptable recommendations on climate-related financial disclosures applicable to organizations across sectors and jurisdictions. In developing its recommendations, the Task Force considered the challenges for preparers of disclosures as well as the benefits of such disclosures to investors, lenders, and insurance underwriters. To achieve this balance, the Task Force engaged in significant outreach and consultation with users and preparers of disclosures and drew upon existing climate-related disclosure regimes. The insights gained from the outreach and consultations directly informed the development of the recommendations.

The Task Force structured its recommendations around four thematic areas that represent core elements of how organizations operate—governance, strategy, risk management, and metrics and targets. The four overarching recommendations are supported by key climate-related financial disclosures—referred to as recommended disclosures—that build out the framework with information that will help investors and others understand how reporting organizations think about and assess climate-related risks and opportunities. In addition, there is guidance to support all organizations in developing climate-related financial disclosures consistent with the recommendations and recommended disclosures as well as *supplemental* guidance for specific sectors. The structure is depicted in Figure 3 below, and the Task Force's recommendations and supporting recommended disclosures are presented in Figure 4 (p. 14).

Figure 3

Recommendations and Guidance

Recommendations
Four widely adoptable recommendations tied to: governance, strategy, risk management, and metrics and targets

Recommended Disclosures
Specific recommended disclosures organizations should include in their financial filings to provide decision-useful information

Guidance for All Sectors
Guidance providing context and suggestions for implementing the recommended disclosures for all organizations

Supplemental Guidance for Certain Sectors
Guidance that highlights important considerations for certain sectors and provides a fuller picture of potential climate-related financial impacts in those sectors

Supplemental guidance is provided for the financial sector and for non-financial sectors potentially most affected by climate change

The Task Force's supplemental guidance is included in the Annex and covers the financial sector as well as non-financial industries potentially most affected by climate change and the transition to a lower-carbon economy (referred to as non-financial groups). The supplemental guidance provides these preparers with additional context and suggestions for implementing the recommended disclosures and should be used in conjunction with the guidance for all sectors.

Figure 4

Recommendations and Supporting Recommended Disclosures

Governance	Strategy	Risk Management	Metrics and Targets
Disclose the organization's governance around climate-related risks and opportunities.	Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.	Disclose how the organization identifies, assesses, and manages climate-related risks.	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.

Recommended Disclosures	**Recommended Disclosures**	**Recommended Disclosures**	**Recommended Disclosures**
a) Describe the board's oversight of climate-related risks and opportunities.	a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term.	a) Describe the organization's processes for identifying and assessing climate-related risks.	a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.
b) Describe management's role in assessing and managing climate-related risks and opportunities.	b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning.	b) Describe the organization's processes for managing climate-related risks.	b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.
	c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.	c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.	c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.

Figure 5 provides a mapping of the recommendations (governance, strategy, risk management, and metrics and targets) and recommended disclosures (a, b, c) for which supplemental guidance was developed for the financial sector and non-financial groups.

- **Financial Sector.** The Task Force developed supplemental guidance for the financial sector, which it organized into four major industries largely based on activities performed. The four industries are banks (lending), insurance companies (underwriting), asset managers (asset management), and asset owners, which include public- and private-sector pension plans, endowments, and foundations (investing).[34] The Task Force believes that disclosures by the financial sector could foster an early assessment of climate-related risks and opportunities, improve pricing of climate-related risks, and lead to more informed capital allocation decisions.

- **Non-Financial Groups.** The Task Force developed supplemental guidance for non-financial industries that account for the largest proportion of GHG emissions, energy usage, and water usage. These industries were organized into four groups (i.e., non-financial groups)—Energy; Materials and Buildings; Transportation; and Agriculture, Food, and Forest Products—based on similarities in climate-related risks as shown in Box 2 (p. 16). While this supplemental guidance focuses on a subset of non-financial industries, organizations in other industries with similar business activities may wish to review and consider the issues and topics contained in the supplemental guidance.

Figure 5

Supplemental Guidance for Financial Sector and Non-Financial Groups

	Industries and Groups	Governance		Strategy			Risk Management			Metrics and Targets		
		a)	b)	a)	b)	c)	a)	b)	c)	a)	b)	c)
Financial	Banks			■			■			■		
	Insurance Companies				■	■	■	■		■		
	Asset Owners				■	■	■	■		■	■	
	Asset Managers				■		■	■		■	■	
Non-Financial	Energy			■	■					■		
	Transportation			■	■					■		
	Materials and Buildings			■	■					■		
	Agriculture, Food, and Forest Products			■	■					■		

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[34] The use of the term "insurance companies" in this report includes re-insurers.

Determination of Non-Financial Groups

In an effort to focus supplemental guidance on those non-financial sectors and industries with the highest likelihood of climate-related financial impacts, the Task Force assessed three factors most likely to be affected by both transition risk (policy and legal, technology, market, and reputation) and physical risk (acute and chronic)—GHG emissions, energy usage, and water usage.

The underlying premise in using these three factors is that climate-related physical and transition risks will likely manifest themselves primarily and broadly in the form of constraints on GHG emissions, effects on energy production and usage, and effects on water availability, usage, and quality. Other factors, such as waste management and land use, are also important, but may not be as determinative across a wide range of industries or may be captured in one of the primary categories.

In taking this approach, the Task Force consulted a number of sources regarding the ranking of various sectors and industries according to these three factors. The various rankings were used to determine an overall set of sectors and industries that have significant exposure to transition or physical risks related to GHG emissions, energy, or water. The sectors and industries were grouped into four categories of industries that have similar economic activities and climate-related exposures.

These four groups and their associated industries are intended to be indicative of the economic activities associated with these industries rather than definitive industry categories. Other industries with similar activities and climate-related exposures should consider the supplemental guidance as well.

The Task Force validated its approach using a variety of sources, including:

1   The TCFD Phase I report public consultation, soliciting more than 200 responses which ranked Energy, Utilities, Materials, Industrials and Consumer Staples/Discretionary, in that order, as the Global Industry Classification Standard (GICS) sectors most important for disclosure guidelines to cover.

2   Numerous sector-specific disclosure guidance documents to understand various breakdowns by economic activity, sector, and industries, including from the following sources: CDP, GHG Protocol, Global Real Estate Sustainability Benchmark (GRESB), Global Reporting Initiative (GRI), Institutional Investors Group on Climate Change (IIGCC), IPIECA (the global oil and gas industry association for environmental and social issues), and the Sustainability Accounting Standards Board (SASB).

3   The Intergovernmental Panel on Climate Change (IPCC) report "Climate Change 2014 – Mitigation of Climate Change" that provides an analysis of global direct and indirect emissions by economic sector. The IPCC analysis highlights the dominant emissions-producing sectors as Energy; Industry; Agriculture, Forestry, and Other Land Use; and Transportation and Buildings (Commercial and Residential).

4   Research and documentation from non-governmental organizations (NGOs) and industry organizations that provide information on which industries have the highest exposures to climate change, including those from Cambridge Institute of Sustainability Leadership, China's National Development and Reform Commission (NDRC), Environmental Resources Management (ERM), IEA, Moody's, S&P Global Ratings, and WRI/UNEPFI.

Based on its assessment, the Task Force identified the four groups and their associated industries, listed in the table below, as those that would most benefit from supplemental guidance.

Energy	Transportation	Materials and Buildings	Agriculture, Food, and Forest Products
– Oil and Gas – Coal – Electric Utilities	– Air Freight – Passenger Air Transportation – Maritime Transportation – Rail Transportation – Trucking Services – Automobiles and Components	– Metals and Mining – Chemicals – Construction Materials – Capital Goods – Real Estate Management and Development	– Beverages – Agriculture – Packaged Foods and Meats – Paper and Forest Products

2. Implementing the Recommendations

a. Scope of Coverage

To promote more informed investing, lending, and insurance underwriting decisions, the Task Force recommends all organizations with public debt or equity implement its recommendations. Because climate-related issues are relevant for other types of organizations as well, the Task Force encourages all organizations to implement these recommendations. In particular, the Task Force believes that asset managers and asset owners, including public- and private-sector pension plans, endowments, and foundations, should implement its recommendations so that their clients and beneficiaries may better understand the performance of their assets, consider the risks of their investments, and make more informed investment choices.

b. Location of Disclosures and Materiality

The Task Force recommends that organizations provide climate-related financial disclosures in their mainstream (i.e., public) annual financial filings.[35] In most G20 jurisdictions, public companies have a legal obligation to disclose material information in their financial filings—including material climate-related information; and the Task Force's recommendations are intended to help organizations meet existing disclosure obligations more effectively.[36] The Task Force's recommendations were developed to apply broadly across sectors and jurisdictions and should not be seen as superseding national disclosure requirements. Importantly, organizations should make financial disclosures in accordance with their national disclosure requirements. If certain elements of the recommendations are incompatible with national disclosure requirements for financial filings, the Task Force encourages organizations to disclose those elements in other official company reports that are issued at least annually, widely distributed and available to investors and others, and subject to internal governance processes that are the same or substantially similar to those used for financial reporting.

The Task Force recognizes that most information included in financial filings is subject to a materiality assessment. However, because climate-related risk is a non-diversifiable risk that affects nearly all industries, many investors believe it requires special attention. For example, in assessing organizations' financial and operating results, many investors want insight into the governance and risk management context in which such results are achieved. The Task Force believes disclosures related to its Governance and Risk Management recommendations directly address this need for context and should be included in annual financial filings.

For disclosures related to the Strategy and Metrics and Targets recommendations, the Task Force believes organizations should provide such information in annual financial filings when the information is deemed material. Certain organizations—those in the four non-financial groups that have more than one billion U.S. dollar equivalent (USDE) in annual revenue—should consider disclosing such information in other reports when the information is not deemed material and not included in financial filings.[37] Because these organizations are more likely than others to be financially impacted over time, investors are interested in monitoring how these organizations' strategies evolve.

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[35] Financial filings refer to the annual reporting packages in which organizations are required to deliver their audited financial results under the corporate, compliance, or securities laws of the jurisdictions in which they operate. While reporting requirements differ internationally, financial filings generally contain financial statements and other information such as governance statements and management commentary.

[36] The Task Force encourages organizations where climate-related issues could be material in the future to begin disclosing climate-related financial information outside financial filings to facilitate the incorporation of such information into financial filings once climate-related issues are determined to be material.

[37] The Task Force chose a one billion USDE annual revenue threshold because it captures organizations responsible for over 90 percent of Scope 1 and 2 GHG emissions in the industries represented by the four non-financial groups (about 2,250 organizations out of roughly 15,000).

The Task Force recognizes reporting by asset managers and asset owners is intended to satisfy the needs of clients, beneficiaries, regulators, and oversight bodies and follows a format that is generally different from corporate financial reporting. For purposes of adopting the Task Force's recommendations, asset managers and asset owners should use their existing means of financial reporting to their clients and beneficiaries where relevant and where feasible. Likewise, asset managers and asset owners should consider materiality in the context of their respective mandates and investment performance for clients and beneficiaries.[38]

The Task Force believes that climate-related financial disclosures should be subject to appropriate internal governance processes. Since these disclosures should be included in annual financial filings, the governance processes should be similar to those used for existing financial reporting and would likely involve review by the chief financial officer and audit committee, as appropriate. The Task Force recognizes that some organizations may provide some or all of their climate-related financial disclosures in reports other than financial filings. This may occur because the organizations are not required to issue public financial reports (e.g., some asset managers and asset owners). In such situations, organizations should follow internal governance processes that are the same or substantially similar to those used for financial reporting.

c. Principles for Effective Disclosures
To underpin its recommendations and help guide current and future developments in climate-related financial reporting, the Task Force developed seven principles for effective disclosure (Figure 6), which are described more fully in Appendix 3. When used by organizations in preparing their climate-related financial disclosures, these principles can help achieve high-quality and decision-useful disclosures that enable users to understand the impact of climate change on organizations. The Task Force encourages organizations to consider these principles as they develop climate-related financial disclosures.

The Task Force's disclosure principles are largely consistent with internationally accepted frameworks for financial reporting and are generally applicable to most providers of financial disclosures. The principles are designed to assist organizations in making clear the linkages between climate-related issues and their governance, strategy, risk management, and metrics and targets.

Figure 6
Principles for Effective Disclosures

1 Disclosures should represent relevant information

2 Disclosures should be specific and complete

3 Disclosures should be clear, balanced, and understandable

4 Disclosures should be consistent over time

5 Disclosures should be comparable among companies within a sector, industry, or portfolio

6 Disclosures should be reliable, verifiable, and objective

7 Disclosures should be provided on a timely basis

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[38] The Task Force recommends asset managers and asset owners include carbon footprinting information in their reporting to clients and beneficiaries, as described in Section D of the Annex, to support the assessment and management of climate-related risks.

3. Guidance for All Sectors

The Task Force has developed guidance to support all organizations in developing climate-related financial disclosures consistent with its recommendations and recommended disclosures. The guidance assists preparers by providing context and suggestions for implementing the recommended disclosures. Recognizing organizations have differing levels of capacity to disclose under the recommendations, the guidance provides descriptions of the types of information that should be disclosed or considered.

a. Governance

Investors, lenders, insurance underwriters, and other users of climate-related financial disclosures (collectively referred to as "investors and other stakeholders") are interested in understanding the role an organization's board plays in overseeing climate-related issues as well as management's role in assessing and managing those issues. Such information supports evaluations of whether climate-related issues receive appropriate board and management attention.

Governance	
Disclose the organization's governance around climate-related risks and opportunities.	
Recommended Disclosure a) Describe the board's oversight of climate-related risks and opportunities.	**Guidance for All Sectors** In describing the board's oversight of climate-related issues, organizations should consider including a discussion of the following: – processes and frequency by which the board and/or board committees (e.g., audit, risk, or other committees) are informed about climate-related issues, – whether the board and/or board committees consider climate-related issues when reviewing and guiding strategy, major plans of action, risk management policies, annual budgets, and business plans as well as setting the organization's performance objectives, monitoring implementation and performance, and overseeing major capital expenditures, acquisitions, and divestitures, and – how the board monitors and oversees progress against goals and targets for addressing climate-related issues.
Recommended Disclosure b) Describe management's role in assessing and managing climate-related risks and opportunities.	**Guidance for All Sectors** In describing management's role related to the assessment and management of climate-related issues, organizations should consider including the following information: – whether the organization has assigned climate-related responsibilities to management-level positions or committees; and, if so, whether such management positions or committees report to the board or a committee of the board and whether those responsibilities include assessing and/or managing climate-related issues, – a description of the associated organizational structure(s), – processes by which management is informed about climate-related issues, and – how management (through specific positions and/or management committees) monitors climate-related issues.

b. Strategy

Investors and other stakeholders need to understand how climate-related issues may affect an organization's businesses, strategy, and financial planning over the short, medium, and long term. Such information is used to inform expectations about the future performance of an organization.

Strategy

Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.

Recommended Disclosure a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term.	**Guidance for All Sectors** Organizations should provide the following information: – a description of what they consider to be the relevant short-, medium-, and long-term time horizons, taking into consideration the useful life of the organization's assets or infrastructure and the fact that climate-related issues often manifest themselves over the medium and longer terms, – a description of the specific climate-related issues for each time horizon (short, medium, and long term) that could have a material financial impact on the organization, and – a description of the process(es) used to determine which risks and opportunities could have a material financial impact on the organization. Organizations should consider providing a description of their risks and opportunities by sector and/or geography, as appropriate. In describing climate-related issues, organizations should refer to Tables 1 and 2 (pp. 10-11).
Recommended Disclosure b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning.	**Guidance for All Sectors** Building on recommended disclosure (a), organizations should discuss how identified climate-related issues have affected their businesses, strategy, and financial planning. Organizations should consider including the impact on their businesses and strategy in the following areas: – Products and services – Supply chain and/or value chain – Adaptation and mitigation activities – Investment in research and development – Operations (including types of operations and location of facilities) Organizations should describe how climate-related issues serve as an input to their financial planning process, the time period(s) used, and how these risks and opportunities are prioritized. Organizations' disclosures should reflect a holistic picture of the interdependencies among the factors that affect their ability to create value over time. Organizations should also consider including in their disclosures the impact on financial planning in the following areas: – Operating costs and revenues – Capital expenditures and capital allocation – Acquisitions or divestments – Access to capital If climate-related scenarios were used to inform the organization's strategy and financial planning, such scenarios should be described.

Strategy

Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.

| **Recommended Disclosure c)** Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario. | **Guidance for All Sectors** Organizations should describe how resilient their strategies are to climate-related risks and opportunities, taking into consideration a transition to a lower-carbon economy consistent with a 2°C or lower scenario and, where relevant to the organization, scenarios consistent with increased physical climate-related risks.

Organizations should consider discussing:

– where they believe their strategies may be affected by climate-related risks and opportunities;

– how their strategies might change to address such potential risks and opportunities; and

– the climate-related scenarios and associated time horizon(s) considered.

Refer to Section D for information on applying scenarios to forward-looking analysis. |

c. Risk Management

Investors and other stakeholders need to understand how an organization's climate-related risks are identified, assessed, and managed and whether those processes are integrated into existing risk management processes. Such information supports users of climate-related financial disclosures in evaluating the organization's overall risk profile and risk management activities.

Risk Management

Disclose how the organization identifies, assesses, and manages climate-related risks.

| **Recommended Disclosure a)** Describe the organization's processes for identifying and assessing climate-related risks. | **Guidance for All Sectors** Organizations should describe their risk management processes for identifying and assessing climate-related risks. An important aspect of this description is how organizations determine the relative significance of climate-related risks in relation to other risks.

Organizations should describe whether they consider existing and emerging regulatory requirements related to climate change (e.g., limits on emissions) as well as other relevant factors considered.

Organizations should also consider disclosing the following:

– processes for assessing the potential size and scope of identified climate-related risks and

– definitions of risk terminology used or references to existing risk classification frameworks used. |
| **Recommended Disclosure b)** Describe the organization's processes for managing climate-related risks. | **Guidance for All Sectors** Organizations should describe their processes for managing climate-related risks, including how they make decisions to mitigate, transfer, accept, or control those risks. In addition, organizations should describe their processes for prioritizing climate-related risks, including how materiality determinations are made within their organizations.

In describing their processes for managing climate-related risks, organizations should address the risks included in Tables 1 and 2 (pp. 10-11), as appropriate. |

Risk Management

Disclose how the organization identifies, assesses, and manages climate-related risks.

Recommended Disclosure c)	Guidance for All Sectors
Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.	Organizations should describe how their processes for identifying, assessing, and managing climate-related risks are integrated into their overall risk management.

d. Metrics and Targets

Investors and other stakeholders need to understand how an organization measures and monitors its climate-related risks and opportunities. Access to the metrics and targets used by an organization allows investors and other stakeholders to better assess the organization's potential risk-adjusted returns, ability to meet financial obligations, general exposure to climate-related issues, and progress in managing or adapting to those issues. They also provide a basis upon which investors and other stakeholders can compare organizations within a sector or industry.

Metrics and Targets

Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.

Recommended Disclosure a)	Guidance for All Sectors
Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.	Organizations should provide the key metrics used to measure and manage climate-related risks and opportunities, as described in Tables 1 and 2 (pp. 10-11). Organizations should consider including metrics on climate-related risks associated with water, energy, land use, and waste management where relevant and applicable.
	Where climate-related issues are material, organizations should consider describing whether and how related performance metrics are incorporated into remuneration policies.
	Where relevant, organizations should provide their internal carbon prices as well as climate-related opportunity metrics such as revenue from products and services designed for a lower-carbon economy.
	Metrics should be provided for historical periods to allow for trend analysis. In addition, where not apparent, organizations should provide a description of the methodologies used to calculate or estimate climate-related metrics.
Recommended Disclosure b)	Guidance for All Sectors
Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.	Organizations should provide their Scope 1 and Scope 2 GHG emissions and, if appropriate, Scope 3 GHG emissions and the related risks.[39]
	GHG emissions should be calculated in line with the GHG Protocol methodology to allow for aggregation and comparability across organizations and jurisdictions.[40] As appropriate, organizations should consider providing related, generally accepted industry-specific GHG efficiency ratios.[41]
	GHG emissions and associated metrics should be provided for historical

[39] Emissions are a prime driver of rising global temperatures and, as such, are a key focal point of policy, regulatory, market, and technology responses to limit climate change. As a result, organizations with significant emissions are likely to be impacted more significantly by transition risk than other organizations. In addition, current or future constraints on emissions, either directly by emission restrictions or indirectly through carbon budgets, may impact organizations financially.

[40] While challenges remain, the GHG Protocol methodology is the most widely recognized and used international standard for calculating GHG emissions. Organizations may use national reporting methodologies if they are consistent with the GHG Protocol methodology.

[41] For industries with high energy consumption, metrics related to emission intensity are important to provide. For example, emissions per unit of economic output (e.g., unit of production, number of employees, or value-added) is widely used. See the Annex for examples of metrics.

Metrics and Targets

Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.

	periods to allow for trend analysis. In addition, where not apparent, organizations should provide a description of the methodologies used to calculate or estimate the metrics.
Recommended Disclosure c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.	**Guidance for All Sectors** Organizations should describe their key climate-related targets such as those related to GHG emissions, water usage, energy usage, etc., in line with anticipated regulatory requirements or market constraints or other goals. Other goals may include efficiency or financial goals, financial loss tolerances, avoided GHG emissions through the entire product life cycle, or net revenue goals for products and services designed for a lower-carbon economy. In describing their targets, organizations should consider including the following: – whether the target is absolute or intensity based, – time frames over which the target applies, – base year from which progress is measured, and – key performance indicators used to assess progress against targets. Where not apparent, organizations should provide a description of the methodologies used to calculate targets and measures.

D Scenario Analysis and Climate-Related Issues

D Scenario Analysis and Climate-Related Issues

Some organizations are affected by risks associated with climate change today. However, for many organizations, the most significant effects of climate change are likely to emerge over the medium to longer term and their timing and magnitude are uncertain. This uncertainty presents challenges for individual organizations in understanding the potential effects of climate change on their businesses, strategies, and financial performance. To appropriately incorporate the potential effects in their planning processes, organizations need to consider how their climate-related risks and opportunities may evolve and the potential implications under different conditions. One way to do this is through scenario analysis.

Scenario analysis is a well-established method for developing strategic plans that are more flexible or robust to a range of plausible future states. The use of scenario analysis for assessing the potential business implications of climate-related risks and opportunities, however, is relatively recent. While several organizations use scenario analysis to assess the potential impact of climate change on their businesses, only a subset have disclosed their assessment of forward-looking implications publicly, either in sustainability reports or financial filings.[42]

The disclosure of organizations' forward-looking assessments of climate-related issues is important for investors and other stakeholders in understanding how vulnerable individual organizations are to transition and physical risks and how such vulnerabilities are or would be addressed. As a result, the Task Force believes that organizations should use scenario analysis to assess potential business, strategic, and financial implications of climate-related risks and opportunities and disclose those, as appropriate, in their annual financial filings.

> Scenario analysis is an important and useful tool for understanding the strategic implications of climate-related risks and opportunities.

This section provides additional information on using scenario analysis as a tool to assess potential implications of climate-related risks and opportunities. In addition, a technical supplement, The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities, on the Task Force's website provides further information on the types of climate-related scenarios, the application of scenario analysis, and the key challenges in implementing scenario analysis.

1. Overview of Scenario Analysis

Scenario analysis is a process for identifying and assessing the potential implications of a range of plausible future states under conditions of uncertainty. Scenarios are hypothetical constructs and not designed to deliver precise outcomes or forecasts. Instead, scenarios provide a way for organizations to consider how the future might look if certain trends continue or certain conditions are met. In the case of climate change, for example, scenarios allow an organization to explore and develop an understanding of how various combinations of climate-related risks, both transition and physical risks, may affect its businesses, strategies, and financial performance over time.

Scenario analysis can be qualitative, relying on descriptive, written narratives, or quantitative, relying on numerical data and models, or some combination of both. Qualitative scenario analysis

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[42] Some organizations in the energy sector and some large investors have made public disclosures describing the results of their climate-related scenario analysis, including discussing how the transition might affect their current portfolios. In some instances, this information was published in financial filings.

explores relationships and trends for which little or no numerical data is available, while quantitative scenario analysis can be used to assess measurable trends and relationships using models and other analytical techniques.[43] Both rely on scenarios that are internally consistent, logical, and based on explicit assumptions and constraints that result in plausible future development paths.

As summarized in Figure 7, there are several reasons why scenario analysis is a useful tool for organizations in assessing the potential implications of climate-related risks and opportunities.

Figure 7
Reasons to Consider Using Scenario Analysis for Climate Change

1   Scenario analysis can help organizations consider issues, like climate change, that have the following characteristics:

– Possible outcomes that are highly uncertain (e.g., the **physical** response of the climate and ecosystems to higher levels of GHG emissions in the atmosphere)

– Outcomes that will play out over the medium to longer term (e.g., timing, distribution, and mechanisms of the **transition** to a lower-carbon economy)

– Potential disruptive effects that, due to uncertainty and complexity, are substantial

2   Scenario analysis can enhance organizations' strategic conversations about the future by considering, in a more structured manner, what may unfold that is different from business-as-usual. Importantly, it broadens decision makers' thinking across a range of plausible scenarios, including scenarios where climate-related impacts can be significant.

3   Scenario analysis can help organizations frame and assess the potential range of plausible business, strategic, and financial impacts from climate change and the associated management actions that may need to be considered in strategic and financial plans. This may lead to more robust strategies under a wider range of uncertain future conditions.

4   Scenario analysis can help organizations identify indicators to monitor the external environment and better recognize when the environment is moving toward a different scenario state (or to a different stage along a scenario path). This allows organizations the opportunity to reassess and adjust their strategies and financial plans accordingly.[44]

5   Scenario analysis can assist investors in understanding the robustness of organizations' strategies and financial plans and in comparing risks and opportunities across organizations.

2. Exposure to Climate-Related Risks

The effects of climate change on specific sectors, industries, and individual organizations are highly variable. It is important, therefore, that all organizations consider applying a basic level of scenario analysis in their strategic planning and risk management processes. Organizations more significantly affected by transition risk (e.g., fossil fuel-based industries, energy-intensive manufacturers, and transportation activities) and/or physical risk (e.g., agriculture, transportation

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[43] For example, see Mark D. A. Rounsevell, Marc J. Metzger, *Developing qualitative scenario storylines for environmental change assessment,* WIREs Climate Change 2010, 1: 606-619. doi: 10.1002/wcc.63, 2010 and Oliver Fricko, et. al., *Energy sector water use implications of a 2° C climate policy,* Environmental Research Letters, 11: 1-10, 2016.

[44] J.N. Maack, *Scenario analysis: a tool for task managers,* Social Analysis: selected tools and techniques, Social Development Papers, Number 36, the World Bank, June 2001, Washington, DC.

and building infrastructure, insurance, and tourism) should consider a more in-depth application of scenario analysis.

a. Exposure to Transition Risks

Transition risk scenarios are particularly relevant for resource-intensive organizations with high GHG emissions within their value chains, where policy actions, technology, or market changes aimed at emissions reductions, energy efficiency, subsidies or taxes, or other constraints or incentives may have a particularly direct effect.

A key type of transition risk scenario is a so-called 2°C scenario, which lays out a pathway and an emissions trajectory consistent with holding the increase in the global average temperature to 2°C above pre-industrial levels. In December 2015, nearly 200 governments agreed to strengthen the global response to the threat of climate change by "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels," referred to as the Paris Agreement.[45] As a result, a 2°C scenario provides a common reference point that is generally aligned with the objectives of the Paris Agreement and will support investors' evaluation of the potential magnitude and timing of transition-related implications for individual organizations; across different organizations within a sector; and across different sectors.

b. Exposure to Physical Risks

A wide range of organizations are exposed to climate-related physical risks. Physical climate-related scenarios are particularly relevant for organizations exposed to acute or chronic climate change, such as those with:

- long-lived, fixed assets;
- locations or operations in climate-sensitive regions (e.g., coastal and flood zones);
- reliance on availability of water; and
- value chains exposed to the above.

Physical risk scenarios generally identify extreme weather threats of moderate or higher risk before 2030 and a larger number and range of physical threats between 2030 and 2050. Although most climate models deliver scenario results for physical impacts beyond 2050, organizations typically focus on the consequences of physical risk scenarios over shorter time frames that reflect the lifetimes of their respective assets or liabilities, which vary across sectors and organizations.

3. Recommended Approach to Scenario Analysis

The Task Force believes that all organizations exposed to climate-related risks should consider (1) using scenario analysis to help inform their strategic and financial planning processes and (2) disclosing how resilient their strategies are to a range of plausible climate-related scenarios. The Task Force recognizes that, for many organizations, scenario analysis is or would be a largely qualitative exercise. However, organizations with more significant exposure to transition risk and/or physical risk should undertake more rigorous qualitative and, if relevant, quantitative scenario analysis with respect to key drivers and trends that affect their operations.

A critical aspect of scenario analysis is the selection of a set of scenarios (not just one) that covers a reasonable variety of future outcomes, both favorable and unfavorable. In this regard, the Task Force recommends organizations use a 2°C or lower scenario in addition to two or three other

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[45] United Nations Framework Convention on Climate Change. "The Paris Agreement," December 2015.

scenarios most relevant to their circumstances, such as scenarios related to Nationally Determined Contributions (NDCs), physical climate-related scenarios, or other challenging scenarios.[46] In jurisdictions where NDCs are a commonly accepted guide for an energy and/or emissions pathway, NDCs may constitute particularly useful scenarios to include in an organization's suite of scenarios for conducting climate-related scenario analysis.

For an organization in the initial stages of implementing scenario analysis or with limited exposure to climate-related issues, the Task Force recommends disclosing how resilient, qualitatively or directionally, the organization's strategy and financial plans may be to a range of relevant climate change scenarios. This information helps investors, lenders, insurance underwriters, and other stakeholders understand the robustness of an organization's forward-looking strategy and financial plans across a range of possible future states.

Organizations with more significant exposure to climate-related issues should consider disclosing key assumptions and pathways related to the scenarios they use to allow users to understand the analytical process and its limitations. In particular, it is important to understand the critical parameters and assumptions that materially affect the conclusions drawn. As a result, the Task Force believes that organizations with significant climate-related exposures should *strive* to disclose the elements described in Figure 8.

Figure 8

Disclosure Considerations for Non-Financial Organizations
Organizations with more significant exposure to climate-related issues should consider disclosing key aspects of their scenario analysis, such as the ones described below.

1	The scenarios used, including the 2°C or lower scenario[47]
2	Critical input parameters, assumptions, and analytical choices for the scenarios used, including such factors as: – Assumptions about possible technology responses and timing (e.g., evolution of products/services, the technology used to produce them, and costs to implement) – Assumptions made around potential differences in input parameters across regions, countries, asset locations, and/or markets – Approximate sensitivities to key assumptions
3	Time frames used for scenarios, including short-, medium-, and long-term milestones (e.g., how organizations consider timing of potential future implications under the scenarios used)
4	Information about the resiliency of the organization's strategy, including strategic performance implications under the various scenarios considered, potential qualitative or directional implications for the organization's value chain, capital allocation decisions, research and development focus, and potential material financial implications for the organization's operating results and/or financial position

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[46] The Task Force's technical supplement, The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities provides more information on scenario inputs, analytical assumptions and choices, and assessment and presentation of potential impacts.

[47] The objective of the Paris Agreement is to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C. The IEA is developing a 1.5°C scenario that organizations may find useful.

4. Applying Scenario Analysis

While the Task Force recognizes the complexities of scenario analysis and the potential resources needed to conduct it, organizations are encouraged to use scenario analysis to assess climate-related risks and opportunities. For organizations just beginning to use scenario analysis, a qualitative approach that progresses and deepens over time may be appropriate.[48] Greater rigor and sophistication in the use of data and quantitative models and analysis may be warranted for organizations with more extensive experience in conducting scenario analysis. Organizations may decide to use existing external scenarios and models (e.g., those provided by third-party vendors) or develop their own, in-house modeling capabilities. The choice of approach will depend on an organization's needs, resources, and capabilities.

In conducting scenario analysis, organizations should *strive* to achieve:

- transparency around parameters, assumptions, analytical approaches, and time frames;

- comparability of results across different scenarios and analytical approaches;

- adequate documentation for the methodology, assumptions, data sources, and analytics;

- consistency of methodology year over year;

- sound governance over scenario analysis conduct, validation, approval, and application; and

- effective disclosure of scenario analysis that will inform and promote a constructive dialogue between investors and organizations on the range of potential impacts and resilience of the organization's strategy under various plausible climate-related scenarios.

In applying scenario analysis, organizations should consider general implications for their strategies, capital allocation, and costs and revenues, both at an enterprise-wide level and at the level of specific regions and markets where specific implications of climate change for the organization are likely to arise. Financial-sector organizations should consider using scenario analysis to evaluate the potential impact of climate-related scenarios on individual assets or investments, investments or assets in a particular sector or region, or underwriting activities.

The Task Force's supplemental guidance recognizes that organizations will be at different levels of experience in using scenario analysis. However, it is important for organizations to use scenario analysis and develop the necessary organizational skills and capabilities to assess climate-related risks and opportunities, with the expectation that organizations will evolve and deepen their use of scenario analysis over time. The objective is to assist investors and other stakeholders in better understanding:

- the degree of robustness of the organization's strategy and financial plans under different plausible future states of the world;

- how the organization may be positioning itself to take advantage of opportunities and plans to mitigate or adapt to climate-related risks; and

- how the organization is challenging itself to think strategically about longer-term climate-related risks and opportunities.

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[48] Organizations considering undertaking scenario analysis may wish to conduct various sensitivity analyses around key climate factors as a precursor to scenario analysis, recognizing that sensitivity analysis and scenario analysis are different, but complementary, processes.

5. Challenges and Benefits of Conducting Scenario Analysis

Scenario analysis is a well-established method for developing strategic plans that are more flexible and robust to a range of plausible future states. As previously discussed (Figure 7, p. 26) it is particularly useful for assessing issues with possible outcomes that are highly uncertain, that play out over the medium to longer term, and that are potentially disruptive. Scenario analysis can help to better frame strategic issues, assess the range of potential management actions that may be needed, engage more productively in strategic conversations, and identify indicators to monitor the external environment. Importantly, climate-related scenario analysis can provide the foundation for more effective engagement with investors on an organization's strategic and business resiliency.

Conducting climate-related scenario analysis, however, is not without challenges. First, most scenarios have been developed for global and macro assessments of potential climate-related impacts that can inform policy makers. These climate-related scenarios do not always provide the ideal level of transparency, range of data outputs, and functionality of tools that would facilitate their use in a business or investment context.

Second, the availability and granularity of data can be a challenge for organizations attempting to assess various energy and technology pathways or carbon constraints in different jurisdictions and geographic locations.

Third, the use of climate-related scenario analysis to assess potential business implications is still at an early stage. Although a handful of the largest organizations and investors are using climate-related scenario analysis as part of their strategic planning and risk management processes, many organizations are just beginning to explore its use. Sharing experiences and approaches to climate-related scenario analysis across organizations, therefore, is critical to advancing the use of climate-related scenario analysis. Organizations may be able to play an important role in this regard by facilitating information and experience exchanges among themselves; collectively developing tools, data sets, and methodologies; and working to set standards. Organizations across many different sectors will inevitably need to learn by doing. Some may seek guidance from other industry participants and experts on how to apply climate-related scenarios to make forward-looking analyses of climate-related risks and opportunities.

Addressing these challenges and advancing the use of climate-related scenario analysis will require further work. These challenges, however, are not insurmountable and can be addressed. Organizations should undertake scenario analysis in the near term to capture the important benefits for assessing climate-related risks and opportunities and improve their capabilities as tools and data progress over time.

E Key Issues Considered and Areas for Further Work

E Key Issues Considered and Areas for Further Work

The diverse perspectives of Task Force members as well as outreach efforts, including two public consultations, resulting in over 500 responses, hundreds of industry interviews, several focus groups, and multiple webinars, provided valuable insight into the challenges that different organizations—both financial and non-financial—may encounter in preparing disclosures consistent with the Task Force's recommendations. The Task Force considered these issues and others in developing and then finalizing its recommendations and sought to balance the burden of disclosure on preparers with the need for consistent and decision-useful information for users (i.e., investors, lenders, and insurance underwriters). This section describes the key issues considered by the Task Force, significant public feedback received by the Task Force related to those issues, the ultimate disposition of the issues, and, in some cases, areas where further work may be warranted. Figure 9 summarizes areas the Task Force identified, through its own analysis as well as through public feedback, as warranting further research and analysis or the development of methodologies and standards.

Figure 9

Key Areas for Further Work

Relationship to Other Reporting Initiatives	Encourage standard setting organizations and others to actively work toward greater alignment of frameworks and to support adoption
Scenario Analysis	Further develop applicable 2°C or lower transition scenarios and supporting outputs, tools, and user interfaces
	Develop broadly accepted methodologies, datasets, and tools for scenario-based evaluation of physical risk by organizations
	Make datasets and tools publicly available and provide commonly available platforms for scenario analysis
Data Availability and Quality and Financial Impact	Undertake further research and analysis to better understand and measure how climate-related issues translate into potential financial impacts for organizations in financial and non-financial sectors
	Improve data quality and further develop standardized metrics for the financial sector, including better defining carbon-related assets and developing metrics that address a broader range of climate-related risks and opportunities
	Increase organizations' understanding of climate-related risks and opportunities
Example Disclosures[49]	Provide example disclosures to assist preparers in developing disclosures consistent with the Task Force's recommendations

[49] In response to the second consultation, organizations asked for example disclosures to gain a better understanding of how the recommended information may be disclosed. The Task Force acknowledges the development of these examples as an area of further work.

1. Relationship to Other Reporting Initiatives

Through the Task Force's outreach efforts, some organizations expressed concern that multiple disclosure frameworks and mandatory reporting requirements increase the administrative burden of disclosure efforts. Specifically, the additional time, cost, and effort required to analyze and disclose new climate-related information could penalize those with less capacity to respond.

The Task Force considered existing voluntary and mandatory climate-related reporting frameworks in developing its recommendations and provides information in the Annex on the alignment of existing frameworks, including those developed by the CDP (formerly the Carbon Disclosure Project), Climate Disclosure Standards Board (CDSB), the Global Reporting Initiative (GRI), the International Integrated Reporting Council (IIRC), and the Sustainability Accounting Standards Board (SASB), with the Task Force's recommended disclosures. The Task Force expects preparers disclosing climate-related information under other regimes will be able to use existing processes and content when developing disclosures based on the Task Force's recommendations.

The Task Force's recommendations provide a common set of principles that should help existing disclosure regimes come into closer alignment over time. Preparers, users, and other stakeholders share a common interest in encouraging such alignment as it relieves a burden for reporting entities, reduces fragmented disclosure, and provides greater comparability for users. The Task Force also encourages standard setting bodies to support adoption of the recommendations and alignment with the recommended disclosures.

2. Location of Disclosures and Materiality

In considering possible reporting venues, the Task Force reviewed existing regimes for climate-related disclosures across G20 countries. While many G20 countries have rules or regulatory guidance that require climate-related disclosure for organizations, most are *not* explicitly focused on climate-related *financial* information.[50] In addition, the locations of these disclosures vary significantly and range from surveys sent to regulators to sustainability reports to annual financial filings (see Appendix 4).

The Task Force also reviewed financial filing requirements applicable to public companies across G20 countries and found that in most G20 countries, issuers have a legal obligation to disclose material information in their financial reports—which includes material, climate-related information. Such reporting may take the form of a general disclosure of material information, but many jurisdictions require disclosure of material information in specific sections of the financial filing (e.g., in a discussion on risk factors).[51]

Based on its review, the Task Force determined that preparers of climate-related financial disclosures should provide such disclosures in their mainstream (i.e., public) annual financial filings.[52] The Task Force believes publication of climate-related financial information in mainstream financial filings will foster broader utilization of such disclosures, promoting an informed understanding of climate-related issues by investors and others, and support shareholder engagement. Importantly, in determining whether information is material, the Task Force believes organizations should determine materiality for climate-related issues consistent with how they determine the materiality of other information included in their financial filings. In addition, the Task Force cautions organizations against prematurely concluding that climate-

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[50] Organization for Economic Co-operation and Development (OECD) and CDSB, *Climate Change Disclosure in G20 Countries: Stocktaking of Corporate Reporting Schemes,* November 18, 2015.

[51] N. Ganci, S. Hammer, T. Reilly, and P. Rodel, *Environmental and Climate Change Disclosure under the Securities Laws: A Multijurisdictional Survey,* Debevoise & Plimpton, March 2016.

[52] To the extent climate-related disclosures are provided outside of financial filings, organizations are encouraged to align the release of such reports with their financial filings.

related risks and opportunities are not material based on perceptions of the longer-term nature of some climate-related risks.

As part of the Task Force's second public consultation, some organizations expressed concern about disclosing information in financial filings that is not clearly tied to an assessment of materiality. The Task Force recognizes organizations' concerns about disclosing information in annual financial filings that is not clearly tied to an assessment of materiality. However, the Task Force believes disclosures related to the Governance and Risk Management recommendations should be provided in annual financial filings. Because climate-related risk is a non-diversifiable risk that affects nearly all sectors, many investors believe it requires special attention. For example, in assessing organizations' financial and operating results, many investors want insight into the governance and risk management context in which such results are achieved. The Task Force believes disclosures related to its Governance and Risk Management recommendations directly address this need for context and should be included in annual financial filings.

For disclosures related to the Strategy and Metrics and Targets recommendations, the Task Force believes organizations should provide such information in annual financial filings when the information is deemed material. Certain organizations—those in the four non-financial groups that have more than one billion USDE in annual revenue—should consider disclosing information related to these recommendations in other reports when the information is not deemed material and not included in financial filings.[53,54] Because these organizations are more likely than others to be affected financially over time due to their significant GHG emissions or energy or water dependencies, investors are interested in monitoring how the organizations' strategies evolve.

In addition, the Task Force recognizes reporting by asset managers and asset owners to their clients and beneficiaries, respectively, generally occurs outside mainstream financial filings (Figure 10). For purposes of adopting the Task Force's recommendations, asset managers and asset owners should use their existing channels of financial reporting to their clients and beneficiaries where relevant and feasible. Likewise, asset managers and asset owners should consider materiality in the context of their respective mandates and investment performance for clients and beneficiaries.

Figure 10

Reporting by Asset Owners

The financial reporting requirements and practices of asset owners vary widely and differ from what is required of organizations with public debt or equity. Some asset owners have no public reporting, while others provide extensive public reporting. For purposes of adopting the Task Force's recommendations, asset owners should use their existing channels of financial reporting to their beneficiaries and others where relevant and feasible.

Reporting by Asset Managers

Reporting to clients by asset managers also takes different forms, depending on the requirements of the client and the types of investments made. For example, an investor in a mutual fund might receive quarterly, or download from the asset manager's website, a "fund fact sheet" that reports, among other information, the top holdings by value, the top performers by returns, and the carbon footprint of the portfolio against a stated benchmark. An investor in a segregated account might receive more detailed reporting, including items such as the aggregate carbon intensity of the portfolio compared with a benchmark, the portfolio's exposure to green revenue (and how this changes over time), or insight into portfolio positioning under different climate scenarios. The Task Force appreciates that climate-related risk reporting by asset managers is in the very early stages and encourages progress and innovation by the industry.

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[53] The Task Force chose a one billion USDE annual revenue threshold because it captures organizations responsible for over 90% of Scope 1 and 2 GHG emissions in the industries represented by the four non-financial groups (about 2,250 organizations out of roughly 15,000).

[54] "Other reports" should be official company reports that are issued at least annually, widely distributed and available to investors and others, and subject to internal governance processes that are substantially similar to those used for financial reporting.

3. Scenario Analysis

As part of the Task Force's second public consultation, many organizations said scenario analysis is a useful tool to help assess risks and understand potential implications of climate change; however, they also identified areas where the Task Force's recommendations and guidance could be improved. In particular, organizations asked the Task Force to identify standardized climate-related scenarios for organizations to use and clarify the information related to scenarios that should be disclosed. They also noted expectations around disclosures and climate-related scenario analysis should be proportionate to the size of the reporting entity and not onerous for smaller organizations. In addition, some organizations noted that the disclosures related to strategy could put organizations at greater risk of litigation given the high degree of uncertainty around the future timing and magnitude of climate-related impacts.

In finalizing its recommendations and guidance, the Task Force clarified organizations should describe how resilient their strategies are to climate-related risks and opportunities, taking into consideration a transition to a lower-carbon economy consistent with a 2°C or lower scenario and, where relevant, scenarios consistent with more extreme physical risks. To address concerns about proportionality, the Task Force established a threshold for organizations in the four non-financial groups that should perform more robust scenario analysis and disclose additional information on the resiliency of their strategies.

On the issue of recommending specific standardized or reference climate-related scenarios for organizations to use, Task Force members agreed that while such an approach is intuitively appealing, it is not a practical solution at this time. Existing, publicly available climate-related scenarios are not structured or defined in such a way that they can be easily applied consistently across different industries or across organizations within an industry.

The Task Force recognizes that incorporating scenario analysis into strategic planning processes will improve over time as organizations "learn by doing." To facilitate progress in this area, the Task Force encourages further work as follows:

- further developing 2°C or lower transition scenarios that can be applied to specific industries and geographies along with supporting outputs, tools, and user interfaces;

- developing broadly accepted methodologies, data sets, and tools for scenario-based evaluation of physical risk by organizations;

- making these data sets and tools publicly available to facilitate use by organizations, reduce organizational transaction costs, minimize gaps between jurisdictions in terms of technical expertise, enhance comparability of climate-related risk assessments by organizations, and help ensure comparability for investors; and

- creating more industry specific (financial and non-financial) guidance for preparers and users of climate-related scenarios.

4. Data Availability and Quality and Financial Impact

The Task Force developed supplemental guidance for the four non-financial groups that account for the largest proportion of GHG emissions, energy usage, and water usage; and, as part of that supplemental guidance, the Task Force included several illustrative metrics around factors that may be indicative of potential financial implications for climate-related risks and opportunities. As part of the second public consultation, several organizations provided feedback on the illustrative metrics, and common themes included (1) improving the comparability and consistency of the metrics, (2) clarifying the links among the metrics, climate-related risks and opportunities, and potential financial implications, (3) simplifying the metrics, and (4) providing additional guidance on the metrics, including how to calculate key metrics. Organizations also raised concerns about

the lack of standardized data and metrics in the financial sector, which complicates preparers' ability to develop decision-useful metrics and users' ability to compare metrics across organizations.

The Task Force recognizes these concerns as well as broader challenges related to data availability and quality, as described below.

- The gaps in emissions measurement methodologies, including Scope 3 emissions and product life-cycle emissions methodologies, make reliable and accurate estimates difficult. [55,56]

- The lack of robust and cost-effective tools to quantify the potential impact of climate-related risks and opportunities at the asset and project level makes aggregation across an organization's activities or investment portfolios problematic and costly.

- The need to consider the variability of climate-related impacts across and within different sectors and markets further complicates the process (and magnifies the cost) of assessing potential climate-related financial impacts.

- The high degree of uncertainty around the timing and magnitude of climate-related risks makes it difficult to determine and disclose the potential impacts with precision.

In finalizing its supplemental guidance, the Task Force addressed the redundancy of the metrics; simplified the non-financial illustrative metrics tables; ensured consistent terminology was used; and clarified the links between the metrics, climate-related risks and opportunities, and potential financial implications. In addition, the Task Force encourages further research and analysis by sector and industry experts to (1) better understand and measure how climate-related issues translate into potential financial impacts; (2) develop standardized metrics for the financial sector, including better defining carbon-related assets; and (3) increase organizations' understanding of climate-related risks and opportunities. As it relates to the broader challenges with data quality and availability, the Task Force encourages preparers to include in their disclosures a description of gaps, limitations, and assumptions made as part of their assessment of climate-related issues.

5. GHG Emissions Associated with Investments

In its supplemental guidance for asset owners and asset managers issued on December 14, 2016, the Task Force asked such organizations to provide GHG emissions associated with each fund, product, or investment strategy normalized for every million of the reporting currency invested. As part of the Task Force's public consultation as well as in discussions with preparers, some asset owners and asset managers expressed concern about reporting on GHG emissions related to their own or their clients' investments given the current data challenges and existing accounting guidance on how to measure and report GHG emissions associated with investments. In particular, they voiced concerns about the accuracy and completeness of the reported data and limited application of the metric to asset classes beyond public equities. Organizations also highlighted that GHG emissions associated with investments cannot be used as a sole indicator for investment decisions (i.e., additional metrics are needed) and that the metric can fluctuate with share price movements since it uses investors' proportional share of total equity.[57]

In consideration of the feedback received, the Task Force has replaced the GHG emissions associated with investments metric in the supplemental guidance for asset owners and asset managers with a weighted average carbon intensity metric. The Task Force believes the weighted

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[55] Scope 3 emissions are all indirect emissions that occur in the value chain of the reporting company, including both upstream and downstream emissions. See Greenhouse Gas Protocol, "Calculation Tools, FAQ."
[56] Product life cycle emissions are all the emissions associated with the production and use of a specific product, including emissions from raw materials, manufacture, transport, storage, sale, use, and disposal. See Greenhouse Gas Protocol, "Calculation Tools, FAQ."
[57] Because the metric uses investors' proportional share of total equity, increases in the underlying companies' share prices, *all else equal*, will result in a decrease in the carbon footprinting number even though GHG emissions are unchanged.

average carbon intensity metric, which measures exposure to carbon-intensive companies, addresses many of the concerns raised. For example, the metric can be applied across asset classes, is fairly simple to calculate, and does not use investors' proportional share of total equity and, therefore, is not sensitive to share price movements.

The Task Force acknowledges the challenges and limitations of current carbon footprinting metrics, including that such metrics should not necessarily be interpreted as risk metrics. Nevertheless, the Task Force views the reporting of weighted average carbon intensity as a first step and expects disclosure of this information to prompt important advancements in the development of decision-useful, climate-related risk metrics. In this regard, the Task Force encourages asset owners and asset managers to provide other metrics they believe are useful for decision making along with a description of the methodology used. The Task Force recognizes that some asset owners and asset managers may be able to report the weighted average carbon intensity and other metrics on only a portion of their investments given data availability and methodological issues. Nonetheless, increasing the number of organizations reporting this type of information should help speed the development of better climate-related risk metrics.

6. Remuneration

In the supplemental guidance for the Energy Group, the Task Force asked such organizations to consider disclosing whether and how performance metrics, including links to remuneration policies, take into consideration climate-related risks and opportunities. As part of its second public consultation, the Task Force asked whether the guidance should extend to organizations beyond those in the Energy group and, if so, to which types of organizations. The majority of organizations that commented on this issue responded that the guidance should be extended to other organizations; and many suggested that the guidance should apply to organizations more likely to be affected by climate-related risks. In consideration of the feedback received, the Task Force revised its guidance to ask organizations, where climate-related risks are material, to consider describing whether and how related performance metrics are incorporated into remuneration policies.

7. Accounting Considerations

As part of its work, the Task Force considered the interconnectivity of its recommendations with existing financial statement and disclosure requirements. The Task Force determined that the two primary accounting standard setting bodies, the International Accounting Standards Board (IASB) and the Financial Accounting Standards Board (FASB), have issued standards to address risks and uncertainties affecting companies. Both International Accounting Standard (IAS) 37 "Provisions, Contingent Liabilities and Contingent Assets" and Accounting Standards Codification (ASC) 450 "Contingencies" provide guidance on how to account for and disclose contingencies. Additionally, IAS 36 "Impairment of Assets" and ASC 360 "Long-lived Asset Impairment" provide guidance on assessing the impairment of long-lived assets. The disclosures of both contingencies and management's assessment and evaluation of long-lived assets for potential impairment are critically important in assisting stakeholders in understanding an organization's ability to meet future reported earnings and cash flow goals.

In most G20 countries, financial executives will likely recognize that the Task Force's disclosure recommendations should result in more quantitative financial disclosures, particularly disclosure of metrics, about the financial impact that climate-related risks have or could have on an organization. Specifically, asset impairments may result from assets adversely impacted by the effects of climate change and/or additional liabilities may need to be recorded to account for regulatory fines and penalties resulting from enhanced regulatory standards. Additionally, cash flows from operations, net income, and access to capital could all be impacted by the effects of

climate-related risks (and opportunities). Therefore, financial executives (e.g., chief financial officers, chief accounting officers, and controllers) should be involved in the organization's evaluation of climate-related risks and opportunities and the efforts undertaken to manage the risks and maximize the opportunities. Finally, careful consideration should be given to the linkage between scenario analyses performed to assess the resilience of an organization's strategy to climate-related risks and opportunities (as suggested in the Task Force's recommendations) and assumptions underlying cash flow analyses used to assess asset (e.g., goodwill, intangibles, and fixed assets) impairments.

8. Time Frames for Short, Medium, and Long Term

As part of the Task Force's second public consultation, some organizations asked the Task Force to define specific ranges for short, medium, and long term. Because the timing of climate-related impacts on organizations will vary, the Task Force believes specifying time frames across sectors for short, medium, and long term could hinder organizations' consideration of climate-related risks and opportunities specific to their businesses. The Task Force is, therefore, not defining time frames and encourages preparers to decide how to define their own time frames according to the life of their assets, the profile of the climate-related risks they face, and the sectors and geographies in which they operate.

In assessing climate-related issues, organizations should be sensitive to the time frames used to conduct their assessments. While many organizations conduct operational and financial planning over a 1-2 year time frame and strategic and capital planning over a 2-5 year time frame, climate-related risks may have implications for an organization over a longer period. It is, therefore, important for organizations to consider the appropriate time frames when assessing climate-related risks.

9. Scope of Coverage

To promote more informed investing, lending, and insurance underwriting decisions, the Task Force recommends all financial and non-financial organizations with public debt and/or equity adopt its recommendations.[58] Because climate-related risks and opportunities are relevant for organizations across all sectors, the Task Force encourages all organizations to adopt these recommendations. In addition, the Task Force believes that asset managers and asset owners, including public- and private-sector pension plans, endowments, and foundations, should implement its recommendations. The Task Force believes climate-related financial information should be provided to asset managers' clients and asset owners' beneficiaries so that they may better understand the performance of their assets, consider the risks of their investments, and make more informed investment choices.

Consistent with existing global stewardship frameworks, asset owners should engage with the organizations in which they invest to encourage adoption of these recommendations. They should also ask their asset managers to adopt these recommendations. Asset owners' expectations in relation to climate-related risk reporting from organizations and asset managers are likely to evolve as data availability and quality improves, understanding of climate-related risk increases, and risk measurement methodologies are further developed.

The Task Force recognizes that several asset owners expressed concern about being identified as the potential "policing body" charged with ensuring adoption of the Task Force's recommendations by asset managers and underlying organizations. The Task Force appreciates that expectations must be reasonable and that asset owners have many competing priorities, but

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[58] Thresholds for climate-related financial disclosures should be aligned to the financial disclosure requirements more broadly in the jurisdictions where a preparer is incorporated and/or operates and is required to make financial disclosures.

encourages them to help drive adoption of the recommendations. Because asset owners and asset managers sit at the top of the investment chain, they have an important role to play in influencing the organizations in which they invest to provide better climate-related financial disclosures.

10. Organizational Ownership

Some organizations have not formalized responsibility for climate-related risk assessment and management. Even for organizations with clearly assigned responsibilities for climate-related issues, the relationship between those responsible for climate-related risk (e.g., "environmental, social and governance" experts, chief investment officers) and those in the finance function can range from regularly scheduled interactions and exchanges of information to minimal or no interaction. According to some preparers, lack of clarity around responsibility for climate-related risk assessments and management, compounded by a lack of integration into organizations' financial reporting processes, could adversely affect implementation of the recommendations.

The Task Force believes that by encouraging disclosure of climate-related financial information in public financial filings, coordination between organizations' climate-related risk experts and the finance function will improve. Similar to the way organizations are evolving to include cyber security issues in their strategic and financial planning efforts, so too should they evolve for climate-related issues.

F Conclusion

F Conclusion

The Task Force's recommendations are a foundation for improved reporting of climate-related issues in mainstream financial filings with several resulting benefits (outlined in Figure 11). The recommendations aim to be ambitious, but also practical for near-term adoption. The Task Force expects that reporting of climate-related risks and opportunities will evolve over time as organizations, investors, and others contribute to the quality and consistency of the information disclosed.

> **Figure 11**
> ## Benefits of Recommendations
>
> – Foundation for immediate adoption and flexible enough to accommodate evolving practices
>
> – Promote board and senior management engagement on climate-related issues
>
> – Bring the "future" nature of issues into the present through scenario analysis
>
> – Support understanding of financial sector's exposure to climate-related risks
>
> – Designed to solicit decision-useful, forward-looking information on financial impacts

1. Evolution of Climate-Related Financial Disclosures

The Task Force recognizes that challenges exist, but all types of organizations can develop disclosures consistent with its recommendations. The recommendations provide a foundation for immediate adoption and are flexible enough to accommodate evolving practices. As understanding, data analytics, and modeling of climate-related issues become more widespread, disclosures can mature accordingly.

Organizations already reporting climate-related financial information under other frameworks may be well positioned to disclose under this framework immediately and are encouraged to do so. For such organizations, significant effort has gone into developing processes and collecting information needed for disclosing under these regimes. The Task Force expects these organizations will be able to use existing processes when providing disclosures in annual financial filings based on the Task Force's recommendations.[59,60] Those with less experience can begin by considering and disclosing how climate-related issues may be relevant in their current governance, strategy, and risk management practices. This initial level of disclosure will allow investors to review, recognize, and understand how organizations consider climate-related issues and their potential financial impact.

Importantly, the Task Force recognizes organizations need to make financial disclosures in accordance with their national disclosure requirements. To the extent certain elements of the recommendations are incompatible with national disclosure requirements for financial filings, the Task Force encourages organizations to disclose those elements through other reports. Such other reports should be official company reports that are issued at least annually, widely distributed and available to investors and others, and subject to internal governance processes that are the same or substantially similar to those used for financial reporting.

2. Widespread Adoption Critical

In the Task Force's view, the success of its recommendations depends on near-term, widespread adoption by organizations in the financial and non-financial sectors. Through widespread adoption, financial risks and opportunities related to climate change will become a natural part of

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[59] The Task Force recognizes the structure and content of financial filings differs across jurisdictions and, therefore, believes organizations are in the best position to determine where and how the recommended disclosures should be incorporated in financial filings.
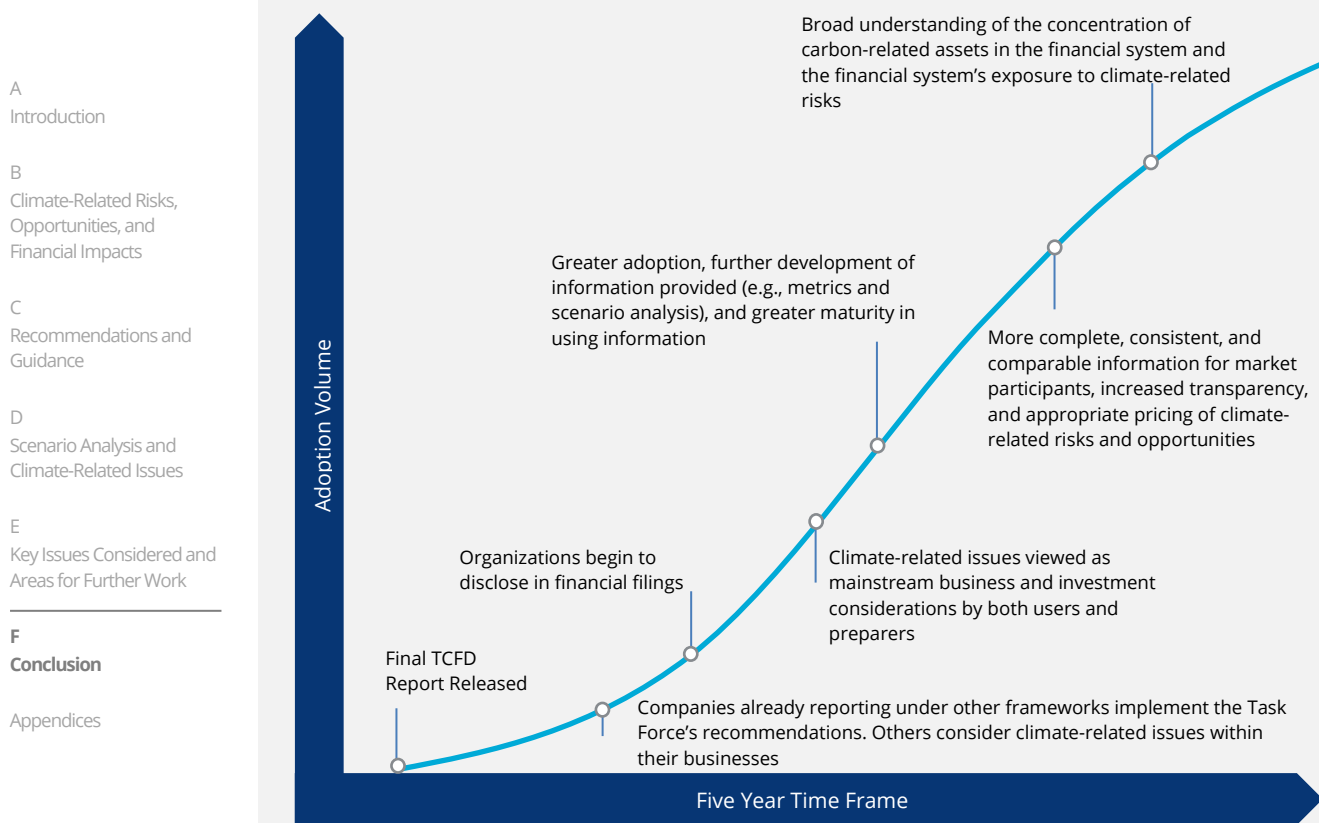
[60] The Task Force encourages organizations where climate-related issues could be material in the future to begin disclosing climate-related financial information outside financial filings to facilitate the incorporation of such information into financial filings once climate-related issues are determined to be material.

organizations' risk management and strategic planning processes. As this occurs, organizations' and investors' understanding of the potential financial implications associated with transitioning to a lower-carbon economy and physical risks will grow, information will become more decision-useful, and risks and opportunities will be more accurately priced, allowing for the more efficient allocation of capital. Figure 12 outlines a possible path for implementation.

Widespread adoption of the recommendations will require ongoing leadership by the G20 and its member countries. Such leadership is essential to continue to make the link between these recommendations and the achievements of global climate objectives. Leadership from the FSB is also critical to underscore the importance of better climate-related financial disclosures for the functioning of the financial system.

Figure 12
Implementation Path *(Illustrative)*

Broad understanding of the concentration of carbon-related assets in the financial system and the financial system's exposure to climate-related risks

Greater adoption, further development of information provided (e.g., metrics and scenario analysis), and greater maturity in using information

More complete, consistent, and comparable information for market participants, increased transparency, and appropriate pricing of climate-related risks and opportunities

Organizations begin to disclose in financial filings

Climate-related issues viewed as mainstream business and investment considerations by both users and preparers

Final TCFD Report Released

Companies already reporting under other frameworks implement the Task Force's recommendations. Others consider climate-related issues within their businesses

Adoption Volume

Five Year Time Frame

The Task Force is not alone in its work. A variety of stakeholders, including stock exchanges, investment consultants, credit rating agencies, and others can provide valuable contributions toward adoption of the recommendations. The Task Force believes that advocacy for these standards will be necessary for widespread adoption, including educating organizations that will disclose climate-related financial information and those that will use those disclosures to make financial decisions. To this end, the Task Force notes that strong support by the FSB and G20 authorities would have a positive impact on implementation. With the FSB's extension of the Task Force through September 2018, the Task Force will work to encourage adoption of the recommendations and support the FSB and G20 authorities in promoting the advancement of climate-related financial disclosures.

Appendices

Appendix 1: Task Force Members

Chairman and Vice Chairs

Michael Bloomberg
Chair
Founder
Bloomberg LP and Bloomberg Philanthropies

Denise Pavarina
Vice Chair
Executive Director
Banco Bradesco

Graeme Pitkethly
Vice Chair
Chief Financial Officer
Unilever

Christian Thimann
Vice Chair
Group Head of Regulation, Sustainability, and
Insurance Foresight
AXA

Yeo Lian Sim
Vice Chair
Special Adviser, Diversity
Singapore Exchange

Members

Jane Ambachtsheer
Partner, Chair – Responsible Investment
Mercer

Matt Arnold
Managing Director and Global Head of Sustainable
Finance
JPMorgan Chase & Co.

Wim Bartels
Partner Corporate Reporting
KPMG

Bruno Bertocci
Managing Director, Head of Sustainable Investors
UBS Asset Management

David Blood
Senior Partner
Generation Investment Management

Richard Cantor
Chief Risk Officer, Moody's Corporation
Chief Credit Officer, Moody's Investor Service

Koushik Chatterjee
Group Executive Director, Finance and Corporate
Tata Group

Eric Dugelay
Global Leader, Sustainability Services
Deloitte

Liliana Franco
Director, Accounting Organization and Methods
Air Liquide Group

Udo Hartmann
Senior Manager, Group Environmental Protection
& Energy Management
Daimler

Neil Hawkins
Corporate Vice President and Chief Sustainability
Officer
The Dow Chemical Company

Thomas Kusterer
Chief Financial Officer
EnBW Energie Baden-Württemberg AG

Diane Larsen
Audit Partner, Global Professional Practice
EY

Stephanie Leaist
Managing Director, Head of Sustainable Investing
Canada Pension Plan Investment Board

Mark Lewis
Managing Director, Head of European Utilities
Equity Research
Barclays

Eloy Lindeijer
Chief, Investment Management, member
Executive Committee
PGGM

Members *(continued)*

Ruixia Liu
General Manager, Risk Department
Industrial and Commercial Bank of China

Masaaki Nagamura
Head, Corporate Social Responsibility
Tokio Marine Holdings

Giuseppe Ricci
Chief Refining and Marketing Officer
ENI

Martin Skancke
Chair, Risk Committee
Storebrand

Andreas Spiegel
Head Group Sustainability Risk
Swiss Re

Steve Waygood
Chief Responsible Investment Officer
Aviva Investors

Fiona Wild
Vice President, Sustainability and Climate Change
BHP Billiton

Michael Wilkins
Managing Director, Environmental & Climate Risk
Research
S&P Global Ratings

Jon Williams
Partner, Sustainability and Climate Change
PwC

Deborah Winshel
Managing Director, Global Head of Impact
Investing
BlackRock

Special Adviser

Russell Picot
Chair, Audit and Risk Committee, LifeSight
Board Chair, HSBC Bank (UK) Pension Scheme
Trustee
Former Group Chief Accounting Officer, HSBC

Secretariat

Mary Schapiro
Special Advisor to the Chair
Former Chair, U.S. Securities and Exchange
Commission

Curtis Ravenel
Global Head, Sustainable Business & Finance
Bloomberg LP

Didem Nisanci
Managing Director
Promontory Financial Group, an IBM Company

Stacy Coleman
Managing Director
Promontory Financial Group, an IBM Company

Jeff Stehm
Director
Promontory Financial Group, an IBM Company

Mara Childress
Principal
Promontory Financial Group, an IBM Company

Veronika Henze
Head of Communications
Bloomberg New Energy Finance

Observers

Susan Nash
Member of Secretariat
Financial Stability Board

Joe Perry
Member of Secretariat
Financial Stability Board

Rupert Thorne
Deputy to the Secretary General
Financial Stability Board

Appendix 2: Task Force Objectives and Approach

1. Objectives

The Task Force engaged with key stakeholders throughout the development of its recommendations to ensure that its work would (1) promote alignment across existing disclosure regimes, (2) consider the perspectives of users and the concerns of preparers of climate-related financial disclosures, and (3) be efficiently implemented by organizations in their financial reporting.

2. Approach

In addition to the expertise of its members, a broad range of external resources informed the Task Force's recommendations, including existing voluntary and mandatory climate-related reporting frameworks, governance and risk management standards, government reports and research, expert resources, and various other stakeholders such as industry participants, trade associations, and non-governmental organizations (NGOs).

a. Leveraging Expertise

Task Force members come from a range of companies, including large financial companies, large non-financial companies, accounting and consulting firms, and credit rating agencies, and brought a range of practical experience, expertise, and global perspectives on preparing and using climate-related financial disclosures. Through eight plenary meetings, Task Force members contributed significantly to developing a consensus-based, industry-led approach to climate-related financial disclosure.

Due to the technically challenging and broad focus of its work, the Task Force also sought input from experts in the field of climate change, particularly in relation to scenario analysis. The Task Force engaged Environmental Resources Management (ERM) to inform its work by developing a technical paper on scenario analysis—The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities. Several members of the Task Force, joined by representatives from 2° Investing Initiative (2°ii), Bloomberg New Energy Finance (BNEF), Bloomberg Quantitative Risk Experts, Carbon Tracker, CDP, and the London School of Economics and Political Science led a working group to oversee ERM's technical considerations. A workshop was also held with experts from Oxford Martin School. Additionally, the International Energy Agency (IEA) provided input regarding how scenario analysis can be conducted and used.

b. Research and Information Gathering

The Task Force's work drew on publications and research conducted by governments, NGOs, industry participants, as well as disclosure regimes with a focus on climate-related issues. The Task Force reviewed existing mandatory and voluntary reporting regimes for climate-related disclosure to identify commonalities and gaps across existing regimes and to determine areas meriting further research and analysis by the Task Force. The work of organizations regarded as standard setters, as well as several organizations active in developing reporting mechanisms for climate-related issues, served as the primary references for the Task Force in developing its recommendations and supporting guidance. The Task Force also considered resources related to sector-specific climate issues in the development of the supplemental guidance.

c. Outreach and Engagement

Engagement with users, preparers, and other stakeholders in relevant industries and sectors across G20 countries and other countries was important in developing the Task Force's recommendations. The Task Force conducted five types of engagement to support this effort: public consultation, industry interviews, focus groups, outreach events, and webinars.

Such engagement served two primary purposes: (1) to raise the level of awareness and educate stakeholders on the Task Force's work and (2) to solicit feedback from stakeholders on the Task Force's proposed recommended disclosures and supplemental guidance for specific sectors. In total, more than 2,700 individuals in 43 countries were included in the Task Force's outreach and engagement (Figure A2.1).

Public Consultations

The Task Force conducted two public consultations. The first followed the April 1, 2016 publication of the Task Force's Phase I Report, which set out the scope and high-level objectives for the Task Force's work. The Task Force solicited input to guide the development of its recommendations for voluntary climate-related financial disclosures. In total, 203 participants from 24 countries responded to the first public consultation. Respondents represented the financial sector, non-financial sectors, NGOs, and other organizations. Public consultation comments indicated support for disclosures on scenario analysis as well as disclosures tailored for specific sectors. Key themes from the first public consultation, which informed the Task Force's recommendations and guidance, are included in Table A2.1 (p. 48).

Figure A2.1

Outreach and Engagement
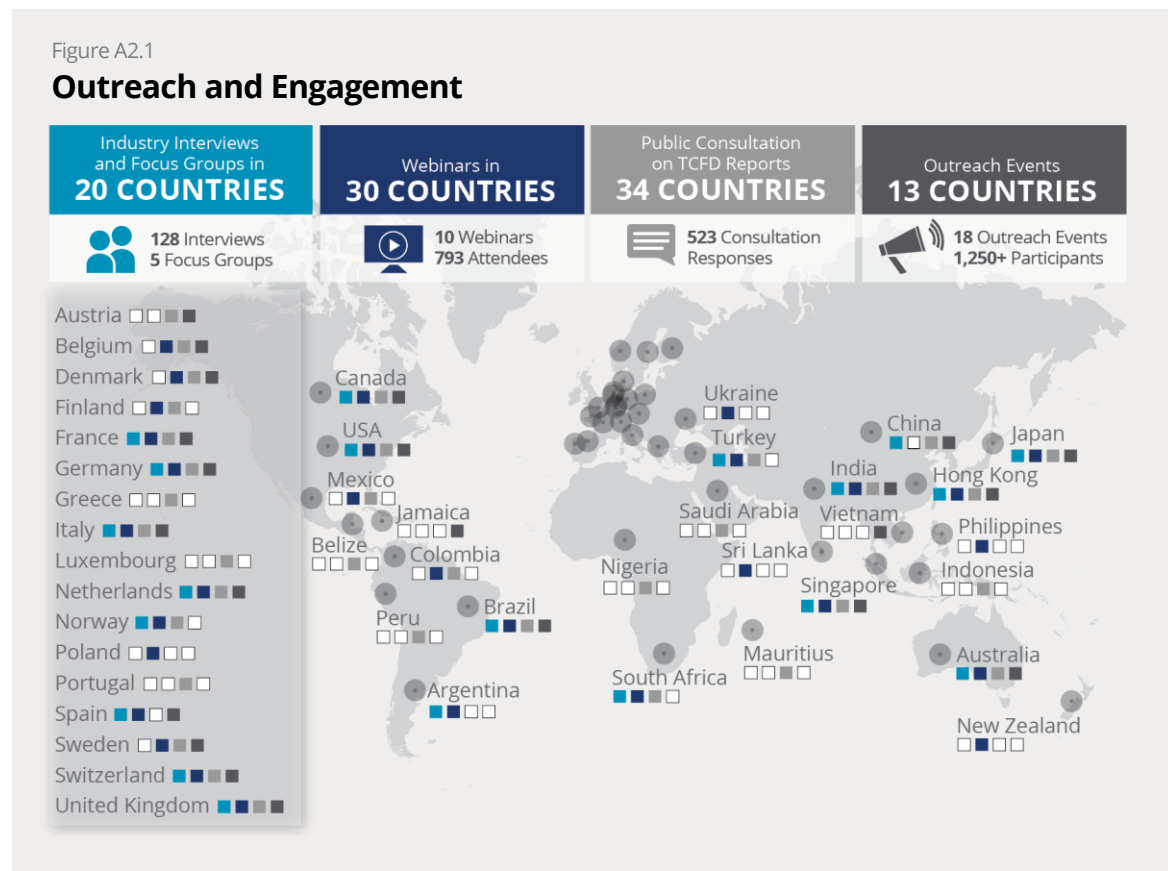
Table A2.1

Key Themes of First Public Consultation (Scope of Work)

Key Themes	Survey Response	
Components of Disclosures	The majority of respondents were in agreement that disclosures should: – be forward-looking, – address the ability to achieve targets, with strategies for achievement, and – align with material risks.	
Sector-Specific Disclosures	Respondents were in favor of disclosures for specific sectors	**62%**
Scenario Analysis	Respondents see scenario analysis as a key component of disclosure	**96%**

A second public consultation followed the release of the Task Force's report in December 2016. The Task Force conducted the second consultation through an online questionnaire designed to gather feedback on the recommendations, guidance, and key issues identified by the Task Force. The Task Force received 306 responses to its online questionnaire and 59 comment letters on the recommendations and guidance from a variety of organizations in 30 countries.[61] The majority of responses came from Europe (57 percent), followed by North America (20 percent), Asia Pacific (19 percent), South America (four percent), and the Middle East/Africa (less than one percent). Fourty-five percent of respondents provided perspective as users of disclosure, 44 percent as preparers of disclosure, and 11 percent as "other." Respondents came from the financial sector (43 percent), non-financial sectors (18 percent), or other types of organizations (39 percent).[62]

Table A2.2

Responses to Second Public Consultation Questions

Questions	Respondent	Percent Responding "Useful"
How useful are the recommendations and guidance for all sectors in preparing disclosures?	Preparers	**75%**
How useful is the supplemental guidance in preparing disclosures?	Preparers	**66%**
If organizations disclose the recommended information, how useful would it be for decision making?	Users	**77%**
How useful is a description of potential performance across a range of scenarios to understanding climate-related impacts on an organization's businesses, strategy, and financial planning?	Financial	**74%**
	Non-Financial	**17%**
	Other	**86%**
How useful are the illustrative examples of metrics and targets?	Financial	**74%**
	Non-Financial	**33%**
	Other	**72%**
How useful would the disclosure of GHG emissions associated with investments be for economic decision-making?	Financial	**68%**
	Other	**74%**

[61] Of the 59 respondents that submitted comment letters, 45 also completed the online questionnaire, resulting in a total of 320 unique responses.

[62] The other types of organizations included research and advocacy NGOs; standard setting NGOs; data analytics, consulting, and research organizations; academia; and accounting associations.

Overall, respondents were generally supportive of the Task Force's recommendations as shown in Table A2.2 (p. 48); however, several provided specific and constructive feedback on the report. The key themes from this feedback are included in Table A2.3. For additional information regarding the results of the second public consultation, please view the TCFD Public Consultation Summary 2017 on the Task Force's website.

Table A2.3

Key Themes of Second Public Consultation (Recommendations)

Key Themes	
Materiality and Location of Disclosures	Clarifying which recommended disclosures depend on materiality assessment and providing flexibility for organizations to provide some or all disclosures in reports other than financial filings.
Scenario Analysis	Improving ease of implementation, and comparability of scenario analysis by specifying standard scenario(s) and providing additional guidance and tools.
Metrics for the Financial Sector	Encouraging further development and standardization of metrics for the financial sector.
Metrics for Non-Financial Sectors	Improving comparability and consistency of the illustrative metrics for non-financial sectors, clarifying the links to financial impact and climate-related risks and opportunities.
Implementation	Providing disclosure examples to support preparers in developing relevant climate-related financial disclosures.

Industry Interviews and Focus Groups

Prior to the December 2016 release of the Task Force's report for public consultation, the Task Force conducted 128 industry interviews with users and preparers of financial statements to gather feedback regarding the Task Force's draft recommendations, supplemental guidance for certain sectors, and other considerations. Industry interview participants included chief financial officers, investment officers, other finance and accounting officers, risk officers, sustainability officers, and others. Forty-three percent of the participants held finance, legal, or risk positions and 39 percent held environmental or sustainability roles.

Task Force representatives conducted two rounds of industry interviews. The initial round of interviews focused on the recommendations and guidance; the second round emphasized specific recommendations and sector-specific guidance. Organizations invited to participate in the interviews met two primary criteria: (1) represented industry and sector leaders likely to be impacted by climate-related risks and opportunities and (2) provided geographic diversity to ensure coverage from each G20 and Financial Stability Board (FSB) represented country.

The interviews provided valuable information that informed the Task Force's recommendations and guidance as reflected in the report issued for public consultation in December 2016. Industry interview themes were consistent with those identified in the second public consultation. Preparers raised concerns about the relationship of the Task Force's recommendations to other reporting initiatives and the accuracy and reliability of information requested. Users commented that establishing consistency in metrics would be beneficial, acknowledged data quality challenges, and provided thoughts on scenario analysis (e.g., would like preparers to use of a range of scenarios, interested in knowing how scenario analysis is used in the organization).

Subsequent to the December 2016 release of the Task Force's report for public consultation, the Task Force conducted five focus groups with 32 individuals from six countries representing organizations in specific sectors and industries to solicit feedback on scenario analysis and carbon footprinting metrics. In the two focus groups for the financial sector, participants expressed support for the Task Force's work, noting current challenges related to quality and consistency in

reported climate-related information. Asset owners and asset managers also provided feedback on the benefits and limitations of different carbon footprinting metrics. In the three focus groups for non-financial sectors, participants in oil and gas and utilities industries provided specific feedback on their use of scenario analysis and challenges related to disclosing certain information in financial filings.

Outreach Events

The Task Force sponsored 18 public outreach events in 13 countries, and Task Force members presented the recommendations at 91 other events including conferences, forums, and meetings sponsored by industry associations, NGOs, government agencies, corporations, and other organizations. The 18 Task Force-sponsored events informed stakeholders of the Task Force's work and recommendations and included panel discussions and keynote speeches by prominent climate-risk and financial experts. Attendees included representatives of financial and non-financial organizations who spanned a variety of corporate functions, including strategy, risk, accounting, portfolio and investment management, corporate sustainability, as well as representatives from industry associations, NGOs, government agencies, research providers, academia, accounting and consulting firms, and media.

Webinars

Prior to the release of the report in December 2016 for public consultation, the Task Force offered seven webinars to educate and increase awareness of the Task Force's efforts as well as to collect additional feedback. Of the seven webinars, the Task Force hosted four webinars and participated in three additional webinars by partnering with the following organizations: Business for Social Responsibility, Global Financial Markets Association, and the National Association of Corporate Directors. These webinars served to supplement the in-person outreach events and offered global stakeholders, regardless of location, an opportunity to engage with the Task Force. The webinars included 538 attendees representing 365 organizations across 23 countries. After the release of the report, the Task Force held three webinars to present its recommendations and to solicit additional feedback. The three webinars included 255 attendees representing 209 organizations across 25 countries. In total, the Task Force offered ten webinars, reaching 793 attendees across 30 countries.

Appendix 3: Fundamental Principles for Effective Disclosure

To underpin its recommendations and help guide current and future developments in climate-related financial reporting, the Task Force developed a set of principles for effective disclosure.[63] As understanding of, and approaches to, climate-related issues evolve over time, so too will climate-related financial reporting. These principles can help achieve high-quality and decision-useful disclosures that enable users to understand the impact of climate change on organizations. The Task Force encourages organizations adopting its recommendations to consider these principles as they develop climate-related financial disclosures.

The Task Force's disclosure principles are largely consistent with other mainstream, internationally accepted frameworks for financial reporting and are generally applicable to most providers of financial disclosures. They are informed by the qualitative and quantitative characteristics of financial information and further the overall goals of producing disclosures that are consistent, comparable, reliable, clear, and efficient, as highlighted by the FSB in establishing the Task Force. The principles, taken together, are designed to assist organizations in making clear the linkages and connections between climate-related issues and their governance, strategy, risk management, and metrics and targets.

Principle 1: Disclosures should present relevant information

The organization should provide information specific to the potential impact of climate-related risks and opportunities on its markets, businesses, corporate or investment strategy, financial statements, and future cash flows.

- Disclosures should be eliminated if they are immaterial or redundant to avoid obscuring relevant information. However, when a particular risk or issue attracts investor and market interest or attention, it may be helpful for the organization to include a statement that the risk or issue is not significant. This shows that the risk or issue has been considered and has not been overlooked.

- Disclosures should be presented in sufficient detail to enable users to assess the organization's exposure and approach to addressing climate-related issues, while understanding that the type of information, the way in which it is presented, and the accompanying notes will differ between organizations and will be subject to change over time.

- Climate-related impacts can occur over the short, medium, and long term. Organizations can experience chronic, gradual impacts (such as impacts due to shifting temperature patterns), as well as acute, abrupt disruptive impacts (such as impacts from flooding, drought, or sudden regulatory actions). An organization should provide information from the perspective of the potential impact of climate-related issues on value creation, taking into account and addressing the different time frames and types of impacts.

- Organizations should avoid generic or boilerplate disclosures that do not add value to users' understanding of issues. Furthermore, any proposed metrics should adequately describe or serve as a proxy for risk or performance and reflect how an organization manages the risk and opportunities.

Principle 2: Disclosures should be specific and complete

- An organization's reporting should provide a thorough overview of its exposure to potential climate-related impacts; the potential nature and size of such impacts; the organization's governance, strategy, processes for managing climate-related risks, and performance with respect to managing climate-related risks and opportunities.

- To be sufficiently comprehensive, disclosures should contain historical and future-oriented information in order to allow users to evaluate their previous expectations relative to actual performance and assess possible future financial implications.

- For quantitative information, the disclosure should include an explanation of the definition and scope applied. For future-oriented data, this includes clarification of the key assumptions used. Forward-looking quantitative disclosure should align with data used by the organization for investment decision making and risk management.

- Any scenario analyses should be based on data or other information used by the organization for investment decision making and risk management. Where appropriate, the organization should also demonstrate the effect on selected risk metrics or exposures to changes in the key underlying methodologies and assumptions, both in qualitative and quantitative terms.

Principle 3: Disclosures should be clear, balanced, and understandable

- Disclosures should be written with the objective of communicating financial information that serves the needs of a range of financial sector users (e.g., investors, lenders, insurers, and others). This requires reporting at a level beyond compliance with minimum requirements. The disclosures should be sufficiently granular to inform sophisticated users, but should also provide concise information for those who are less specialized. Clear communication will allow users to identify key information efficiently.

- Disclosures should show an appropriate balance between qualitative and quantitative information and use text, numbers, and graphical presentations as appropriate.

- Fair and balanced narrative explanations should provide insight into the meaning of quantitative disclosures, including the changes or developments they portray over time. Furthermore, balanced narrative explanations require that risks as well as opportunities be portrayed in a manner that is free from bias.

- Disclosures should provide straightforward explanations of issues. Terms used in the disclosures should be explained or defined for a proper understanding by the users.

Principle 4: Disclosures should be consistent over time

- Disclosures should be consistent over time to enable users to understand the development and/or evolution of the impact of climate-related issues on the organization's business. Disclosures should be presented using consistent formats, language, and metrics from period to period to allow for inter-period comparisons. Presenting comparative information is preferred; however, in some situations it may be preferable to include a new disclosure even if comparative information cannot be prepared or restated.

- Changes in disclosures and related approaches or formats (e.g., due to shifting climate-related issues and evolution of risk practices, governance, measurement methodologies, or accounting practices) can be expected due to the relative immaturity of climate-related disclosures. Any such changes should be explained.

Principle 5: Disclosures should be comparable among organizations within a sector, industry, or portfolio

- Disclosures should allow for meaningful comparisons of strategy, business activities, risks, and performance across organizations and within sectors and jurisdictions.

- The level of detail provided in disclosures should enable comparison and benchmarking of risks across sectors and at the portfolio level, where appropriate.

- The placement of reporting would ideally be consistent across organizations—i.e., in financial filings—in order to facilitate easy access to the relevant information.

Principle 6: Disclosures should be reliable, verifiable, and objective

- Disclosures should provide high-quality reliable information. They should be accurate and neutral—i.e., free from bias.

- Future-oriented disclosures will inherently involve the organization's judgment (which should be adequately explained). To the extent possible, disclosures should be based on objective data and use best-in-class measurement methodologies, which would include common industry practice as it evolves.

- Disclosures should be defined, collected, recorded, and analyzed in such a way that the information reported is verifiable to ensure it is high quality. For future-oriented information, this means assumptions used can be traced back to their sources. This does not imply a requirement for independent external assurance; however, disclosures should be subject to internal governance processes that are the same or substantially similar to those used for financial reporting.

Principle 7: Disclosures should be provided on a timely basis

- Information should be delivered to users or updated in a timely manner using appropriate media on, at least, an annual basis within the mainstream financial report.

- Climate-related risks can result in disruptive events. In case of such events with a material financial impact, the organization should provide a timely update of climate-related disclosures as appropriate.

Reporters may encounter tension in the application of the fundamental principles set out above. For example, an organization may update a methodology to meet the comparability principle, which could then result in a conflict with the principle of consistency. Tension can also arise within a single principle. For example, Principle 6 states that disclosures should be verifiable, but assumptions made about future-oriented disclosures often require significant judgment by management that is difficult to verify. Such tensions are inevitable given the wide-ranging and sometimes competing needs of users and preparers of disclosures. Organizations should aim to find an appropriate balance of disclosures that reasonably satisfy the recommendations and principles while avoiding overwhelming users with unnecessary information.

Appendix 4: Select Disclosure Frameworks

To the extent there is corporate reporting of climate-related issues, it happens through a multitude of mandatory and voluntary schemes. Although a complete and comprehensive survey of existing schemes is beyond the scope of this report, the Task Force on Climate-related Financial Disclosures (TCFD or Task Force) considered a broad range of existing frameworks, both voluntary and mandatory. The tables in Appendix 4 outline select disclosure frameworks considered by the Task Force and describe a few key characteristics of each framework, including whether disclosures are mandatory or voluntary, what type of information is reported, who the target reporters and target audiences are, where the disclosed information is placed, and whether there are specified materiality standards.[64] These disclosure frameworks were chosen to illustrate the broad range of disclosure regimes around the world; the tables are broken out into disclosure frameworks sponsored by governments, stock exchanges, and non-governmental organizations (NGOs).

The information presented in the tables below (A4.1, A4.2, and A4.3) is based on information released by governments, stock exchanges, and standard setters and is supplemented by the United Nations Environment Programme (UNEP), "The Financial System We Need: Aligning the Financial System with Sustainable Development," October 2015, and the Organization for Economic Co-operation and Development (OECD), "Report to G20 Finance Ministers and Central Bank Governors," September 2015.

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[64] These tables were originally included in the Task Force's Phase I Report and have been updated where appropriate.

Table A4.1

Select Disclosure Frameworks: Governments

Region: Framework	Target Reporter	Target Audience	Mandatory or Voluntary	Materiality Standard	Types of Climate-Related Information	Disclosure Location	External Assurance Required
Australia: National Greenhouse and Energy Reporting Act (2007)	Financial and non-financial firms that meet emissions or energy production or consumption thresholds	General public	Mandatory if thresholds are met	Based on emissions above a certain threshold	GHG emissions, energy consumption, and energy production	Report to government	Regulator may, by written notice to corporation, require an audit of its disclosures
European Union (EU): EU Directive 2014/95 regarding disclosure of non-financial and diversity information (2014)	Financial and non-financial firms that meet size criteria (i.e., have more than 500 employees)	Investors, consumers, and other stakeholders	Mandatory; applicable for the financial year starting on Jan. 1, 2017 or during the 2017 calendar year	None specified	Land use, water use, GHG emissions, use of materials, and energy use	Corporate financial report or separate report (published with financial report or on website six months after the balance sheet date and referenced in financial report)	Member States must require that statutory auditor checks whether the non-financial statement has been provided Member States may require independent assurance for information in non-financial statement
France: Article 173, Energy Transition Law (2015)	Listed financial and non-financial firms Additional requirements for institutional investors	Investors, general public	Mandatory	None specified	Risks related to climate change, consequences of climate change on the company's activities and use of goods and services it produces. Institutional investors: GHG emissions and contribution to goal of limiting global warming	Annual report and website	Mandatory review on the consistency of the disclosure by an independent third party, such as a statutory auditor
India: National Voluntary Guidelines on Social, Environmental, and Economic Responsibilities of Business (2011)	Financial and non-financial firms	Investors, general public	Voluntary	None specified	Significant risk, goals and targets for improving performance, materials, energy consumption, water, discharge of effluents, GHG emissions, and biodiversity	Not specified; companies may furnish a report or letter from owner/chief executive officer	Guidelines include third-party assurance as a "leadership indicator" of company's progress in implementing the principles

Select Disclosure Frameworks: Governments *(continued)*

Region: Framework	Target Reporter	Target Audience	Mandatory or Voluntary	Materiality Standard	Types of Climate-Related Information	Disclosure Location	External Assurance Required
United Kingdom: Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013	Financial and non-financial firms that are "Quoted Companies," as defined by the Companies Act 2006	Investors / shareholders ("members of the company")	Mandatory	Information is material if its omission or misrepresentation could influence the economic decisions shareholders take on the basis of the annual report as a whole (section 5 of the UK FRC June 2014 Guidance on the Strategic Report)	The main trends and factors likely to affect the future development, performance, and position of the company's business, environmental matters (including the impact of the company's business on the environment), and GHG emissions	Strategic Report and Directors' Report	Not required, but statutory auditor must state in report on the company's annual accounts whether in the auditor's opinion the information given in the Strategic Report and the Directors' Report for the financial year for which the accounts are prepared is consistent with those accounts
United States: NAICs, 2010 Insurer Climate Risk Disclosure Survey	Insurers meeting certain premium thresholds - $100M in 2015	Regulators	Mandatory if thresholds are met	None specified	General disclosures about climate change-related risk management and investment management	Survey sent to state regulators	Not specified
United States: SEC Guidance Regarding Disclosure Related to Climate Change	Financial and non-financial firms subject to Securities and Exchange Commission (SEC) reporting requirements	Investors	Mandatory	US securities law definition	Climate-related material risks and factors that can affect or have affected the company's financial condition, such as regulations, treaties and agreements, business trends, and physical impacts	Annual and other reports required to be filed with SEC	Depends on assurance requirements for information disclosed

Select Disclosure Frameworks: Exchange Listing Requirements and Indices

Region: Framework	Target Reporter	Target Audience	Mandatory or Voluntary	Materiality Standard	Types of Climate-Related Information	Disclosure Location	External Assurance Required
Australia: Australia Securities Exchange Listing Requirement 4.10.3; Corporate Governance Principles and Recommendations (2014)	Listed financial and non-financial firms	Investors	Mandatory (comply or explain)	A real possibility that the risk in question could substantively impact the listed entity's ability to create or preserve value for security holders over the short, medium or long term	General disclosure of material environmental risks	Annual report must include either the corporate governance statement or company website link to the corporate governance statement on company's website	Not specified, may depend on assurance requirements for annual report
Brazil: Stock Exchange (BM&FBovespa) Recommendation of report or explain (2012)	Listed financial and non-financial firms	Investors, regulator	Voluntary (comply or explain)	Criteria explained in Reference Form (Annex 24) of the Instruction CVM nº 480/09	Social and environmental information including methodology used, if audited/reviewed by an independent entity, and link to information (i.e., webpage)	Discretion of company	Not specified
China: Shenzhen Stock Exchange Social Responsibility Instructions to Listed Companies (2006)	Listed financial and non-financial firms	Investors	Voluntary: social responsibilities Mandatory: pollutant discharge	None specified	Waste generation, resource consumption, and pollutants	Not specified	Not specified; companies shall allocate dedicated human resources for regular inspection of implementation of environmental protection policies
Singapore: Singapore Exchange Listing Rules 711A & 711B and Sustainability Reporting Guide (2016) ("Guide")	Listed financial and non-financial firms	Investors	Mandatory (comply or explain)	Guidance provided in the Guide, paragraphs 4.7-4.11	Material environmental, social, and governance factors, performance, targets, and related information specified in the Guide	Annual report or standalone report, disclosed through SGXNet reporting platform and company website	Not required

Select Disclosure Frameworks: Exchange Listing Requirements and Indices (continued)

Region: Framework	Target Reporter	Target Audience	Mandatory or Voluntary	Materiality Standard	Types of Climate-Related Information	Disclosure Location	External Assurance Required
South Africa: Johannesburg Stock Exchange Listing Requirement Paragraph 8.63; King Code of Governance Principles (2009)	Listed financial and non-financial firms	Investors	Mandatory; (comply or explain)	None specified	General disclosure regarding sustainability performance	Annual report	Required
World, regional, and country-specific indices: S&P Dow Jones Indices Sustainability Index, Sample Questionnaires	Financial and non-financial firms	Investors	Voluntary	None specified	GHG emissions, SOx emissions, energy consumption, water, waste generation, environmental violations, electricity purchased, biodiversity, and mineral waste management	Nonpublic	Disclose whether external assurance was provided and whether it was pursuant to a recognized standard

Select Disclosure Frameworks: Non-Governmental Organizations

Framework	Target Reporter	Target Audience	Mandatory or Voluntary	Materiality Standard	Types of Climate-Related Information	Disclosure Location	External Assurance Required
Global: Asset Owners Disclosure Project 2017 Global Climate Risk Survey	Pension funds, insurers, sovereign wealth funds ≥$2bn AUM	Asset managers, investment industry, government	Voluntary	None specified	Information on whether climate change issues are integrated in investment policies, engagement efforts, portfolio emissions intensity for scope 1 emissions, climate change-related portfolio risk mitigation actions	Survey responses; respondents are asked whether responses may be made public	Disclose whether external assurance was provided
Global: CDP Annual Questionnaire (2016)	Financial and non-financial firms	Investors	Voluntary	None specified	Information on risk management procedures related to climate change risks and opportunities, energy use, and GHG emissions (Scope 1-3)	CDP database	Encouraged; information requested about verification and third party certification
Global: CDSB CDSB Framework for Reporting Environmental Information & Natural Capital	Financial and non-financial firms	Investors	Voluntary	Environmental information is material if (1) the environmental impacts or results it describes are, due to their size and nature, expected to have a significant positive or negative effect on the organization's current, past or future financial condition and operational results and its ability to execute its strategy or (2) omitting, misstating, or mis-interpreting it could influence decisions that users of mainstream reports make about the organization	Environmental policies, strategy, and targets, including the indicators, plans, and timelines used to assess performance; material environmental risks and opportunities affecting the organization; governance of environmental policies, strategy, and information; and quantitative and qualitative results on material sources of environmental impact	Annual reporting packages in which organizations are required to deliver their audited financial results under the corporate, compliance or securities laws of the country in which they operate	Not required, but disclose if assurance has been provided over whether reported environmental information is in conformance with the CDSB Framework

Select Disclosure Frameworks: Non-Governmental Organizations *(continued)*

Framework	Target Reporter	Target Audience	Mandatory or Voluntary	Materiality Standard	Types of Climate-Related Information	Disclosure Location	External Assurance Required
Global: CDSB Climate Change Reporting Framework, Ed. 1.1 (2012)	Financial and non-financial firms	Investors	Voluntary	Allow "investors to see major trends and significant events related to climate change that affect or have the potential to affect the company's financial condition and/or its ability to achieve its strategy"	The extent to which performance is affected by climate-related risks and opportunities; governance processes for addressing those effects; exposure to significant climate-related issues; strategy or plan to address the issues; and GHG emissions	Annual reporting packages in which organizations are required to deliver their audited financial results under the corporate, compliance or securities laws of the territory or territories in which they operate	Not required unless International Standards on Auditing 720 requires the auditor of financial statements to read information accompanying them to identify material inconsistencies between the audited financial statements and accompanying information
Global: GRESB Infrastructure Asset Assessment & Real Estate Assessment	Real estate asset/portfolio owners	Investors and industry stakeholders	Voluntary	None specified	Real estate sector-specific requirements related to fuel, energy, and water consumption and efficiencies as well as low-carbon products	Data collected through the GRESB Real Estate Assessment disclosed to participants themselves and: • for non-listed property funds and companies, to those of that company or fund's investors that are GRESB Investor Members; • for listed real estate companies, to all GRESB Investor Members that invest in listed real estate securities.	Not required, but disclose whether external assurance was provided
Global: GRI Sustainability Reporting Standards (2016)	Organizations of any size, type, sector, or geographic location	All stakeholders	Voluntary	Topics that reflect the reporting organization's significant economic, environmental, and social impacts or substantively influence the decisions of stakeholders	Materials, energy, water, biodiversity, emissions, effluents and waste, environmental compliance, and supplier environmental assessment	Stand-alone sustainability reports or annual reports or other published materials that include sustainability information	Not required, but advised

Select Disclosure Frameworks: Non-Governmental Organizations *(continued)*

Framework	Target Reporter	Target Audience	Mandatory or Voluntary	Materiality Standard	Types of Climate-Related Information	Disclosure Location	External Assurance Required
Global: IIGCC Oil & Gas (2010) Automotive (2009) Electric Utilities (2008)	Oil and gas industries	Investors	Voluntary	None specified	GHG emissions and clean technologies data	Not specified	Not specified
	Automotive industry	Investors	Voluntary	None specified	GHG emissions and clean technologies data	Company's discretion	Not specified
	Electrical utilities	Investors	Voluntary	None specified	GHG emissions and electricity production	Company's discretion	Disclose how GHG emissions information was verified
Global: IIRC International Integrated Reporting Framework (2013)	Public companies traded on international exchanges	Investors	Voluntary	Substantively affect the company's ability to create value over the short, medium, and long term	General challenges related to climate change, loss of ecosystems, and resource shortages	Standalone sustainability or integrated report	Not specified; discussion paper released on issues relating to assurance
Global: IPIECA Oil and gas industry guidance on voluntary sustainability reporting	Oil and gas industries	All stakeholders	Voluntary	Material sustainability issues are those that, in the view of company management and its external stakeholders, affect the company's performance or strategy and/or assessments or decisions about the company	Energy consumption	Sustainability reporting	Not required, but encouraged
Global: PRI Reporting Framework (2016)	Investors	Investors	Voluntary	None specified	Investor practices	Transparency report	Not specified
United States: SASB Conceptual Framework (2013) and SASB Standards (Various)	Public companies traded on US exchanges	Investors	Voluntary	A substantial likelihood that the disclosure of the omitted fact would have been viewed by the reasonable investor as having significantly altered the "total mix" of the information made available	Information on sustainability topics that are deemed material, standardized metrics tailored by industry	SEC filings	Depends on assurance requirements for information disclosed

GREENHOUSE GAS (GHG) EMISSIONS SCOPE LEVELS[69]

- **Scope 1** refers to all direct GHG emissions.

- **Scope 2** refers to indirect GHG emissions from consumption of purchased electricity, heat, or steam.

- **Scope 3** refers to other indirect emissions not covered in Scope 2 that occur in the value chain of the reporting company, including both upstream and downstream emissions. Scope 3 emissions could include: the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g., transmission and distribution losses), outsourced activities, and waste disposal.[70]

INTERNAL CARBON PRICE is an internally developed estimated cost of carbon emissions. Internal carbon pricing can be used as a planning tool to help identify revenue opportunities and risks, as an incentive to drive energy efficiencies to reduce costs, and to guide capital investment decisions.

MANAGEMENT refers to those positions an organization views as executive or senior management positions and that are generally separate from the board.

NATIONALLY DETERMINED CONTRIBUTION (NDC) refers to the post-2020 actions that a country intends to take under the international climate agreement adopted in Paris.

ORGANIZATION refers to the group, company, or companies, and other entities for which consolidated financial statements are prepared, including subsidiaries and jointly controlled entities.

PUBLICLY AVAILABLE 2°C SCENARIO refers to a 2°C scenario that is (1) used/referenced and issued by an independent body; (2) wherever possible, supported by publicly available datasets; (3) updated on a regular basis; and (4) linked to functional tools (e.g., visualizers, calculators, and mapping tools) that can be applied by organizations. 2°C scenarios that presently meet these criteria include: IEA 2DS, IEA 450, Deep Decarbonization Pathways Project, and International Renewable Energy Agency.

RISK MANAGEMENT refers to a set of processes that are carried out by an organization's board and management to support the achievement of the organization's objectives by addressing its risks and managing the combined potential impact of those risks.

SCENARIO ANALYSIS is a process for identifying and assessing a potential range of outcomes of future events under conditions of uncertainty. In the case of climate change, for example, scenarios allow an organization to explore and develop an understanding of how the physical and transition risks of climate change may impact its businesses, strategies, and financial performance over time.

SECTOR refers to a segment of organizations performing similar business activities in an economy. A sector generally refers to a large segment of the economy or grouping of business types, while "industry" is used to describe more specific groupings of organizations within a sector.

STRATEGY refers to an organization's desired future state. An organization's strategy establishes a foundation against which it can monitor and measure its progress in reaching that desired state. Strategy formulation generally involves establishing the purpose and scope of the

[69] World Resources Institute and World Business Council for Sustainable Development, *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition),* March 2004.
[70] IPCC, *Climate Change 2014 Mitigation of Climate Change,* Cambridge University Press, 2014.

organization's activities and the nature of its businesses, taking into account the risks and opportunities it faces and the environment in which it operates.

SUSTAINABILITY REPORT is an organizational report that gives information about economic, environmental, social, and governance performance and impacts. For companies and organizations, sustainability —the ability to be long-lasting or permanent—is based on performance and impacts in these four key areas.

VALUE CHAIN refers to the upstream and downstream life cycle of a product, process, or service, including material sourcing, production, consumption, and disposal/recycling. Upstream activities include operations that relate to the initial stages of producing a good or service (e.g., material sourcing, material processing, supplier activities). Downstream activities include operations that relate to processing the materials into a finished product and delivering it to the end user (e.g., transportation, distribution, and consumption).

Abbreviations

2°C —2° Celsius

ASC—Accounting Standards Codification

BNEF—Bloomberg New Energy Finance

CDSB—Climate Disclosure Standards Board

ERM—Environmental Resources Management

EU—European Union

FASB—Financial Accounting Standards Board

FSB—Financial Stability Board

G20—Group of 20

GHG—Greenhouse gas

GICS—Global Industry Classification Standard

GRI—Global Reporting Initiative

IAS—International Accounting Standard

IASB—International Accounting Standards Board

IEA—International Energy Agency

IIGCC—Institutional Investors Group on Climate Change

IIRC—International Integrated Reporting Council

IPCC—Intergovernmental Panel on Climate Change

NGO—Non-governmental organization

OECD—Organization for Economic Co-operation and Development

R&D—Research and development

SASB—Sustainability Accounting Standards Board

TCFD—Task Force on Climate-related Financial Disclosures

UN—United Nations

UNEP—United Nations Environment Programme

USDE—U.S. Dollar Equivalent

WRI—World Resources Institute

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TAB 18

Embracing Innovation
in Government
Global Trends 2018

استشـــراف حكومــات المستقبــل
SHAPING FUTURE GOVERNMENTS

In collaboration with

OECD
BETTER POLICIES FOR BETTER LIVES

WORLD GOVERNMENT SUMMIT القمة العالمية للحكومات

In collaboration with

OECD
BETTER POLICIES FOR BETTER LIVES

OPSI Observatory of
Public Sector Innovation

مركز محمد بن راشد للابتكار الحكومي
MOHAMMED BIN RASHID CENTRE
FOR GOVERNMENT INNOVATION

Contents

How are governments innovating to address unprecedented challenges?

The current global political and economic setting is complex and fast-changing, with society transforming in ways that challenge existing views about the world and how it is governed. Technology is disrupting the status quo and creating a future of unknowns. Meanwhile, globalism has accelerated and a backlash has formed as a result of growing economic inequalities. Gender equality remains an uphill battle, conflict is forcing record numbers from their homes, trust in government is near record lows, and climate change and job automation crises are fast approaching. These challenges can seem insurmountable, but their significance is mirrored by the potential for governments to take action with new approaches to policies and services. Governments are rising to the occasion and innovating to cope with new realities and to build a better future for their people.

A Global Review of Government innovation

The OECD Observatory of Public Sector Innovation (OPSI) serves as a forum to share lessons and insights on government innovation.[1] To further its mission and learn from leading-edge innovators, OPSI has partnered with the Government of the United Arab Emirates (UAE) and its Mohammed Bin Rashid Centre for Government Innovation (MBRCGI),[2] which serves to stimulate and enrich the culture of innovation within government. As part of the MENA-OECD Governance Programme, OPSI and the MBRCGI conducted a global review involving extensive research and an open Call for Innovations to explore how governments are innovating in response to the enormous challenges of today's complex world. By identifying and sharing these trends and examples through this review and by serving as a global innovation forum, the OECD and MBRCGI hope to inspire action, embed successes, reduce the impact of failure, and speed up the transformative process of innovation to deliver better outcomes for people. This review is published in conjunction with the 2018 World Government Summit,[3] which brings together over 130 countries and 4 000 people to discuss innovative ways to solve the challenges facing humanity.

1. OPSI is part of the OECD Directorate for Public Governance (GOV). See www.oecd.org/gov.

2. See www.mbrcgi.gov.ae.

3. See www.worldgovernmentsummit.org.

One of the features of the summit is the *Edge of Government*[4], a series of interactive exhibits that bring innovations to life. These exhibits include two of the case studies presented in this review, as discussed later.

Through research and the Call for Innovations, OPSI and the MBRCGI identified three key trends in public sector innovation that build upon trends identified through a global review issued in 2017.[5] These trends form the structure of this review. Each section includes a discussion of innovative initiatives by governments and their partners, real-world examples of the trend in action and recommendations to help countries unlock innovation. The trends focus on:

Identity

Key trends in public innovation identified through this review

Systems approaches and enablers

Inclusiveness and vulnerable populations

276
submissions
from **58** countries

10
featured as case studies in this review

4. See https://edge.worldgovernmentsummit.org.

5. See http://oe.cd/eig.

Identity

An identity is a fundamental requirement for individuals and businesses to access government services and participate in society and the economy, and for governments to help unlock the potential of innovative services. Governments and their partners are innovating to conceive of new ways to provide identities to individuals and businesses through emerging technologies. They are also helping citizens demonstrate the unique combination of knowledge, skills and experiences that make up their own personal identities. In an interconnected and increasingly borderless world, they are questioning traditional conceptions of national identity and pushing the boundaries of what it means to be a citizen and resident.

SEVERAL THEMES HAVE BEEN OBSERVED IN THIS AREA:

Countries are rolling out new identity programmes.

The latest developments are in biometrics and blockchain, but can raise privacy concerns.

Open standards can help individuals express their unique identities.

Technology is enabling better decisions in business identity.

Innovation is spurring new discussions in national and individual identity.

KEY RECOMMENDATIONS

1. Develop identity solutions that fit with the culture of the country.

2. Make trade-offs clearly understandable by the population.

3. Think beyond traditional concepts of identity.

4. Use open standards and application programming interfaces (APIs) to unlock potential.

Identity

Image sources are included in the main body of the report

CASE STUDY: **Aadhaar** – *India*

Aadhaar is the world's largest biometric identity programme, covering 1.2 billion Indian citizens. Each recipient receives a unique ID number and submits their fingerprints and iris scans. Designed to mitigate fraud by ensuring benefits go to the right person, the initiative has expanded to many parts of everyday life in India. As the programme has grown, so have privacy and security controversies, including a landmark Supreme Court ruling that recognised privacy as a human right, which may have implications for the future of Aadhaar.
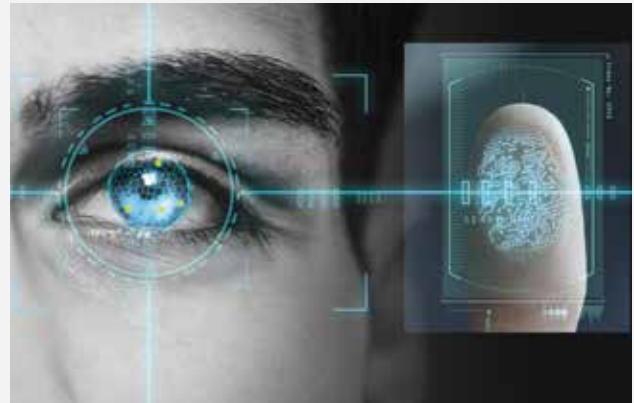
CASE STUDY: **Be Badges** – *Belgium*

Individuals learn and develop throughout their entire lives, whether in school, training, careers or their personal lives. However, few options exist to highlight skills not gained from formal credentials, such as diplomas and certificates. To address this, the Belgian government launched Be Badges, a digital platform where employers, schools and others can formally recognise individuals' experiences. Badge-earners can share their badges with others and the labour market, and employers can access the platform to find new employees.

CASE STUDY: **Australian Trade Mark Search** – *Australia*

Over 87% of a company's value is rooted in intangible assets, including trademarks that represent its identity. However, ensuring the uniqueness of a company's brand can be difficult and time consuming. To help, IP Australia launched Australian Trade Mark Search, a revolutionary image recognition and AI tool that helps companies to create a trademark that serves as a critical foundation upon which the rest of their businesses can be built, and helps distinguish their identity and their unique products and services in the marketplace.

CASE STUDY: **Data Embassy** – *Estonia*

Estonia is renowned for its technologically advanced government. Nearly every government service is performed electronically. As a result, Estonia is highly dependent on its information systems. To protect its data, Estonia conceived of data embassies – servers physically stored in other countries that fall legally under Estonian jurisdiction. Copies of key databases are stored on these servers and can be accessed in the event of a major incident. Through this initiative and others, Estonia is becoming a "country without borders", and in the process raising questions about the meaning of sovereignty and national identity in a digital world.

Systems approaches and enablers

Governments are using innovation to lead a paradigm shift in the way they provide services. The most innovative approaches refrain from layering one reform on top of another, instead repacking them in ways that allow them to get to the real purpose of the underlying change. Systems approaches step back and view the entire operation of government as an interconnected system rather than disparate pieces. They transform and re-align the underlying processes and methods to change the way government works in a cross-cutting way, while involving all of the affected actors both inside and outside government. In so doing, they leverage a number of tools and enabling conditions to succeed.

SEVERAL THEMES HAVE BEEN OBSERVED IN THIS AREA:

Innovators are embracing systems approaches to tackle complex problems, while also transcending administrative boundaries.

Countries are getting better at problem diagnostics to initiate systems change.

Systems approaches involve trade-offs which must be evaluated.

Systems innovators are looking for scale: From incremental to radical.

Innovators use systems approaches to transform the public sector itself.

KEY RECOMMENDATIONS

1. Focus on a problem, not a method.

2. Apply new problem diagnostic tools.

3. Analyse the potential systemic effects and value trade-offs of innovations.

4. Stay open to emergent, bottom-up change.

5. Experiment with transformative change inside government.

Systems approaches and enablers

CASE STUDY: **APEX** – *Singapore*

APEX is a whole-of-government platform which establishes common application programming interfaces (APIs) that allow public agencies to share data with other agencies and private entities. APEX enables different government data programmes to talk to each other, providing uniform governance, consistency and reliable performance. It enables innovation through a central catalogue and self-service portal where innovators can easily leverage common APIs as building blocks to create new services and experiences for citizens. One of the initial pilots is MyInfo, a service that removes the need for citizens to repeatedly provide their personal information to government services. APEX addresses a major systemic challenge: systems interoperability.

CASE STUDY: **Predictiv** – *United Kingdom*

Predictiv is an online platform for running behavioural experiments. It enables governments to run randomised controlled trials (RCTs) with an online population of participants, and to test whether new policies and interventions work before they are deployed in the real world. Predictiv has the potential to profoundly change governments' working methods by drastically reducing the time needed to test new interventions. In addition, while time constraints and political realities sometimes make it hard to run "field trials" on live policy, Predictiv makes experimental methods more accessible.

CASE STUDY: **Free Agents and GC Talent Cloud** – *Canada*

Canada has been testing several models for recruiting and mobilising talent within the public service in the digital age. The most ambitious of its projects is the Talent Cloud, which aims to become a validated, searchable repository of cross-sector talent. It envisions a digital marketplace where workers have access to rights, benefits and union representation, while retaining the flexibility to choose work inside and outside government, as offered. It represents a departure from the permanent hiring model in the public service, instead organising talent and skills for project-based work. While still at the visionary stage, Talent Cloud has produced several spin-off projects, such as Free Agents, that are innovative and successful in their own right.

Inclusiveness and vulnerable populations

In the face of major cross-cutting challenges such as migration, ageing population crises, uncertainties about the future of work and job automation, and continued gender and economic inequalities, governments are turning to innovation to build more inclusive societies. Governments are rallying behind the Sustainable Development Goals (SGDs), finding new paths towards gender equality, and easing the transition and economic circumstances for migrants. A few are also looking for innovative ways to prepare society for the challenges of the future. There remains a long way to go and there may be some gaps in the road ahead, but inclusiveness is growing and a safety net is being strung. The world is at a juncture that challenges governments to acknowledge new realities and create new solutions for everyone through innovation.

PEACE, JUSTICE AND STRONG INSTITUTIONS

Inclusiveness and vulnerable populations

SEVERAL THEMES HAVE BEEN OBSERVED IN THIS AREA:

Governments and organisations are innovating to meet the SDGs.

Gender equality is an uphill battle, but innovative countries are narrowing the gap.

Governments must adjust to ageing societies.

Waves of migration help solve some challenges but contribute to others.

Systems approaches are supporting the most vulnerable.

Governments need to innovate in the face of job automation.

KEY RECOMMENDATIONS

1. Connect with international communities to drive united progress.

2. Ensure all members of society are considered and consulted in policy making and service delivery.

3. Begin preparing today for supporting the next generation of vulnerable populations.

CASE STUDY: **Seoul 50+ policy** – *Republic of Korea*

Seoul's 50+ policy represents an innovative convergence of social welfare, employment and life-long learning policies, geared towards addressing the needs of an ageing society. The policy addresses the needs and characteristics of citizens aged between 50-64 and enables them to remain active, work and participate in community life. As part of the 50+ Policy, the Seoul Metropolitan Government is establishing a comprehensive infrastructure with a foundation, campuses and centres across the city. In so doing, it is redefining the meaning of "work" in an era of ageing populations.

CASE STUDY: **Financial Inclusion Programme for Migrants** – *Mexico*

The Financial Inclusion Programme for Migrants is an innovative financial services initiative that provides bank accounts and other support to a unique set of migrants – Mexican citizens repatriating from the United States amid a political climate that has added a great degree of uncertainty to their lives. To help these citizens, the National Savings and Financial Services Bank (Bansefi), a development bank created by the federal government to reach vulnerable populations, has opened 11 strategically located service branches along the US-Mexico border and one at the Mexico City airport. These provide repatriating citizens with financial services and vital information.

CASE STUDY: **Asker Welfare Lab** – *Norway*

Asker Welfare Lab is a new concept for service delivery centred solely on the citizen, where all relevant municipal services together with external partners – the Investment Team – invest jointly in a person's welfare. The lab adopts an investment mind-set and treats citizens as co-investors. The aim is to raise the living standards of vulnerable individuals, thereby bettering the quality of life of each person and family in the programme. Most importantly, experts have to partner with the citizens whose lives they want to change, on the basis that "No decision about me shall be taken without me". Public sector investment is closely monitored through a new form of reporting that focuses on the realisation of outcomes.

Introduction

Governments face both unprecedented challenges and immense possibilities

The current global political and economic setting is complex and fast-changing. Society is in the midst of an incredible transformation that challenges both existing systems and views about how the world works and how it should be governed. Emerging technologies are not only disrupting the status quo, they are altering existing preconceptions and creating a future of unknowns. Ten years ago – when the iPhone first launched, Twitter was taking off and Uber did not yet exist – few could have imagined today's constantly connected and endlessly interconnected world, where the majority of the population use mobile Internet on a daily basis (see Figure 1).

This interconnectedness has accelerated the already rapid pace of globalisation, further spurring structural adjustments that demand a government response, as well a growing backlash caused by resentment to growing inequality worldwide. There is a widespread sentiment in many countries that the benefits of this connected and fast-changing world have been concentrated in too few hands. In the vast majority of advanced countries, the gap between rich and poor has reached its highest level for three decades. Today, the richest 10% of the population

in the OECD area earn nearly 10 times the income of the poorest 10%, up from seven times in the 1980s. The problem is only getting worse (see Figure 2), with just eight men controlling as much wealth as the bottom half of the world (Mullany, 2017). This situation affects people's trust in institutions, and their belief in the benefits of a globalised world. At present, only 43% of citizens trust their government, and this rate is dropping (see Figure 3). There is a general belief that governments are unable to protect the best interests of their people (OECD, 2016a: 198).

Figure 1: **A constantly connected world: total daily and mobile Internet users, 2016**
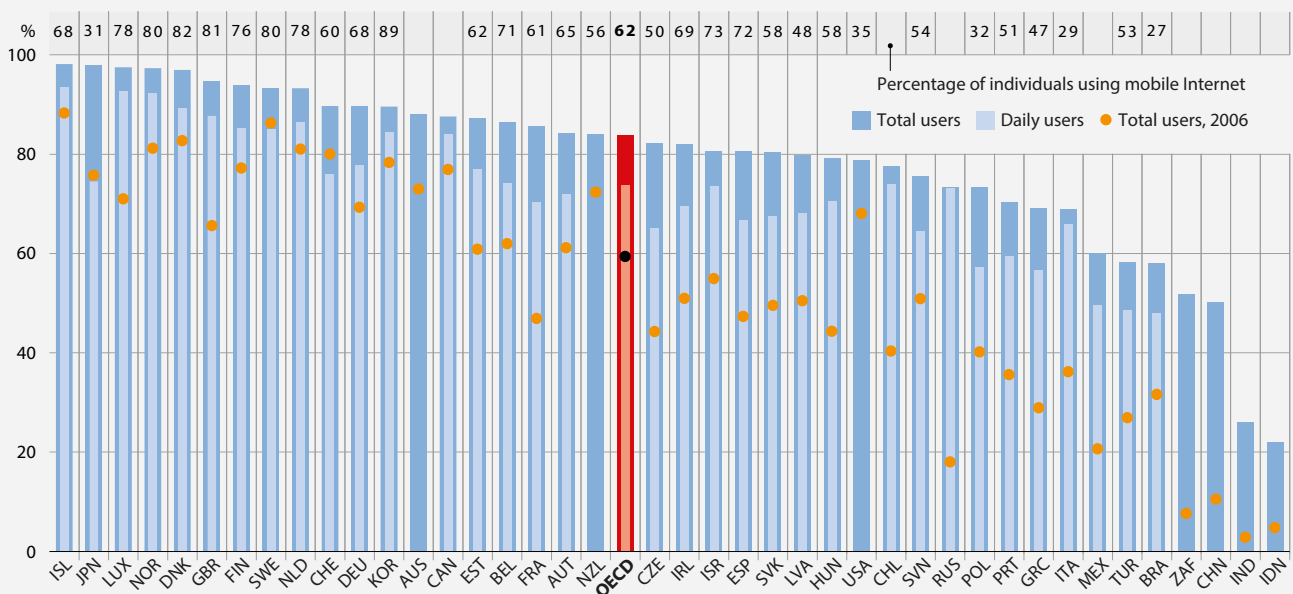
Source: OECD (2017a: 196).

Figure 2: **The rich get richer and the poor poorer**

Household incomes, OECD average
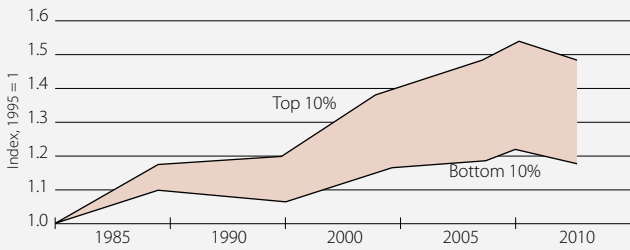
Source: OECD (2016: 66).

Waning faith in the ability of governments to manage global challenges represents a poor foundation for navigating even further waves of change. The combination of technological change and globalisation is reshaping the notion of work, human purpose and livelihoods. The OECD estimates that 10% of jobs in OECD countries are at high risk of being automated (OECD, 2016a), while the tasks of an additional 25% of the workforce will change significantly because of automation (OECD, 2016c: 57).

Figure 3: **Confidence in national government in 2016 and its change since 2007**

Legend: ■ % in 2016   ● Percentage points change since 2007

Countries (x-axis): ISR, SVK, DEU, POL, CHE, CZE, ISL, JPN, GBR, HUN, LVA, TUR, KOR, NOR, CAN, NZL, **OECD**, ITA, IRL, AUT, SWE, FRA, AUS, EST, USA, NLD, PRT, DNK, LUX, MEX, BEL, ESP, CHL, SVN, GRC, FIN, BRA, COL, CRI, IDN, IND, LIT
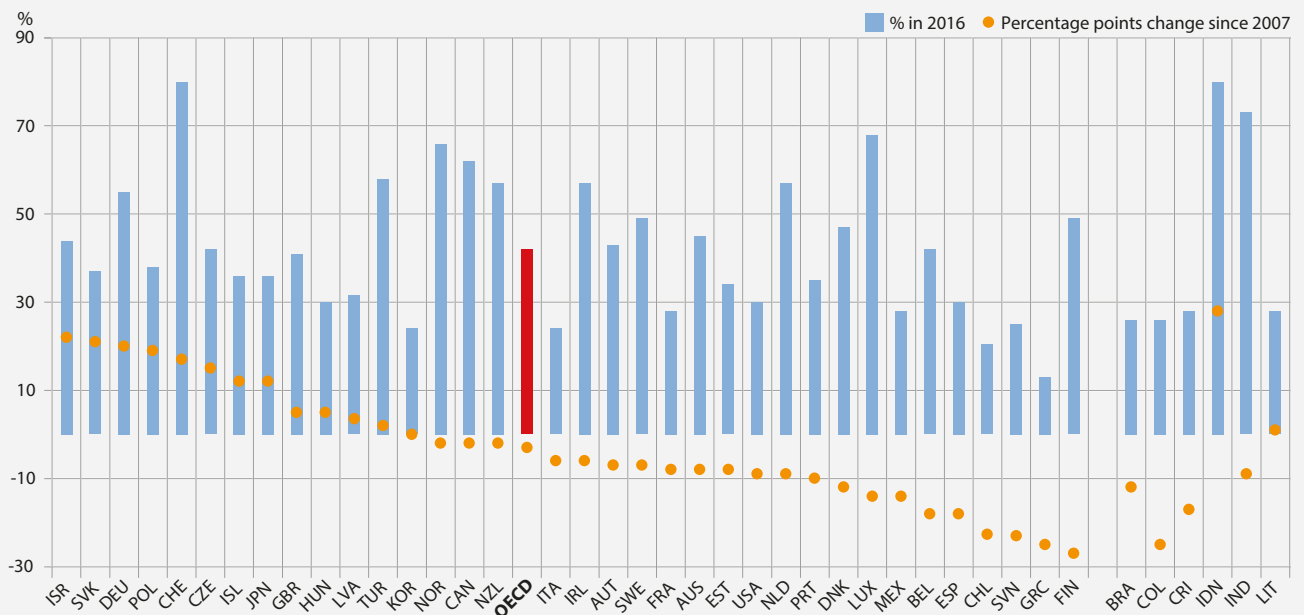
Source: Gallup World Poll.

Introduction

Major demographic shifts also feed this transformation. The current generation of young people worldwide is the largest ever; however, the proportion of young people in OECD countries has declined over the last 50 years with clear consequences for intergenerational spending on pensions, healthcare and education. Many countries are faced with an ageing population, placing increasing pressure on many government programmes and social dynamics (see the Inclusiveness and Vulnerable Populations section of this review on page 75).

Migration pressures are another compounding factor. Record numbers of people are being forced from their homes due to conflict or violence and environmental factors such as climate change, with more than 1.5 million new asylum requests registered by OECD countries in 2016 compared to the previous year.[6] This trend exerts considerable pressure on governments to adapt their public services to ensure no one is left behind.

6. See www.oecd.org/newsroom/oecd-calls-on-countries-to-step-up-integration-efforts-for-migrants-and-refugees.htm.

Given the scale of change, the magnitude of the accompanying transformation and the resulting uncertainty for the future, one thing is clear: there is no going backwards. The rate of change is accelerating at an exponential pace. There is a strong imperative for countries and individuals to question the status quo and discuss possible ways forward. New approaches are needed to ensure that everyone has the opportunity to improve their well-being in an increasingly globalised and digitalised economy. The only path to a prosperous, productive and inclusive future is to modernise, and more importantly, to innovate.

Innovation in government is about opening up new ways to positively influence the everyday lives of people, and new approaches to encourage them to become partners in shaping the future of government together. It involves overcoming old structures and modes of thinking and embracing new technologies, processes and ideas. In order to be sustainable, it must also be based on securing the public's trust, building faith in the government's ability to adeptly navigate a fast-changing world, and acting as sound stewards of their resources.

Governments are innovating to tackle these challenges and seize these possibilities

The OECD Observatory of Public Sector Innovation's (OPSI) mission is to serve as a forum for shared lessons and insights into the practice of innovation in government. Since 2014, it has worked to meet the needs of countries and cities around the world, providing a collective resource to identify, collect and analyse new ways of designing and delivering public policies and services. In a time of increasing complexity, rapidly changing demands and considerable fiscal pressures, governments need to understand, test and embed new ways of doing things. OPSI works to empower public servants with new insights, knowledge, tools and connections to help them explore new possibilities by:

- **Uncovering emerging practices and identifying what's next.** Identifying new practices at the leading edge of government, connecting those engaging in new ways of thinking and acting, and considering what these new approaches mean for the public sector.

- **Exploring how to turn the new into the normal.** Studying innovation in different public sector contexts and investigating potential frameworks and methods to unleash creativity and innovation and ways to connect them with the day-to-day work of public servants.

- **Providing trusted advice on how to foster innovation.** Sharing guidance and resources about the ways in which governments can support innovation to obtain better outcomes for their people.

To help achieve this mission and to learn from governments at the leading edge of this field, OPSI has forged a partnership with the Government of the United Arab Emirates (UAE) and its Mohammed Bin Rashid Centre for Government Innovation (MBRCGI)[7] as part of the MENA-OECD Governance Programme. The MBRCGI serves to stimulate and enrich the culture of innovation within government. Together, OPSI and the MBRCGI conducted a global review of government-led innovation to identify how governments respond to the enormous challenges of today's complex world and

to highlight recent trends and examples in public sector innovation. By identifying and sharing these trends and examples through this review and by serving as a global forum for connecting ideas and innovators around the world, the OECD and MBRCGI hope to inspire action, embed successes, reduce the impact of failure, and speed up the transformative process of innovation to deliver value for citizens at new heights and scales. OECD and the MBRCGI invite public servants interested in innovation to connect with OPSI and join a growing community of innovators to share ideas and initiatives that may help others learn, and to seek out additional information and connections related to the examples covered in this review and the over 400 innovation case studies contained on OPSI's online platform.[8]

This review is published in conjunction with the 2018 World Government Summit,[9] which brings together over 130 countries and over 4 000 government officials, thinkers, policy makers and industry experts to discuss innovative ways to solve the challenges facing humanity. One of the features of the summit is the *Edge of Government,* a series of interactive exhibits that bring innovations to life.[10] These exhibits include two of the case studies presented in this review, as discussed later. This review represents the second collaborative initiative from the partnership between OPSI and the MBRCGI.

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7. See www.mbrcgi.gov.ae.

8. See http://oe.cd/opsi. OPSI may be contacted on Twitter @OPSIgov or via email at opsi@oecd.org. OPSI publishes an innovation newsletter every two weeks (see http://bit.ly/2AFsnKb for registration and past issues).

9. See www.worldgovernmentsummit.org.

10. See https://edge.worldgovernmentsummit.org.

Introduction

It follows the 2017 report *Embracing Innovation in Government: Global Trends,*[11] which was launched at the World Government Summit 2017. Last year's review identified key trends that demonstrate leading-edge practices and the paths governments are taking to meet growing challenges and citizen expectations. It found that governments have created innovation divisions, labs and ministries (e.g. Denmark's Ministry of Public Sector Innovation),[12] as well as apps, tools and methodologies to address specific public sector challenges and engage with citizens as partners and co-creators. It also found that governments are leveraging emerging technologies to rapidly redefine the role of government and the ways in which it provides services to citizens and residents. In addition, it found that many states are reconceptualising the back-office functions of government as opportunities to develop innovative programmes and services. These trends are still highly relevant and represent the foundation for future innovation.

However, more remains to be done. Around the world, the majority of government innovation agendas are built on loosely defined concepts and inconsistent implementation strategies. Most governments do not incorporate innovation into competency frameworks that prepare civil servants to meet challenges, and close to half have not allocated dedicated funding for innovation (OECD, 2016c). Perhaps, most importantly, innovation too often occurs in pockets and silos – an age-old challenge of government – such as hubs and labs. As long as this is the case, innovation may at best burn like a series of bright matches, but will never ignite a fire across government.

This review's most significant and hopeful finding is the enthusiasm governments have for addressing these challenges and building the infrastructure needed to ignite this fire. Even if innovation and the systems and skills required to foster it are still in a process of maturation, the trends and examples contained in this review demonstrate that governments are acknowledging the need for change. Moreover, such change must transcend fragmented government structures designed for earlier times that employ tools and problem-solving methods that no longer work in the context of unprecedented complexity and uncertainty. Governments are building the enabling conditions and mechanisms that serve as foundational building blocks for innovation, and adopting innovative

solutions and approaches than can provoke cascading effects for new innovations to be built upon. Furthermore, these processes promote interconnectivity, taking a systemic approach to public sector transformation instead of viewing government as a series of discrete entities. All of this is being done with a key purpose in mind: to build a more inclusive society that ensures the well-being of all people.

Proof of this innovation can be seen in the crowdsourced Call for Innovations that OPSI and the MBRCGI conducted to identify examples of innovative practices in governments worldwide (see Figure 5).[13]

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13. See http://oe.cd/2017callforinnovations.

Figure 4: Trends identified through this review

Key trends in public innovation identified through this review

Figure 5: Call for innovations results
Run from July 25, 2017 through September 22, 2017

276
submissions from **58** countries

10
featured as case studies in this review

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11. See http://oe.cd/eig.

12. See https://uk.fm.dk/about-us/minister-for-public-innovation.

Through its recent research and the Call for Innovations, OPSI has identified three key trends in public sector innovation that build upon trends identified last year and catalyse innovation in a cross-cutting, interconnected manner (see Figure 4). These three trends form the structure of this review. Each respective section includes a discussion of innovative initiatives by governments and their partners, real-world examples of the trend in action, and recommendations to help countries unlock innovation. The trends focus on:

Identity

An identity is a fundamental requirement for individuals and businesses to access government services and participate in society and the economy, and for governments to help unlock the potential of new innovative services. Governments and their partners are innovating to conceive of new ways to provide identities to individuals and businesses through emerging technologies. They are also helping citizens demonstrate the unique combination of knowledge, skills and experiences that make up their own personal identities. In an interconnected and increasingly borderless world, they are also questioning traditional conceptions of national identity and pushing the boundaries of what it means to be a citizen and resident.

Systems approaches and enablers

Governments are using innovation to lead a paradigm shift in the way they provide government services. The most innovative approaches refrain from layering one reform on top of another, instead repacking them in ways that allow them to get to the real purpose of the underlying change. Systems approaches step back and view the entire operation of government as an interconnected system rather than disparate pieces. They transform and re-align the underlying processes and methods to change the way government works in a cross-cutting way, while involving all of the affected actors both inside and outside government. In so doing, they leverage a number of tools and enabling conditions to succeed.

Inclusiveness and vulnerable populations

In the face of major cross-cutting challenges such as migration, ageing population crises, uncertainties about the future of work and job automation, and continued gender and economic inequalities, governments are turning to innovation to build more inclusive societies. Governments are rallying behind the Sustainable Development Goals (SGDs), finding new paths towards gender equality, and easing the transition and economic circumstances for migrants. A few are also looking for innovative ways to prepare society for the challenges of job automation and the future of work. There remains a long way to go and there may be some gaps in the road ahead, but inclusiveness is growing and a safety net is being strung. The world is at a juncture that challenges governments to acknowledge new realities and create new solutions for everyone through innovation.

Trend 1:
Identity

Every citizen, resident and business needs to have an identity to access government services and participate in society and the economy. While this seems simple, the process is often complicated and in many contexts can be controversial. Governments are conceiving of new ways of providing identities to individuals though biometrics and emerging technologies such as blockchain. They are also helping businesses make better decisions about their brand identities in an increasingly competitive marketplace, and helping citizens demonstrate the unique combination of knowledge, skills and experiences that make up their own personal identities. In the modern interconnected world, governments and individuals are also raising questions about national identity and re-imagining what it means to be a citizen in an increasingly borderless world. Government innovators are exploring these many aspects of identity and pursuing initiatives that serve as essential building blocks of innovation.

DIGITAL IDENTITIES HAVE BECOME THE FOUNDATION OF DIGITAL ECONOMIES

As all sectors of the economy digitise, it becomes increasingly critical for users of digital services to have a digital identity in order to access accounts and services. Such identities have existed in the private sector since the early days of the Internet, with users easily logging into services to access email, social media networks and bank accounts. In many ways, the provision of digital identities transformed the purpose and function of the Internet. The evolution of the Web from a publishing medium to an interactive platform for the delivery of personal services made possible electronic commerce, electronic government, and many other rich and diverse online interactions, from electronic learning to social networks and the broader participative Web. The possibility for individuals to establish a personalised interaction with, and be recognised by, a remote computer has ushered in two decades of innovation, making Internet services pervasive, ubiquitous and increasingly essential in everyday life. It has transformed economies and societies, and served as a core building block for the modern economy (OECD, 2011).

Figure 6: **Log-in page for *The New York Times* using Facebook and Google digital identities**

Source: https://newyorktimes.com

Figure 7: **Individuals using the Internet for sending filled forms via public authorities' websites in the past 12 months, 2006 and 2016**

Source: OECD (2017b: 205).

In recent years, federated digital identities have provided a means to link an individual's digital identity across multiple platforms and systems (e.g. Google, Facebook, Twitter and GitHub) through a single sign-on (see Figure 6). The public sector has experienced some success in providing digital users access to specific services, or even all services provided by a single department; however, it has faced challenges in building a more federated model to provide citizens and other users with a single identity that can be used across digital and even non-digital services. The current siloed approach that exists in most governments, which requires individuals to create and manage a digital identity for each online service or offering and involves multiple databases containing sensitive information, is not sustainable. It increases the risk of data breaches and identity theft and reduces willingness to engage online. As shown in Figure 7, citizens' usage of governments' digital services has increased significantly in recent years, but remains fairly low in most countries. A significant factor in this regard is users' privacy and security concerns (Figure 8). Secure, private digital identity management is fundamental for the further development of digital economies.

Figure 8: **Individuals not submitting official forms online due to privacy and security concerns, 2016**

Source: OECD (2017a: 203).

Trend 1: Identity

Electronic authentication provides a level of assurance that someone or something is who or what it claims to be in a digital environment. It plays a key role in establishing trust for digital commerce, digital government and many other social interactions. It also constitutes an essential component of any strategy to protect information systems and networks, financial data, personal information and other assets from unauthorised access or identity theft. Electronic authentication is therefore essential for establishing accountability online. The Recommendation states, among other things, that countries should:

- establish technology-neutral approaches for domestic and cross-border digital authentication of persons and entities;

- foster the use of digital authentication products, services and safeguards;

- encourage interoperable authentication methods for cross-sector and cross-border interactions; and

- ensure privacy and security of user data.

*A "Recommendation" is a legal instrument which, although not legally binding, is considered by member countries to carry great moral force. OECD Recommendations are adopted when member countries are prepared to make the political commitment necessary to implement the principles set out in the text. This type of instrument is often referred to as "soft law".

Source: OECD (2007).

Accordingly, the OECD issued a formal Recommendation on Electronic Authentication (see Box 1), which countries are acting to implement, for example, through the United Kingdom's Identity Assurance Principles.[14]

COUNTRIES ARE ROLLING OUT NEW IDENTITY PROGRAMMES

By 2021, an estimated 3.6 billion citizens will hold a national digital ID card (Acuity Market Intelligence, 2017). A growing number of countries already have fully functioning and successful national digital identity programmes in place. Estonia, for example, is the perennial success story of an advanced digital government underpinned by secure and reliable digital identities for all citizens. The country's "X-Road" data-exchange network

and connected biometric national ID card allows its citizens and residents to conduct virtually all government and even private sector transactions online using their ID card and a PIN. Such transactions include voting, banking, filing taxes, and accessing health records and prescriptions (Eggers, 2016). However, Estonia's situation is unique in that its population of 1.3 million is proportionate to a few large tech companies.[15] This allows Estonia to serve as a testbed of innovation and experimentation, from which the world can learn. Estonia's identification scheme now serves as a platform for numerous other ground-breaking and innovative initiatives, as discussed later.

No other country has reached the level of digital identity sophistication set by Estonia, though many are innovating to unlock the promise of digital governments to meet the growing expectations of their people. These innovative countries have made great strides in the last few years in developing national digital identity programmes. Many of the most recent innovations have come from countries facing challenges related to larger populations and cultural resistance to any type of national identity card. This has necessitated innovation in its own right to develop a solution that is acceptable to the population.

- In March 2016, the Agency for Digital Italy (AgID) launched "Sistema Pubblico per la gestione dell'Identità Digitale" (SPID), a digital identity solution that enables users to access government digital services (e.g. view health records and pay school fees) through a single sign-on. Their digital identities are issued by private sector identity providers. SPID is compliant with the European Union's eIDAS regulation (see Box 2), which will make it interoperable with other national identity programmes that meet the same standard as they come online.[16]

- In April 2017, the United States Digital Service (USDS) and 18F launched Login.gov, a single sign-on solution for government websites that enables citizens to access public services across agencies using the same username and password (and two-factor authentication via mobile phones or an authenticator application). At present, Login.gov allows users access to just a handful

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14. See https://identityassurance.blog.gov.uk/2015/09/11/gov-uk-verify-identity-assurance-principles.

15. For example, the global employee counts of Amazon (541 900 as of 2017), IBM (380 000 as of 2016) and Samsung (308 745 as of 2016) total 1.23 million employees (Cakebread, 2017; IBM, 2016; Samsung, 2016).

16. AgID submission to the OECD Call for Innovations crowdsourcing exercise, 29 August 2017.

of services, but this is expected to change in the near future as the roll out continues, replacing hundreds of individual logins. All data are end-to-end encrypted and are not shared with partner agencies unless the user gives explicit permission (Minton and Mills, 2017). The code and support documentation for the platform are available online as open source, allowing other countries to learn from and potentially even adapt the technology for their own purposes.[17]

- In May 2016, The United Kingdom Government Digital Service (GDS) launched GOV.UK Verify, an online solution that allows people to create a digital identity in order to access digital services (e.g. pay their taxes or access social benefits). In order to create a trustworthy digital identity, a user provides evidence such as a passport and bank and mobile phone account data to a certified company, which then verifies their identity against different trustworthy public and private sector sources. The process takes 5-15 minutes. To ensure security, the data are not stored centrally and there is no unnecessary sharing of information. According to the United Kingdom, "A citizen will be able to use their digital identity across their full digital life without their actions being tracked or profiled."[18] An independent group of privacy advocates has been set up to provide advice to the government on the development of the service. The initiative is the first of its kind in the world, according to the United Kingdom (GOV.UK, 2017). In 2018, the service will be rolled out to the private sector.

- In October 2017, the Australian Government launched a beta version of Govpass, a digital single sign-on programme that seeks to replace over 30 different logins for all digital services. To verify themselves, a user provides details from a number of personal documents (e.g. a birth certificate or driver's license), which are then verified by the government document issuer. Users also upload a photo which is submitted for comparison with existing photo IDs. All submitted data and photos are deleted after verification is complete. The service will be rolled out more broadly in 2018 (Hitchcock, 2017). The Australian government has recognised digital identity as the most important of all the key digital priorities (Easton, 2017).

Box 2: EIDAS (ELECTRONIC IDENTIFICATION, AUTHENTICATION AND TRUST SERVICES)

eIDAS is an EU regulation passed in July 2014 that sets standards for digital identification and trust services for electronic transactions in the European Single Market, including electronic signatures and proof of authentication. It is designed to facilitate interoperable and seamless digital interactions across the European Union. In September 2018, usage of a compatible digital identity system will become mandatory.

Source: www.cryptomathic.com/newsevents/blog/understanding-eidas.

Box 3: THE TALLINN DECLARATION

On 6 October 2017, all the EU member states and European Free Trade Area (EFTA) countries unanimously approved the Tallinn Declaration to mark an EU-wide commitment to ensure high-quality, user-centric and seamless cross-border digital services for citizens and businesses. Among the series of commitments and principles, the members committed to speeding up and promoting the widespread use of digital identities, consistent with eIDAS.

Source: https://ec.europa.eu/digital-single-market/en/news/ministerial-declaration-egovernment-tallinn-declaration.

More countries are planning to follow suit. For example, Singapore views the upcoming launch of a new national identity as a strategic priority and a "prerequisite" to the digital economy (Rohaidi, 2017). In another highly novel example, China will begin allowing WeChat[19] users to use the app as their national ID. In the initial pilot in the city of Guangzhou, limited functionality using the WeChat ID will be accessible through facial recognition alone, with full functionality granted after a user visits an offline station to physically validate their paper ID cards (Wildau, 2017). It is increasingly clear that countries are accelerating efforts to provide digital identities to their citizens, often in innovative ways, through multiple different arrangement mechanisms that fit the unique needs of their countries. In 2017, all EU countries signed the Tallinn Declaration on eGovernment, which formalises these commitments (see Box 3). For these countries, the Digital Single Market

is one of the main priorities of the European Commission, contributing considerably to economic resilience and growth. To ensure its success, electronic identification and guarantees regarding privacy are essential. Citizens and businesses must be given assurances that treatment of their data respects existing data protection legislation.

This enhanced focus on innovative identity programmes will likely have significant positive spill-over effects for the private sector, especially as the Tallinn Declaration commits countries to enabling private sector use of government digital identities, in order to build services useful to citizens. While many private services provide various levels of assurance for their digital identities, governments are generally the primary issuers of the most trustworthy credentials for individuals' identity attributes (OECD, 2011). This high level of confidence in users' identities may open doors to services and transactions not presently conceived.

THE LATEST DEVELOPMENTS ARE IN BIOMETRICS AND BLOCKCHAIN, BUT CAN RAISE PRIVACY CONCERNS
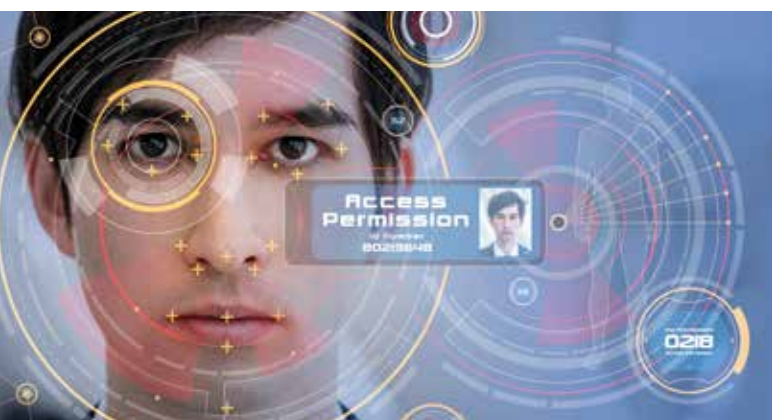
BIOMETRICS
Biometrics involves the use of automated tools to identify an individual through physical characteristics, such as fingerprints, iris scans or face recognition.[20] Many people use biometrics multiple times a day, for example, by unlocking their Apple iPhone with their fingerprint or through facial recognition (Glaser, 2016). In the public sector, biometric government identities are not a recent innovation, with Malaysia issuing the first biometric passport 10 years ago.[21] However, biometric IDs are now being applied in new ways and used at an unprecedented scale, with a corresponding escalation in controversy and resistance among some opponents. Over 120 countries

are now deploying biometric passports and over 50 are implementing biometric eID cards.[22] Biometric eIDs contain a photo of the cardholder and some form of bio-identification, most usually fingerprints, and can be used for the purposes of highly accurate identification.

The benefits of biometric identities are undeniable. Identity confirmation can be determined with a high level of accuracy, thereby minimising identity theft and replacing the need for "face-to-face" validation. When compared to current practices which usually involving passwords and PINs, biometrics cannot be easily defrauded by others (Glaser, 2016). In government, they can dramatically reduce beneficiary fraud, make digital interactions seamless, enable electronic signatures, and allow for simpler interactions for both government and businesses, thereby making it easier to create innovative programmes and services (Singh, 2017). They are rapidly becoming a standard for accessing services because of their efficiency, effectiveness and security of access.[23]

However, biometric IDs have also sparked fierce controversy. Opponents of biometric identities argue that they could be used to monitor and track individuals, leading to lack of privacy, and take away citizens' ability to control data about themselves.[24] With biometric IDs, a detailed profile of an individual can be used to infer current situations and predict future behaviours in a manner not possible with traditional methods of identity. While this may offer user convenience and benefits to organisations in terms of innovative new services, changes in the nature of digital identity will introduce policy concerns if not implemented in a sufficiently secure and privacy-respecting manner that allows the citizen to own their personal data and control how it is used. Some opponents fear that biometric identities and the data collected, if not carefully protected and controlled by the citizen, may result in individuals becoming trapped in the profiles created for them. Under such a scenario, an individual born into an impoverished family or who makes mistakes early in life may never be able to escape the ramifications of these circumstances. They could become mired in a cycle of disadvantage and find themselves consistently treated negatively by businesses and government agencies as a result of their

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20. See www.rand.org/natsec_area/products/biometrics.html.

21. See http://passport.com.my/biometric_passports.htm.

22. See www.gemalto.com/govt/identity/2016-national-id-card-trends.

23. See www.rand.org/natsec_area/products/biometrics.html.

24. See www.rand.org/natsec_area/products/biometrics.html.

profile. Interestingly, recent research indicates that robust democracies are less likely to adopt strong biometric identity programmes and are more likely to have privacy and data protections laws (Venkataramakrishnan, 2017).

In addition to privacy concerns, there are legitimate concerns about information security. Recent years have seen major hacks and data breaches of personally identifiable information (PII) in both the private and public sectors. Notable examples include a data breach at credit reporting company Equifax that disclosed sensitive data on 143 million US consumers,[25] and a data breach at the US Office of Personnel Management (OPM) that resulted in the disclosure of critically sensitive information for over 21.5 million records, including detailed security-clearance background information and fingerprints of 5.6 million public employees.[26] The real-world consequences of a massive leak of biometric information, such as the fingerprints compromised in the OPM hack, are not fully known. Discussion of biometric information in this review is not intended to endorse or promote its use, but instead to demonstrate its innovative potential as well as the challenging questions and trade-offs governments must address in today's digital world.

A strong example of the innovative application of biometric identity, as well as the potential for associated controversy and backlash, is the Government of India's Aadhaar (meaning "foundation") programme, launched in 2009. Aadhaar has grown to become the largest biometric initiative on Earth and centres on databases of names, addresses, phone numbers, fingerprints, photos and iris scans of 1.2 billion Indians, representing a staggering 15% of the global population. Its introduction is provoking debates about privacy and surveillance that are novel in their own right. With a population of over 1.3 billion,[27] India is poised to overtake China as the most populous country in the world in the next seven years (Rukmini, 2017). The government must handle identity-related issues on a massive scale and is seeking to remedy numerous problems by assigning a uniform identity to every individual in the country. A full case study on Aadhaar is presented later in this section.

25. See www.oecd.org/going-digital/oecd-digital-economy-outlook-paris-2017.htm.

26. See www.opm.gov/news/releases/2015/09/cyber-statement-923.

27. Custom data taken from the World Population Prospects 2017 website (https://esa.un.org/unpd/wpp/DataQuery) and https://en.wikipedia.org/wiki/United_Nations_Department_of_Economic_and_Social_Affairs.
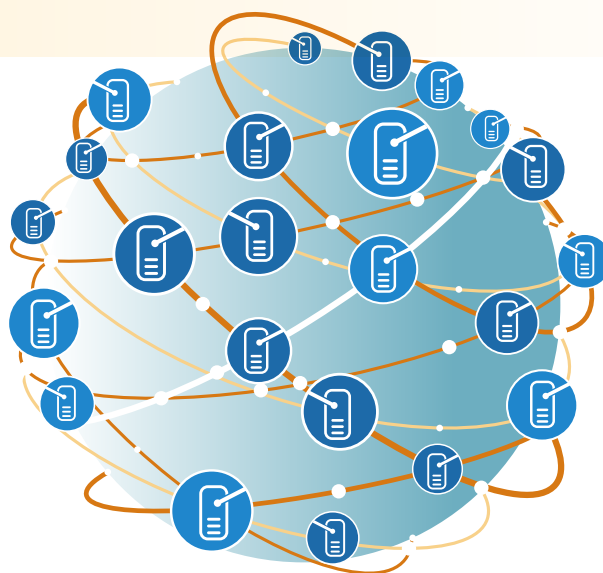
BLOCKCHAIN

The most novel types of emerging identity programmes involve the use of blockchain (see Box 4).

Box 4: **WHAT IS BLOCKCHAIN?**

Blockchain has been a frequent topic of discussion in recent years, yet its technical complexity can make it difficult to describe or understand. According to the World Economic Forum, "currently, most people use a trusted middleman such as a bank to make a transaction. But blockchain allows consumers and suppliers to connect directly, removing the need for a third party".

By using cryptography to keep exchanges secure, blockchain provides a decentralised database, or "digital ledger", of transactions visible to everyone on the network. This network is essentially a chain of computers that must all approve an exchange before it can be verified and recorded. The network of computers is the "chain" and the verified transaction is referred to as the "block". Once verified, the block transaction is added permanently and cannot be altered.

Blockchain is most commonly associated with Bitcoin, a digital "cryptocurrency" that has attained record-breaking values in recent months, reaching a peak value of nearly USD 20 000 per bitcoin and a total value over USD 326 billion in December 2017, (Rosenfeld and Cheng, 2017) and fluctuating dramatically thereafter. However, blockchain has potential uses far beyond digital currency, including government-issued credentials and identities.

Source: www.weforum.org/agenda/2016/06/blockchain-explained-simply/, https://gsa.github.io/emerging-technology-atlas, https://blockchain.info/charts/market-cap.

Relevant to this review's section on inclusiveness and vulnerable populations (see page 75) is the innovative blockchain identity project ID2020.[28] ID2020 is a public-private partnership between United Nations agencies, private sector companies such as Microsoft and Accenture, and foundations such as the Rockefeller Foundation. ID2020 has the potential to make a profound impact on the public sector as well as the 1.1 billion people in the world who live without an officially recognised identity, including many refugees. The lack of an officially recognised identity severely limits people's access to education, healthcare, voting, banking and housing options, among many other things.[29] It also renders them more vulnerable to risks of exploitation, such as human trafficking.[30] ID2020 aims to tackle these challenges by providing these individuals with an identity through a platform based on blockchain and built on open standards and an interoperable application programme interface (API).[31] They are currently experimenting with a functional prototype.[32] Biometrics will also be incorporated through the use of fingerprints and iris scans.[33] It is of paramount importance to ID2020 that the identities for individuals are user-owned, and that the platform enables users to have direct control over who has access to their data and when it is shared.[34]

"This could be the greatest poverty killer app we've ever seen."
Jim Yong Kim, *President of the World Bank*

The ID2020 initiative is founded on the belief that the present convergence of trends provides an unprecedented opportunity to achieve the goal of universal digital identity (see Figure 9) through co-ordinated, concerted efforts. ID2020's philosophy is grounded in the UN's Universal Declaration of Human Rights (UDHR), which states that "everyone has the right to recognition everywhere as a person before the law"[35] and Sustainable Development

Goal (SDG) 16.9 (see Box 5).[36] The initiative is being executed through the ID2020 Alliance, a network of non-governmental organisations (NGOs) and companies working together to co-ordinate funding, and also build standards and innovative technology solution responsive to the needs of countries and individuals, and incorporate innovative technologies. The initiative plans to introduce a safe and verifiable identity system by 2030. In the short term, the goals are to experiment and test different technology solutions and partner with governments and organisations for early implementation.

Box 5: **SUSTAINABLE DEVELOPMENT GOAL 16.9**

"By 2030, provide legal identity for all, including birth registration."
Source: https://sustainabledevelopment.un.org/sdg16

Figure 9: **Enabling trends for ID2020**

Growing political willpower: SDG target to "provide legal identity for all" by 2030

Rising global connectivity: Rapid proliferation of smart devices, broadband and computing power

Emerging technologies: Blockchain working alongside long-proven biometrics

Global calls for a new identity model: User experience demands, regulations for security, and privacy and user-owned data

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28. See http://id2020.org.

29. See https://newsroom.accenture.com/news/accenture-microsoft-create-blockchain-solution-to-support-id2020.htm.

30. See https://static1.squarespace.com/static/578015396a4963f7d4413498/t/596e5d636a49635fe12cf40b/1500405109983/ID2020+Alliance+Governance.

31. A fuller explanation of APIs can be found on page 63.

32. See https://static1.squarespace.com/static/578015396a4963f7d4413498/t/596e5d636a49635fe12cf40b/1500405109983/ID2020+Alliance+Governance.

33. See https://newsroom.accenture.com/news/accenture-microsoft-create-blockchain-solution-to-support-id2020.htm.

34. See https://static1.squarespace.com/static/578015396a4963f7d4413498/t/596e64b037c581db7dcc748a/1500406962140/ID2020_2017SummitHighlights.pdf.

35. See www.un.org/en/universal-declaration-human-rights.

36. See the *Inclusiveness and Vulnerable Populations* section of this review on page 75 for more information on SDGs.

Also in the development arena, the company "AID:Tech"[37] has been launched to leverage blockchain to provide digital delivery of benefits via a digital identity. AID:Tech has already been piloted to deliver international aid to Syrian refugees in Lebanon. Working alongside the International Federation of Red Cross and Red Crescent Societies (IFRC), the company delivered identity in the form of 500 smart cards to 100 Syrian families (see Figure 10). Each smart card contains records of aid entitlement, which beneficiaries are able to redeem at local merchants (see Figure 11). In the pilot, all provisions were successfully redeemed, and all attempts at fraud were caught and stopped at the point of sale. AID:Tech's core goal is to achieve social and financial impacts for the world's under-served by combining identity and emerging technology. There are currently around 2 billion people in the world without access to a bank account. Their lack of access to formal social and financial services are direct inhibitors to development. In addition, 1.1 trillion is lost every year from developing countries due to theft and fraud. AID:Tech believes their solutions, in partnership with governments and other organisations, can help solve these problems.[38]

Figure 10: AID:Tech identity card and app

Figure 11: Use of AID:Tech digital identity to deliver benefits

Source: AID:Tech submission to OECD Call for Innovations. Submitted on 31 August 2017.

These blockchain identity programmes are still in their infancy. However, blockchain is considered by some to be as revolutionary as the Internet itself. OPSI will be tracking future development in this space, and expects significant innovation in this area in the near future.

37. See https://aid.technology.

38. AID:Tech submission to the OECD Call for Innovations crowdsourcing exercise, 31 August 2017.

Trend 1: Identity

OPEN STANDARDS CAN HELP INDIVIDUALS EXPRESS THEIR UNIQUE IDENTITIES

Identity is not just a matter of providing an individual with a formal credential. It can also be a question of allowing individuals to express the unique aspects of their selves and the experiences that make them who they are, and to recognise these aspects in others. For example, "Be Badges" is an innovative application of Mozilla's Open Badges platform by the government of Belgium, which allows users to provide others with virtual badges that communicate skills and achievements of interest in the job market. This concept has recently been expanded to ESCO Badges, which syncs up with the European Unions' new ESCO classification of skills and competences. A full case study on innovative uses of open badges for public good can be found on page 33.

TECHNOLOGY IS ENABLING BETTER DECISIONS IN BUSINESS IDENTITY

Government's role in the identity space extends beyond the provision of identity credentials for individuals. Governments are also involved in facilitating the development of private sector identities through recognising and registering brands and trademarks to help their businesses succeed in a global marketplace. There are approximately 31.5 million trademarks in force globally and about 8.5 million trademark applications per year. Thus, millions of existing brand identities must be considered before a business can finalise a trademark representing who they are. This is no simple task for governments, but one of the Call for Innovations case studies examined for this review has created an innovative new technology to give businesses a new edge. In February 2017, IP Australia, the Australian Government agency that administers intellectual property (IP) rights, launched the Australian Trade Mark Search to

help companies make informed decisions around their branding and business identity strategies. Australian Trade Mark Search combines world-leading image recognition and artificial intelligence (AI) to power a search engine of company identities, including branding, logos and other trademarks to help companies distinguish their brand identity from others. Its goal is to provide a platform that allow members of the public to search for brand identities using only an image, such as a drawing or digital sketch. A full case study on this initiative can be found on page 37.

INNOVATION IS SPURRING NEW DISCUSSIONS ABOUT NATIONAL AND INDIVIDUAL IDENTITY

As technology continues to enhance global interconnectivity, national borders become less relevant. A 2016 survey from the BBC World Service shows that, for the first time, nearly half (49%) of the 20 000 people surveyed across 14 countries see themselves more as global citizens than citizens of their own country. A 2016 World Economic Forum survey of 26 000 participants from 181 countries also found that 36% of young people (ages 18-35) defined themselves as global citizens (Dai, 2016).

People worldwide are now more mobile than ever before. Individuals may live in one country and work in another, shop across borders or move permanently to a new home abroad (see Figure 12).

Individuals are not the only ones to question the role for country borders. Estonia, the aforementioned testbed of government innovation, is on the way to transforming itself into a "country without borders" (MoEAC, 2016), and has launched several innovative initiatives that re-imagine traditional thinking around identity and national boundaries.

The Government of Estonia has implemented "e-Residency", a transnational digital identity available to anyone interested in running an online global EU-based company from anywhere in the world, regardless of their nationality or place of residence. This flagship initiative aims to create a new borderless digital society for global citizens, allowing individuals to become virtual e-residents via a secure digital ID card that will enable them to establish a company within a day, apply for a digital bank account and credit card, conduct e-banking, digitally sign documents and contracts, and declare taxes. The Estonian government launched the e-Residency programme to

Figure 12: **Individuals participating in globalisation**

429m international travellers

361m cross-border e-commerce shoppers

240m people living outside home country

44m cross-border online workers

13m cross-border online students

5m students studying abroad

914m social networking users with at least one foreign connection
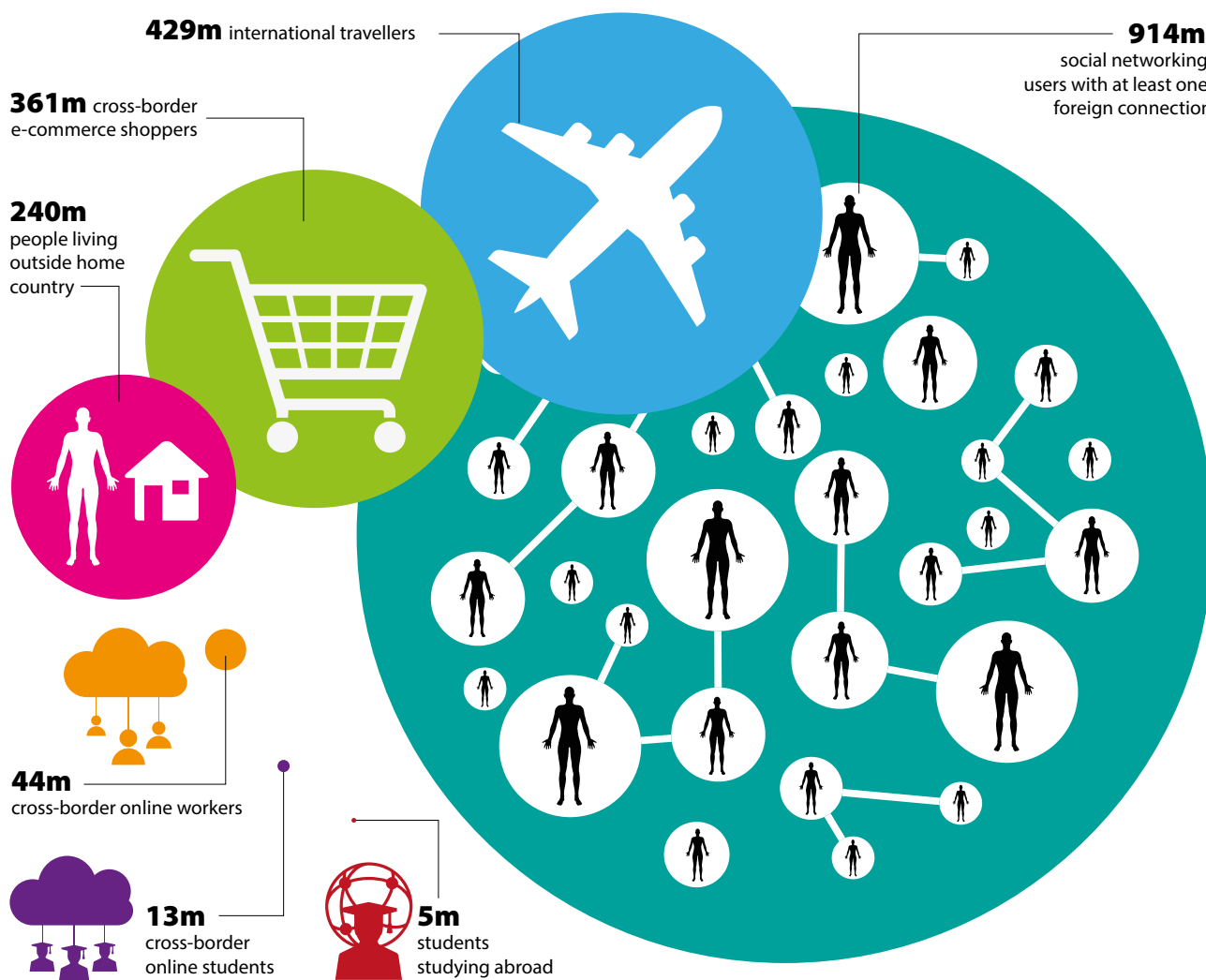
make Estonia bigger by building a digital population and help unleash the world's entrepreneurial potential.[39] The e-Residency programme just celebrated its third anniversary, and has amassed nearly 30 000 e-residents from 151 countries around the world who have set up nearly 3 000 businesses (Korjus, 2017).[40] Estonia's goal is to attract 10 million e-residents to add to the country's population of 1.3 million physical residents by 2025. The initiative has been very successful financially – every EUR 1 invested in the programme is projected to return EUR 100 to the Estonian economy through taxes and wages, according to a study by Deloitte.[41] Other countries

are taking notice and starting to replicate the model. Azerbaijan has launched a similar programme, and a number of other countries are exploring the possibility (Korjus, 2017).

In addition to e-Residency, Estonia is developing the world's first Data Embassy to help address a challenge that has arisen from the country's efforts to be digital-only and paperless: how to ensure the digital continuity of the country by securing its data against risks of cyber-attack or major disaster. The Data Embassy consists of servers held in other countries but under the full legal jurisdiction of Estonia. These store constantly updated data that would allow the state and its services to continue in the event of a catastrophe (in-depth coverage of Estonia's Data Embassy can be found in the case study on page 42.

39. Government of Estonia submission to the OECD Call for Innovations crowdsourcing exercise, 30 August 2017.

40. A real-time dashboard of e-resident applications can be found at https://app.cyfe.com/dashboards/195223/5587fe4e52036102283711615553.

41. See http://news.err.ee/646254/deloitte-e-residency-brought-14-4-million-to-estonia-in-first-three-years.

Trend 1: Identity

Recommendations

Providing digital identities that enable citizens to authenticate themselves in order to conduct trusted transactions is a foundational step in creating modern and innovative government services and moving towards a digital economy and society. Helping people to make these virtual identities more reflective of their personalities and achievements, to the extent they see fit, can also open doors to new possibilities. Businesses too can benefit by crafting their own unique identities, and governments can help by providing new tools to help them succeed in the new economies. Governments are also benefiting from today's interconnected world by re-thinking traditional concepts of borders and identity. To maximise the potential for identity-related programmes, OPSI recommends that governments:

1. Develop identity solutions that fit with the culture of the country. Countries are looking at identity programmes through a variety of lenses. What works for one country may not work for another. Governments must appreciate the cultural realities of their countries to determine the best approach for the creation and use of identity programmes. For example, the United Kingdom created a biometric national identity programme in 2008 and issued identity cards to thousands of people, but the programme was scrapped in 2010 as constituting a "substantial erosion of civil liberties" (Kirk, 2010). Through its GOV.UK Verify programme, discussed earlier, the country is now building identity solutions more suitable for a country that conceptualises and values privacy in this way. All countries can and should build digital identity programmes that unlock digital services from government and the private sector. However, there is no single best approach to creating a digital identity programmes. Each country will need to identify an approach that best reflects their national values.

2. Make trade-offs clearly understandable by the population. Even when following the principles in the previous recommendation, governments will always need to make trade-offs when developing an identity solution. Transparent public consultations are essential to determine and communicate these trade-offs to their citizens and residents.

3. Think beyond traditional concepts of identity. There are many aspects of personal, business and even national identity. Governments should consider ways to help ensure their citizens and residents are able to express and leverage all facets of their identity, and recognise the same in others. For example, in Belgium the launch of Be Badges is adding new vectors to the labour market. As the world becomes more connected, national borders may continue to lose some aspects of their relevance. Countries should not fear this development, but instead consider the potential impact and explore and even embrace the opportunities that may result.

4. Use open standards and application programming interfaces (APIs) to unlock potential. Identity can be seen as a unique set of characteristics that makes up an individual, business, or nation. However, identity can also be seen as a platform for connecting people and building trust-based exchanges and relationships in a modern economy. The use of open standards and interfaces, such as the Open Badges standard in Be Badges, and open APIs, such as in Aadhaar, enables the creation of new services, with identity as the foundation, that have the potential to catalyse innovation at a scale not yet imaginable.

CASE STUDY

Aadhaar – India

Aadhaar – meaning "foundation" in several Indian languages – is the largest biometric identity programme in the world. Since its launch in 2009, Aadhaar has enrolled nearly 1.2 billion Indian citizens and residents (about 15% of the global population), including over 99% of all Indian adults. Each Aadhaar recipient receives a unique 12-digit ID number, and submits their photo and their biometric data in the form of fingerprints and iris scans. Originally designed to help mitigate fraud, waste and abuse in social benefit programmes by ensuring benefits went to the right person, the initiative has grown to encompass many parts of everyday life in India, such as bank transactions and activating a mobile phone. Use of Aadhaar is mandatory for a growing number of these programmes. As the programme has grown, so has the controversy surrounding it, including a landmark November 2017 Indian Supreme Court ruling that for the first time recognised privacy as a fundamental human right, which may have implications for the future of Aadhaar. As far as digital identities are concerned, all eyes are on India.

Trend 1: Identity

THE PROBLEM

India had major problems in identifying beneficiaries for social programmes. A significant proportion of residents lacked formal identity credentials, and many of those who had credentials possessed ones that were only recognised locally. Inadequate identity records and verification processes meant that government agencies frequently distributed social welfare benefits to the same people multiple times, or to people who did not qualify. Prior to Aadhaar, it was estimated that 58% of subsidised food grains and 38% of subsidised kerosene disbursed under government programmes did not reach their intended beneficiaries (Government of India, 2005). This resulted in tremendous waste of resources. Such issues also affected other social programmes including scholarships, healthcare, pensions and subsidised household goods. Significantly, some eligible households were denied social assistance for which they qualified because they could not easily prove their identity.

AN INNOVATIVE SOLUTION

To overcome these problems, the Indian government launched Aadhaar – an ambitious programme intended to provide every man, woman and child living in India with a unique digital identity based on their biometric information (thumbprints and iris scans). Unique identification through this biometric information makes it simpler for authorities to verify that subsidised goods are delivered to the right recipients and limits the scope of fraudulent activities.

The initial target of Aadhaar was the country's Public Distribution System (PDS), a government-subsidised programme designed to enhance food security and serve as a safety net for the 330 million Indians who are nutritionally at risk. The food is distributed at over 500 000 "fair price shops", making it the largest distribution network of its type in the world. The primary challenge for the government has been widespread pilferage and diversion of food grains meant for low-income beneficiaries. Prior to the introduction of Aadhaar, pilferage could occur in a number of ways:

- Sales records were manually recorded, making it impossible to know whether a sale actually took place, whether food was fraudulently diverted by FPS staff, or whether the staff overcharged for provisions.

- Individuals would secure bogus rations cards by creating fictitious families.

- Individuals would use genuine rations cards stolen or purchased from someone else.

By enabling end-to-end digitisation of distribution and sales processes, Aadhaar helps eliminate these issues. Diversion during transport and delivery to fair price shops is mitigated through Aadhaar-enabled automatic weighing of the rations, which is tied directly to the current handler's Aadhaar identity.[42] If the weight is not accurate, the transfer of goods cannot take place and the identity of the handler is known. To mitigate abuse at the beneficiary end, each fair price shop is equipped with digital point-of-sale devices used by shop employees to authenticate beneficiaries using their fingerprints or iris scans (see Figure 13). The device links to the Aadhaar database via a mobile, Wi-Fi or cabled internet connection, and then verifies the beneficiary's identity and eligibility. When payment is required, the benefits are paid for using cashless payments through Aadhaar, so no money physically changes hands, which prevents overcharging of customers. The rations are also weighed to ensure the appropriate amount is given to the beneficiary (see Figure 14). A shop is unable to dispense benefits to individuals who are not eligible or who have already received their ration, or if the weight is incorrect. In some states, disabled beneficiaries are authenticated and the rations provided directly to the home, while in other states, a relative or neighbour can be designated to collect the rations. Finally, Aadhaar has made the process more efficient by allowing the government to determine the inventories of each FPS in real-time, so they can replenish just the right amount of inventory when required. This mitigates the possibility of shops operating black markets using excess stock, as was frequently the case in the past.

In addition to reducing fraud in PDS, Aadhaar's streamlined and automated system means that beneficiaries:

- Receive SMS messages to alert them to the existence of new supplies, rather than having to physically check the shop repeatedly.

- Can view a map of all stores and their current inventory level via a mobile app.

- Authenticate their identity instantly to collect their benefits, reducing in-store wait times from half a day to a matter of minutes.

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42. When supplies change hands from one person to another (e.g. when a deliverer drops off supplies at a fair price shop), both the deliverer and recipient must authenticate simultaneously to validate the transaction, which also involves an automated weighting. This ensures clear lines of accountability without the potential for either party to divert supplies.

Figure 13: **Obtaining rice using fingerprints**

Figure 14: **Weighing rice at a fair price shop**

● Select the shop where they prefer to receive their benefits. A central database manages the benefits and permits authentication of a beneficiary at any location, thereby promoting choice and mobility.

In addition to social services such as PDS, Aadhaar also now encompasses over 3 500 government and non-government services in India, ranging from opening bank accounts to making digital payments, enrolling in school, activating a mobile phone, receiving pension payments, filing taxes, voting and making e-signatures.[43],[44] The government has also launched DigiLocker,[45] a platform for issuing, sharing and verifying documents and certificates, in an effort to move towards a paperless society.

Government officials believe that the full potential of Aadhaar is not yet apparent,[46] and that the next wave of innovation will come from the private sector with businesses using Aadhaar as a platform. The system includes an open application programming interface (API), which allows the programme to serve as a platform for private sector companies to build services using Aadhaar identity management as a foundation, which has the potential to enable a whole ecosystem of apps. For example, Google's Tez app allows people to send instant digital payments to friends, relatives and businesses. Tez gained 7.5 million users in its first five weeks, drastically increasing the number of Aadhaar transactions (see Figure 15) (Pahwa, 2017). Given the open nature of its interface, the architect of Aadhaar believes that in the future people will use Aadhaar in ways that are unimaginable today (Mirchandani, 2017).

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43. See https://economictimes.indiatimes.com/tdmc/your-money/7-benefits-of-aadhaar-card/tomorrowmakersshow/58412087.cms.

44. See http://etaal.gov.in/etaal/auth/Login.aspx.

45. See https://digilocker.gov.in.

46. Interviews with J. Sathyanarayana, Indian Administrative Service (IAS), Chairman of the Unique Identification Authority of India (UIDAI) and Advisor to the Chief Minister of Andhra Pradesh, and Ajay Sawhney, IAS, Secretary to the Government of India for the Ministry of Electronics and Information Technology, 12 December 2017.

Figure 15: **Count of Aadhaar transactions**

July 1st–September 30th 2017 in millions
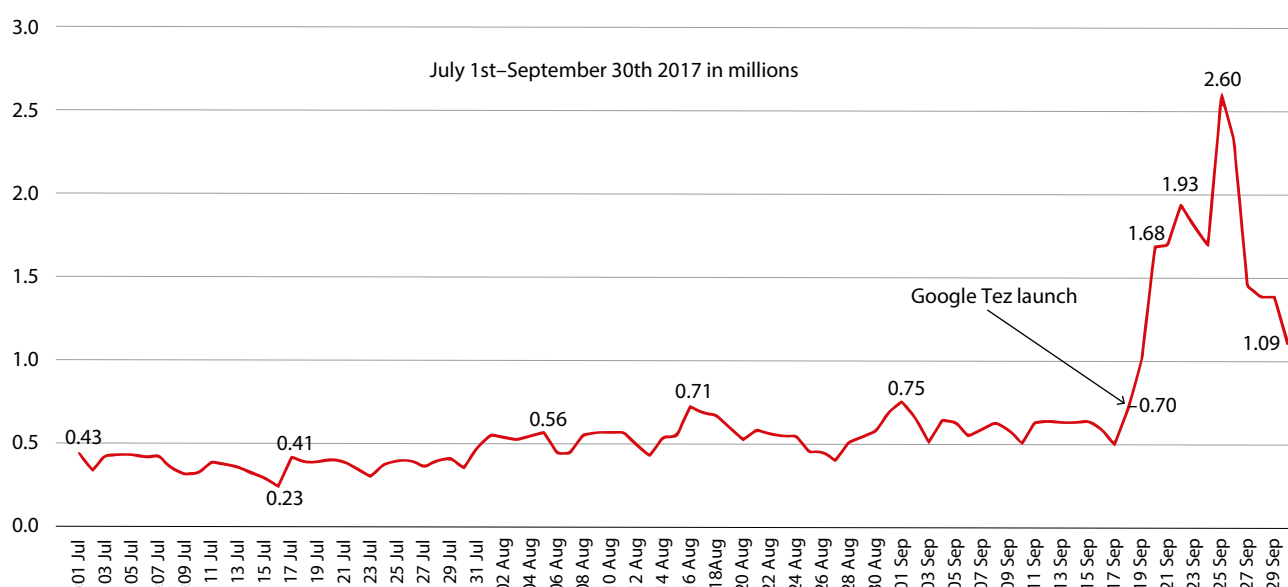
Source: National Payments Corporation of India (NPCI) via Reserve Bank of India (RBI); Pahwa (2017).

Undoubtedly, Aadhaar has been as controversial as it has been innovative. As more services become integrated through Aadhaar, it becomes possible to piece together data to create a detailed profile of an individual. Over time, such profiles could even be used to predict future behaviours in ways impossible with traditional methods of identity. Privacy advocates argue that this can limit social mobility, as people could be trapped by their class, past actions or any associated stigma. Some also argue this could constitute a step towards a surveillance state, or misuse by the private sector, as businesses continue to enable Aadhaar authentication on their services (Kolachalam, 2017). Some also raise security concerns about the potential for privacy leaks or hacks of the Aadhaar database, which could potentially result in fraudulent use of an individual's identity. This concern is not without merit, as sensitive Aadhaar data have already been breached on several occasions. In July 2017, the names, addresses, Aadhaar numbers and bank account details of 1.4 million pensioners were accidentally leaked by a state Social Security office (Sethi, Bansal and Roy, 2017). Most recently, Indian newspaper The Tribune reported that they were able to purchase access to Aadhaar details for every registered Aadhaar number – including names, addresses, postal codes, phone numbers and email addresses (but not biometrics) – from anonymous sellers on WhatsApp. The transaction took 10 minutes and cost EUR 7. For an additional EUR 4, the newspaper was able to obtain software that would allow them to print their own Aadhaar cards with

the obtained information (Khaira, 2018). The source of the stolen information was one of tens of thousands of private Aadhaar registration providers licensed to process new Aadhaar registrations, who thus had access to the Aadhaar database (*The Economist,* 2018). The government responded by giving users the ability to generate and use virtual IDs instead of their Aadhaar number. This extra layer of privacy can help mask the identities of users even if their data is compromised (Singhl, 2018). They also restricted the number of Aadhaar registration providers with access to the Aadhaar database (*The Economist,* 2018). However, it is too early to determine the extent to which these actions will address security concerns.

In interviews with the OECD, senior officials in the Indian government countered privacy and security concerns, stating that Aadhaar data operations are founded on three core principles:

1. *Minimal data:* the government collects only the data needed to prove identity. Other information, such as race, religion, education and profession, are not collected.

2. *Optimal ignorance:* although the Aadhaar database authenticates individuals, no data are sent to the government regarding the usage of the Aadhaar account. This limits the ability of the government to accumulate data on an individual's habits. In addition, no information from the Aadhaar database is shared

with a service provider. The Aadhaar system only provides the servicer with a yes or no (authenticated or not). Finally, by law, anyone who collects Aadhaar data is mandated to use them only for the purpose for which they are needed. Even if a large business has many different Aadhaar-enabled services, they cannot share Aadhaar data among themselves without the consent of the identity holder.

3. **Federated databases:** all services that use Aadhaar (e.g. PDS, scholarships, pensions, businesses) maintain their own database containing the data of relevance to them. This lack of centralisation protects privacy by helping to prevent data from multiple sources being combined to enable profiling. It also protects security, as there is no central knowledge base, and thus no central host for attacks or leaks.[47] In addition, informed consent by the Aadhaar identity owner is required for one service to share information with another.

Officials further stated that the need for physical biometrics to authenticate a user largely precludes the possibility of fraudulent transactions in the event of a data breach. To further mitigate privacy and security risks, the government has assembled a data protection committee comprising privacy and security experts, headed by a former member of the Supreme Court. This committee can make recommendations on policy and legislation to ensure the protection of privacy and security going forward. One of their first acts was to develop a data protection framework, which is currently in draft form.[48] Government leaders expect the framework to be launched in the first half of 2018.[49]

In spite of the above core principles, the controversies surrounding Aadhaar have played out in the Indian judicial system. In August 2017, in response to a case brought about by a series of petitions by privacy advocates challenging the constitutionality of Aadhaar, the Indian Supreme Court unanimously issued a landmark ruling that the constitution of India provides that all Indians have a fundamental right to privacy (see Box 6). In so doing, the court overruled two previous rulings.[50] While this judgement has set a major new precedent for Indian society, it makes no formal ruling on whether Aadhaar violates privacy. However, it clears the way for a future court hearing to proceed, using this new precedent as an argument (Mirchandani, 2017).[51] According to the Aadhaar CEO,[52] and the original architect of Aadhaar (Mirchandani, 2017), this should have no bearing on the programme, as the system is premised on the belief that there is a right to privacy and is said to collect minimal data. The ruling also provides that, under certain instances, such as social welfare and public safety, the government can circumscribe this right, although this would need to be tested on a case-by-case basis. It is not clear what the ruling could mean for the future of Aadhaar, but numerous parties, from proponents of biometric and national identities to privacy advocates, are watching closely.

Box 6: **SUPREME COURT RULING ON THE RIGHT TO PRIVACY**

"The right to privacy is an element of human dignity. The sanctity of privacy lies in its functional relationship with dignity. Privacy ensures that a human being can lead a life of dignity by securing the inner recesses of the human personality from unwanted intrusion. Privacy recognises the autonomy of the individual and the right of every person to make essential choices which affect the course of life. In doing so privacy recognises that living a life of dignity is essential for a human being to fulfil the liberties and freedoms which are the cornerstone of the Constitution."

Source: www.countercurrents.org/2017/08/24/right-to-privacy-judgement-highlights-and-full-judgement.

NOVELTY

Aadhaar is the largest identity programme ever created and has resulted in the biggest repository of biometric data in existence. The scale of its current system and the potential for its use as a platform is unprecedented.

RESULTS AND IMPACT

In just a few years, Aadhaar has given almost 1.2 billion Indians a nationally recognised identity that unlocks a wide variety of government and private sector services.

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47. Interview with Ajay Bhushan Pandey, CEO of the Unique Identification Authority of India (UIDAI) and Secretary for IT, 11 December 2017.

48. See http://meity.gov.in/writereaddata/files/white_paper_on_data_protection_in_india_171127_final_v2.pdf.

49. Interviews with J. Sathyanarayana, Indian Administrative Service (IAS), Chairman of the Unique Identification Authority of India (UIDAI) and Advisor to the Chief Minister of Andhra Pradesh, and Ajay Sawhney, IAS, Secretary to the Government of India for the Ministry of Electronics and Information Technology, 12 December 2017.

50. See http://indianexpress.com/article/india/right-to-privacy-judgment-a-fundamental-right-here-are-the-two-judgments-supreme-court-overruled-4811117/ for information on the two previous rulings.

51. See https://thewire.in/170700/right-to-privacy-aadhaar-supreme-court.

52. Interview with Ajay Bhushan Pandey, CEO of the Unique Identification Authority of India (UIDAI), 11 December 2017.

Connection of services to Aadhaar is completely changing sectors across India. Over USD 12 billion in financial transactions have taken place (Mirchandani, 2017), and over a billion bank accounts and mobile phones have been linked to Aadhaar.[53]

Aadhaar has also simplified and made more efficient many processes, resulting in better services for citizens and residents and significant cost-savings for the government. By mitigating fraud and abuse, the initiative has saved the government an estimated USD 10 billion over the last 2.5 years, according to the Aadhaar CEO.[54] Pilferage of food benefits, for example, has been drastically reduced.[55]

New data also show that Aadhaar has promoted financial inclusiveness and gender equity. The Centre for Global Development conducted a survey of Aadhaar users in the state of Rajasthan to learn more about their experience (Gelb et al., 2017).[56] It found that nearly all households now have at least one bank account, and a significant proportion of them are held by women. Before the introduction of Aadhaar, only 44% of women had bank accounts; this proportion has now grown to 90%. It also found that women tend to do the most banking for the family.

Aadhaar has fundamentally changed bargaining power from supplier to consumer, according to Nandan Nilekani, the original architect of Aadhaar and the cofounder of the major tech company InfoSys (Mirchandani, 2017). For PDS alone, customer wait times have fallen from hours to minutes. Enhanced mobility allows customers to receive their rations at any shop they like. If a shop provides bad service, keeps irregular hours or tries to scam customers (e.g. overcharging or putting stones in the rice to manipulate weighing), customers have the ability to vote with their feet and go instead to another of the many shops. The government tracks usage data and shuts down underperforming shops, thus providing them with an incentive for good customer service.

The function and functionality of Aadhaar has had a perceptible influence on citizens' trust in their government and each other, according to Aadhaar government officials. Receiving their payments and benefits on time and knowing that the government is protecting them against corruption and diversion helps to increase citizens' trust in government (Mirchandani, 2017). It increases trust among communities, as beneficiaries no longer fear that others may take what is rightfully theirs. It also increases trust among servicers and businesses in clients and users, as their visibility means they cannot defraud them. For example, Aadhaar helps to increase banks' trust in clients, increasing the likelihood that they will lend to them. According to the Aadhaar CEO, the Aadhaar identity and the trust it inspires will help to unleash the full potential of each Indian,[57] although critics may not agree.

The results and impact of Aadhaar are poised to expand beyond the borders of India. Despite the ongoing controversies, over 20 other countries are interested in potentially implementing similar identity programmes and the underlying technology, according to reports (Jayadevan, 2018).

USER PERSPECTIVE

Feedback on Aadhaar-enabled services, such as PDS and pensions, was generally positive in the Centre for Global Development survey. Most respondents found that Aadhaar services were at least as good as the previous systems, with many stating they were better and only a few believing they were worse. Users generally found the services to be faster and more convenient, and appreciated that no one else could steal goods meant for them. There were some challenges, however, with 25% of users reporting having to authenticate three or four times before being accepted by the system, and some saying that the system has not worked for them at all (Gelb et al., 2017).

CHALLENGES AND LESSONS LEARNED

Aadhaar's main challenges stem from the privacy and security concerns of people and advocacy groups. Strong political support on the part of the Congress and the Prime Minister, as well as the Finance Ministry, was crucial to the success of Aadhaar in terms of programme implementation and subsequent interactions. Collaboration across many divisions and levels of government has also been critical, according to the original Aadhaar architect (Mirchandani, 2017).

53. Interviews with J. Sathyanarayana, Indian Administrative Service (IAS), Chairman of the Unique Identification Authority of India (UIDAI) and Advisor to the Chief Minister of Andhra Pradesh, and Ajay Sawhney, IAS, Secretary to the Government of India for the Ministry of Electronics and Information Technology, 12 December 2017

54. Interview with Ajay Bhushan Pandey, CEO of the Unique Identification Authority of India (UIDAI) , 11 December 2017.

55. Interview with Guru Prasad, National Informatics Centre, India, 12 December 2017.

56. The survey interviewed 633 households from both urban and rural areas, with a mix of incomes and land-owning statuses. Sixty-three percent of the respondents were women.

57. Interview with Ajay Bhushan Pandey, CEO of the Unique Identification Authority of India (UIDAI), 11 December 2017.

CASE STUDY

Be Badges – Belgium

People learn and develop throughout their entire lives. Whether in school, training, careers or their personal lives, individuals continue to grow and acquire new competencies and skills. However, there are few options for people to highlight and showcase these skills beyond formal credentials, such as diplomas and certificates, or unverified and non-detailed feedback, such as LinkedIn endorsements. In 2016, the Belgian federal agency Selor[58] launched Be Badges,[59] a Digital Platform where employers, schools and training centres can formally recognise skills and experiences earned by individuals. Badge-earners can share these skills digitally with others and the labour market, and prospective employers and recruitment agencies can access the platform to find new skilled employees.

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58. Selor was a separate agency of the Belgian federal government responsible, among other things, for the recruitment of public servants at all levels of government (federal, regional and local). Its name was a portmanteau of Selection and Orientation. The entity was recently incorporated as part of the Government of Belgium's Directorate-General Recruitment and Development and no longer exists as a separate agency.

59. See www.bebadges.be.

THE PROBLEM

Job seekers often face numerous discouraging challenges in their paths towards new employment. These include taking many similar and time-consuming tests covering the same essential information. Conversely, employers spend a significant amount of resources on developing such tests to help ensure the skilled candidates they select meet their needs. In addition, tests or systems of recognition have historically tended to favour formal degrees and diplomas at the expense of soft skills or skills acquired through non-academic settings.

AN INNOVATIVE SOLUTION

Be Badges is a digital platform where training centres, employing companies and hiring agencies can award digital badges – visual representations of a soft or hard skill – to people they have trained, employed and tested (see Figure 16). It is built on the Open Badges philosophy and standard initiated by the Mozilla Foundation in 2011.[60] Open Badges are "verifiable, portable digital badges with embedded metadata about skills and achievements" and serve as a form of "open recognition".[61]

The aim of the platform is to enable badge-holders to obtain formal recognition of informal learning and skills obtained. The badges serve as proof that the badge-holder has demonstrated or developed certain skills. They can be earned through processes such as completion of a training programme or passing a test. They can also be awarded for the successful completion of projects, which may be ignored by typical credentials and forms of certification.[62]

Only organisations verified by the Be Badges team may issue Be Badges.[63] Badge-issuing organisations provide a thorough description of the skills involved in the awarding of a badge. Each badge contains digital information that confirms the value of this

recognition, the skills the individual demonstrated, how they were tested and the criteria met. This information empowers badge-holders to promote their verified skills on the job market, including through online resumes, websites and social media accounts such as LinkedIn. Employers can also access the Be Badges platform to identify potential candidates with the skills profile they need. Be Badges enable users to obtain recognition for their skills, as well as the job they deserve.[64] The platform also enables badge-holders to monitor the number of times a badge has been viewed.[65]

Figure 16: **Three parties involved in Be Badges**

ISSUERS
Companies that assess the presence of competencies and/or experiences of candidates (training centres, employing companies, hiring agencies, etc.).

EARNERS
People who have demonstrated certain competencies and receive a badge for this purpose.

DISPLAYERS
Organisations that encounter an earner's badge (e.g. on a job application or via social media). The display can view the badge and accompanying information and act accordingly (e.g. recruiting and hiring).

Source: Be Badges team.

Selor has extensive experience in evaluating job candidates, as it screens up to 100 000 public service candidates per year. Only 2-3% of these candidates get a job; however, there are many others who were screened positively but were not selected. Selor wanted to enable these candidates to bring their positive screening

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60. See https://openbadges.org.

61. See https://openbadges.org/get-started.

62. See https://youtu.be/jlYUuwwy3v4.

63. See www.bebadges.be/how-does-it-work.

64. See https://youtu.be/jlYUuwwy3v4.

65. See www.bebadges.be/how-does-it-work.

Figure 17: **Summer of Code Meetup** *Source*: Be Badges team.

results to other employers so they would not have to be tested again for the presence of identical or similar competencies. With Be Badges, Selor wants to look further than only formal degrees and education and, by doing so, find a new answer to challenges of talent and job mobility, waste of talent, employability, and talent mismatch.

Since its inception, Be Badges has been an ongoing open source community effort. Open meetups are organised to engage with all interested parties from both public and private organisations, as well as individual users. Participants collaborate through an open meetup group[66] and an open Slack channel.[67] Participants and users are considered to be codevelopers and partners helping to spread open badges.

Over 3 000 organisations around the world are now using Open Badges (the open standard upon on which Be Badges are built) to build talent and recognise achievement. The system is constructed around an open standard that enables Open Badges to be interoperable and shared across the Internet. Badge-holders can combine badges from numerous badge issuers to provide a complete picture of their experience and achievements.[68] Selor actively supports the Open Badges community in spreading this standard, not only as outcomes of learning experiences, but also as an entry point to labour markets and the building blocks of a digital curriculum vitae (CV) or resume. As part of this

community, Selor works with, learns from and helps to inform different organisations working on Open Badges worldwide, sharing knowledge and expertise in the spirit of open innovation and the open source philosophy. Because Open Badges represent an interoperable open standard, badge recipients can collect other types of badges not provided by Be Badges in "digital backpacks" to further illustrate other elements of their identity.

Selor is already scaling the idea beyond the Belgian labour market. In 2017, Selor co-initiated, together with the Belgian Digital Transformation Office,[69] Jobpunt Vlaanderen[70] and Cognizone,[71] an Open Knowledge Summer of Code[72] project to build a tool linking Open Badges to the newly launched European Skills/Competences, Qualifications and Occupations (ESCO) multilingual taxonomy of the European Commission (see Figure 17).[73] The resulting product, ESCO Badges, is now available online as an open-source beta platform.[74] By linking badges to the new ESCO taxonomy, ESCO Badges make it easier for displayers to correctly assess the exact skill represented by the badge via the principle of linked open data.[75]

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66. See www.meetup.com/Belgian-Open-Badges-Meetup.

67. See http://bebadges.herokuapp.com. Slack (slack.com) is a digital collaborative workspace. A Slack channel is a conversation space where discussions can be organised around any topic.

68. See https://openbadges.org/get-started.

69. See https://bosa.belgium.be/en/dg-digital-transformation.

70. See www.jobpunt.be.

71. See www.cogni.zone.

72. See http://2017.summerofcode.be.

73. See https://ec.europa.eu/esco/portal/home. Part of the Europe 2020 Strategy, ESCO identifies and categorises skills, competences, qualifications and occupations relevant for the EU labour market and education and training. It facilitates dialogue between the labour market and the education/training sector by providing a common language that could help overcome labour market imbalances and increase occupational and geographical mobility in the European Union.

74. See http://escobadges.eu.

75. See Figure 18 for a photo of the Be Badges and ESCO Badges team presenting their work at a conference.

NOVELTY

Be Badges represent a unique form of innovation worldwide, both in terms of government usage of Open Badges and the application of Open Badges in the labour market, according to Selor.

RESULTS AND IMPACT

Even though Be Badges, and the associated ESCO Badges, programmes are fairly new, they have already ushered in significant progress in Belgium. The City of Ghent, Belgium's second-largest municipality, conducted a pilot, together with Jobpunt Vlaaderen, allowing some candidates with sufficient Be Badge qualifications to bypass the initial selection phase and pass directly to a second stage of hiring. Be Badges have also been incorporated into pilots at Belgian educational institutions and universities, such as Odisee, one of the largest educational institutions in Flanders, Belgium.[76]

Over time, Be Badges and ESCO Badges could have the ability to promote "open recognition". This allows individuals to be recognised for all aspects of their identity, not just those listed on a certificate. This has the potential to unlock new types of motivations in individuals, and to build a more diverse and inclusive job market.

USER PERSPECTIVE

At present, little information from the users' point of view is available. Programme leadership has indicated that implementation and use of the programme is relatively recent and that a more significant focus on user perspectives is underway as the team iterates the original products.

CHALLENGES AND LESSONS LEARNED

Within government, it proved somewhat challenging to get people to accept the notion of undertaking the work involved in a transparent, open manner, for example, through open meetup groups and on open online platforms. Some people believed that time spent on open channels was not the core business of government. However, this initial reluctance fell away as it became evident that working in the open enhanced the product and service in ways that would have been impossible in a closed system.

Another challenge consisted of explaining the standards and benefits of open badges to a non-technical audience. However, production of a short video[77] that walks interested individuals through the product and benefits proved a highly effective means of convincing people of the merits of the programme and familiarising them with the underlying concepts.

A lingering challenge that Be Badges and ESCO Badges teams face is building acceptance of badges in the job market. This challenge will require constant work and must be addressed through continuous and clear communication on the benefit of the programme, highlighting success stories over time from the perspectives of issuers and badge-holders.

76. See www.bebadges.be/single-post/2017/01/25/What-if-LinkedIn-endorsements-would-have-real-value.

77. See https://youtu.be/jIYUuwwy3v4.

Figure 18: **Conference presentation of Be Badges and ESCO Badges** *Source*: Be Badges team.

CASE STUDY

Australian Government
IP Australia

Australian Trade Mark Search – Australia

Over 87% of a company's value is rooted in its intangible assets, including brands and trademarks that represent the identity of a business (Stathis, 2015). A good trademark is a way of identifying a unique product or service in the marketplace. It distinguishes a company's brand identity from others in the same or a similar industry. This initial step is a critical foundation upon which the rest of the business is built. However, the steps to ensure the uniqueness of a company's brand are difficult and time consuming. IP Australia, the government agency that administers intellectual property (IP) rights in Australia, has launched Australian Trade Mark Search[78] to help businesses thrive in a global economy.[79] Powered by industry partner TrademarkVision's revolutionary image recognition and AI technology, the solution provides security for businesses by protecting their most important assets and has significant global applicability.

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78. See https://search.ipaustralia.gov.au/trademarks/search.
79. See https://youtu.be/CKzx0mKt9PU for a demo video.

Trend 1: Identity

THE PROBLEM

The value of brand identities continues to grow internationally. In 1975, it was estimated that 80% of the value of top companies were tangible assets. In 2016, the situation has reversed with more than 87% of the value of top companies consisting of intangible assets – including brand identity (Stathis, 2015). There are approximately 31.5 million trademarks in force globally and at least 8.5 million trademark applications per year. There are over 70 000 applications per year in Australia alone, ranging from individuals or small businesses interested in registering their first trademark through to multi-national corporations. If a business applies for a trademark that is too similar to an existing trademark, it is rejected. This can result in loss of time and money for the applicant, especially if they have already entered the marketplace. If a business does not apply for a trademark, they may miss the opportunity to secure their most valuable asset.

Millions of trademarks must be considered before a new businesses or product can enter the market. Searching trademarks allows businesses worldwide to make informed decisions around their branding strategies. Moreover, an effective trademark search conducted before entering the market can provide invaluable business insights that have cascading effects for the future of the business. Having a system in place that enables members of the public to search trademarks is therefore vital. Australia has had the ability to search electronically for trademarks since the 1990s, but the system was highly complex, requiring words to search visual elements in an existing database of brand identities. IP Australia has a unique glossary of over 3 500 English word terms describing visual elements of trademarks. Previously, this was the only way to search visual elements (see Figure 19).

Novice users found the process nearly impossible and even specially trained experts expressed frustration at the complexities involved. For many, the use of text-based searches to locate images similar in visual appearance was inherently difficult. It could also lead to lack of awareness among businesses of existing trademarks similar to their own, which could result in expensive rebranding processes or potential lawsuits.

AN INNOVATIVE SOLUTION

To help Australian businesses launch as early as possible with a successful brand identity strategy, IP Australia decided to rethink their approach by adopting industry-leading practices and pushing the boundaries of trademark search systems. They assembled a small, multi-disciplinary team (see Figure 23) and empowered them to work innovatively. In February 2017, they launched the Australian Trade Mark Search. The new system leverages revolutionary combined image searching and machine-learning technology to drastically simplify trademark searching and break down barriers for users. Instead of using text descriptions to search for brand identities, users can upload a logo and instantaneously search IP Australia's database of 400 000 images, which then returns trademark results based on visual similarity through image recognition. The process renders image searches more achievable for businesses, both in Australia and globally, not least because it is language independent, an important factor in the global market (see Figures 20 and 21). It also helps to increase the quality of trademark applications in Australia, delivering greater economic benefits to Australian business. As a result, fewer businesses will file applications for trademarks similar or the same as previously registered trademarks, and can have greater confidence in the applications they file.

Figure 19: Previous trademark search using words

Source: IP Australia.

Figure 20: Australian Trade Mark Search by image
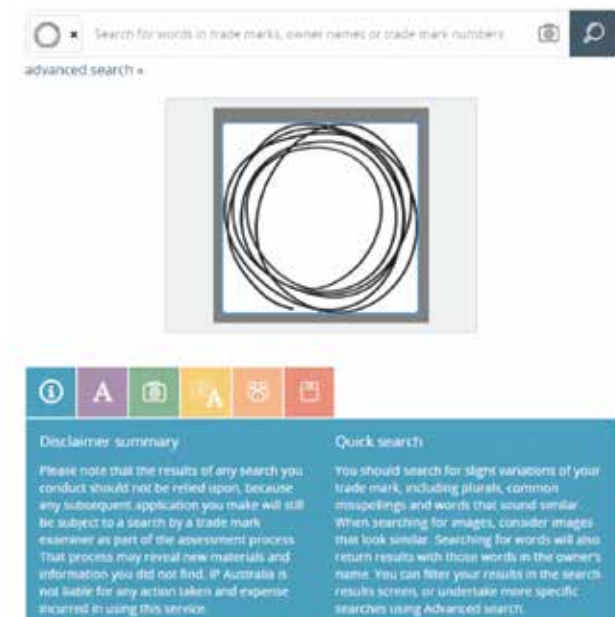
Source: IP Australia.

In developing the system, IP Australia collaborated closely with private sector partners and the Australian start-up TrademarkVision, identified through an open tender process. They also worked closely with users to understand their needs, including through face-to-face codesign sessions and exposure to alpha (prototype) and beta (test) systems as the project progressed. The use of state-of-the-art technologies and agile delivery processes resulted in the development of Australian Trade Mark Search as a platform for continuous improvement over time, as user needs, expectations and technical capabilities change. This will allow the service to evolve iteratively, ensuring its continued relevance and success, according to IP Australia leaders.

The success of Australian Trade Mark Search for brand identities has led IP Australia to expand the technology into other IP domains. The next public-facing IP Australia search solution will be Australian Design Search, which will allow users to search registered industrial designs using images.

Figure 21: Australian Trade Mark Search results
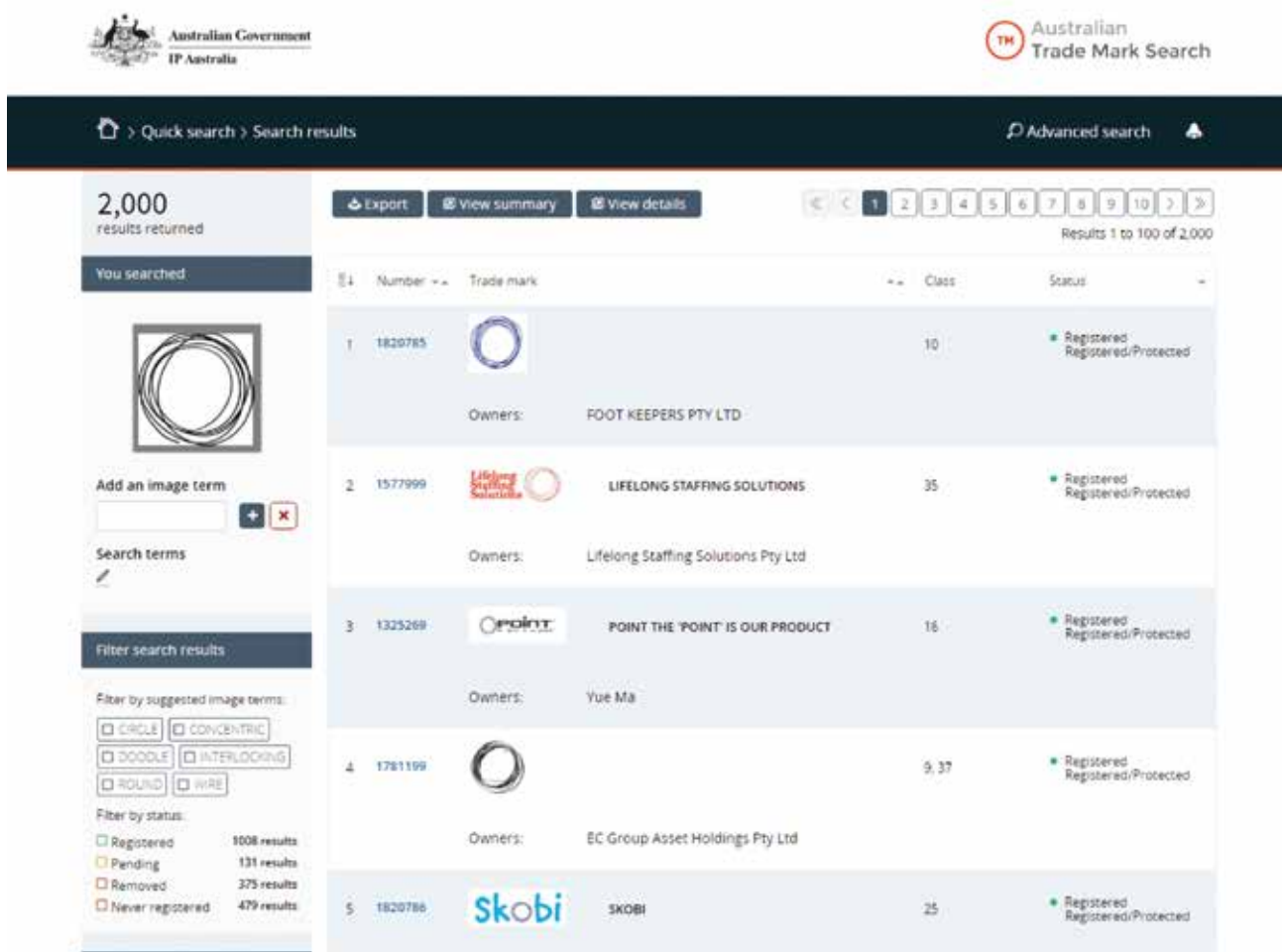
Source: IP Australia.

Figure 22: Australian Designs Image Search
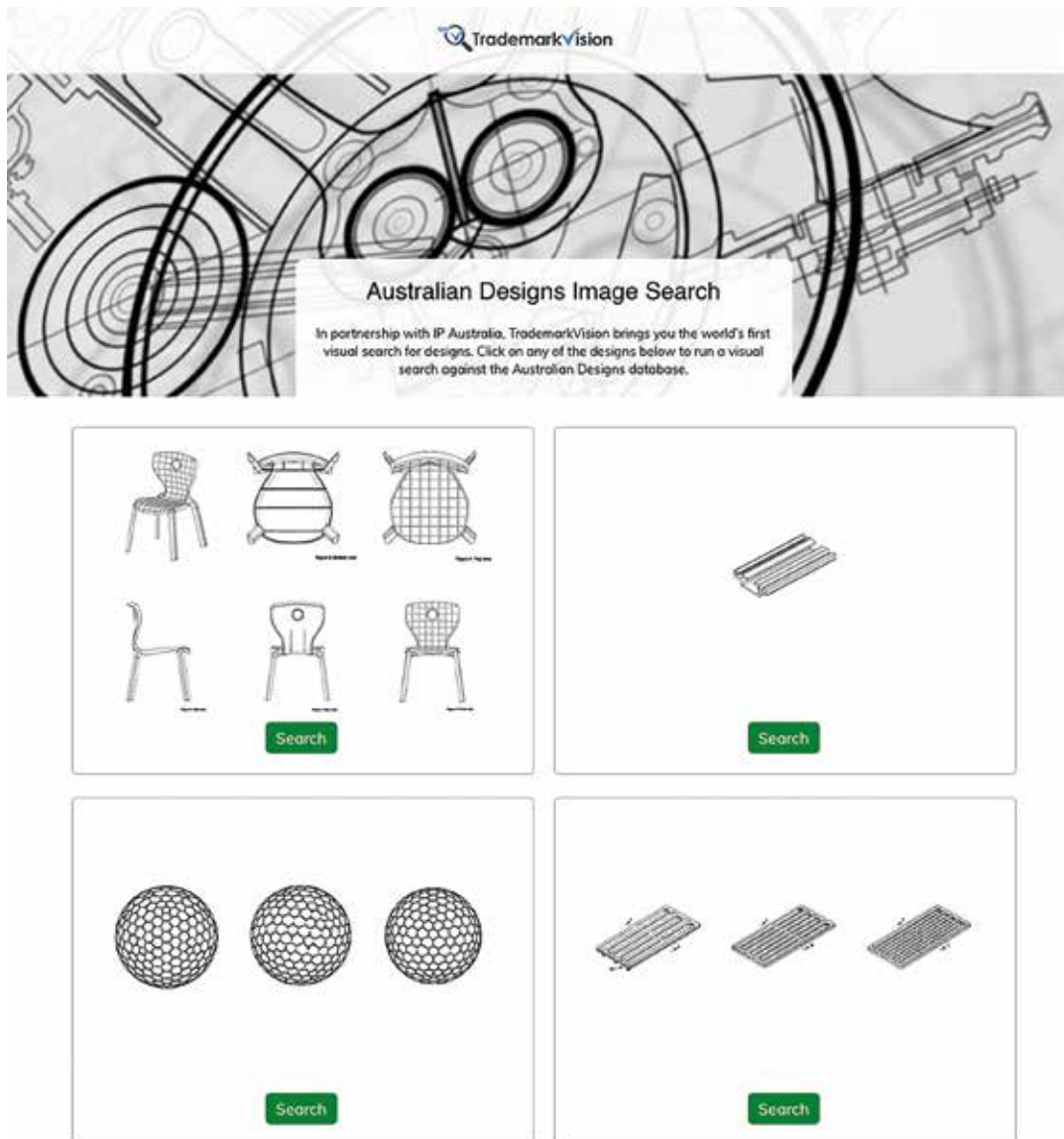
Source: IP Australia.

IP Australia was the first IP office to provide a public demonstration of this capability (see Figure 22). This world-first initiative has generated interest at international conferences and among Australian bodies for industrial designers, as it has the potential to greatly simplify the process of searching registered designs in Australia. As industrial designs are exclusively visually based, image recognition has great potential to help businesses understand whether their product is sufficiently new and distinctive to be registered for design protection, or if they are at risk of infringing on another registered design.

In the future, IP Australia will extend the functionality of this technology to patents and plant breeder's rights.

NOVELTY

Image recognition technology is most commonly photo-based and used to identify life-like objects in images (e.g. automatic image tagging on Facebook). Very few trademarks contain photos or life-like objects. The vast majority are highly stylised or cartoon representations of things. This makes Australian Trade Mark Search, and the underlying technology from their partner TrademarkVision, a unique and specialised form of image recognition technology. Trademark search systems, some of which use image recognition, have been available for some time, but the Australian Trade Mark Search technology disrupts this field by using machine learning algorithms to detect objects within a trademark image.

RESULTS AND IMPACT

One year after its launch, Australian Trade Mark Search is receiving over a million views per month. IP Australia has seen a 54% reduction in calls related to trademark searching, demonstrating greater ability on the part of businesses to meet their own information needs, and saving Australian businesses time and money. Knowledge of, and conversations around, Australian trademarks in the media and among small business and start-up networks continues to mature. This in turn helps businesses to launch quickly with unique and compelling brand identities, which are crucial for competitiveness in the global marketplace. Australian Trade Mark Search also leads to efficiencies within government, as trademark examiners now use the system to evaluate trademark applications with greater ease and speed than before.

The novelty and success of Australian Trade Mark Search is also being recognised on the world stage. The system is considered to be exemplary and is influencing and inspiring many other governments. International IP offices continue to reach out to IP Australia to understand how to develop similar solutions that will influence millions of businesses worldwide, from the world's largest corporations to the smallest start-ups. IP Australia was awarded the silver medal in the 2017 Prime Minister's Awards for Excellence in Public Sector Management.[80] In addition, *Fast Company* magazine recognised its partner, TrademarkVision, as one of the world's 10 most innovative companies for AI and machine learning.[81]

USER PERSPECTIVE

IP Australia conducted a survey among novice searchers on their experience with the new image search tool. Out of those that responded, 87% found the system "easy to use". This represents a dramatic improvement on the previous search system. Feedback from users also described the new tool as "very fact and informative", "much better than the [previous] website" and "so much more user friendly".

CHALLENGES AND LESSONS LEARNED

One of the core challenges IP Australia faced was identifying novice users. Over a third of the system's users are first-time or one-off searchers. While their interactions with IP Australia are often short-term, they remain an

important segment. To locate such users, IP Australia attended small business and start-up events to meet those who were familiar with the system and those who had yet to try it. As a result of these interactions, they realised that two modes were necessary: a quick search mode for more casual users, and an expert mode for advanced users, many of whom worked in the legal sector or in-house for large corporations.

Working closely with these and other users in their own environments helped IP Australia to understand their uses and needs. This broad research and user-centred focus also helped to identify existing products that met needs, while highlighting the importance of agility and flexibility for future use. This led IP Australia to determine that a custom solution was necessary. Without this process, they would have likely chosen an off-the-shelf solution, which would have resulted in compromised outcomes and costly remediation.

Another critical lesson learned during the innovation lifecycle and resulting success of Australian Trade Mark Search was the extensive due diligence performed on available solutions in IP and similar industries, according to IP Australia officials. During the development phase, IP Australia approached other IP offices around the world and evaluated many potential solutions available on the market.

Figure 23: **The IP Australia team**

Source: IP Australia.

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80. See www.act.ipaa.org.au/pms%20-awards-winners2017.

81. See www.fastcompany.com/company/trademarkvision.

CASE STUDY

The world's first data embassy – Estonia

Through its e-Estonia initiative,[82] Estonia has built a digital society and developed the most technologically advanced government in the world. Practically every government service is paperless and performed electronically. As a result, Estonia is highly dependent on its information systems and the data stored on them. To protect its data, Estonia developed the concept of data embassies – servers outside the country that are legally under Estonian jurisdiction. The digital copies of key databases they store can be accessed in the event of a major data incident in the country, thereby protecting the digital lifeblood of this small Nordic country. Estonia is on its way to becoming a "country without borders" (MoEAC, 2016), and the data embassy is one of several Estonian programmes that blurs the lines of national borders and sovereign identity in a digital world.

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82. See https://e-estonia.com.

THE PROBLEM

As part of its digitisation process, Estonia has actively implemented a "paperless governance" policy. This has resulted in a situation in which essential databases (e.g. land, population and business registries) exist only in digital form. While the benefits of a paperless government are immense, it does raise a few challenges. One is the issue of how to secure data that could become vulnerable in the event of a major natural disaster or cyber, terrorist or military attack. Such an attack is not purely theoretical; Estonia has faced a number of cyber-attacks in recent years. In 2007, Russian attackers took 58 Estonian websites offline, including those of the government, most newspapers and many banks.[83]

AN INNOVATIVE SOLUTION

This initial attack demonstrated the need for an outside-the-country solution, which was subsequently discussed for several years by cyber-security experts, academics and state IT professionals. To address the problem, Estonia launched the world's first data embassy in partnership

83. See https://e-estonia.com/estonia-to-open-the-worlds-first-data-embassy-in-Luxembourg.

with the Government of Luxembourg. In June 2017, the Prime Minister of Estonia and the Prime Minister of Luxembourg signed a unique bilateral agreement between the two governments regarding Estonian data and related systems (see Figure 24), which are stored in Luxembourg's government-owned data centre. This agreement creates the basis for establishing the world's first data embassy. The data embassy is an extension of the Estonian government cloud, meaning that the Estonian state owns server resources outside its borders. These will be used not only for data backup, but also for operating critical services. As with physical Estonian embassies, the servers are considered sovereign embassies in foreign data centres.

"One of the most important tasks of any country is to ensure continuity both on a state level as well as in terms of public services. The Estonian digital and information society is already so highly sophisticated that it is no longer possible to move back to a paper era. Therefore, we have to do our utmost to ensure cyber security, including maintaining digital continuity."
Siim Sikkut, *Government Chief Information Officer Estonia*

Figure 24: **Signing ceremony between Estonia and Luxembourg** *Source*: Government of Estonia.

While opening the first data embassy involves placing Estonian systems and data in another sovereign county, it creates an additional security guarantee for Estonian sovereignty. Estonia will back up critical data and services important for the functioning of the state outside the physical territory of Estonia, while Luxembourg guarantees that the data and the servers are protected by the same legal guarantees as the data and servers in Estonia. This approach will help ensure the country's digital continuity – its capability to maintain services and digital data regardless of interruptions.

The data embassy benefits Estonian citizens, who will be the recipients of a more reliable and secure digital society. Additionally, it creates an extra security guarantee for 30 000 and more e-residents of Estonia, as discussed previously, who expect Estonian digital services to be available at any time independent of location.

After the first data centre in Luxembourg is fully implemented and lessons are learned, Estonia is likely to open additional data embassies in other countries.[84] Data embassy leaders believe that the concept should be considered by every government as countries become more and more technologically advanced. A number of countries have already contacted Estonia and are planning to establish a network of data embassies abroad.

NOVELTY
The data embassy is the first of its kind. It introduces an innovative new paradigm in a digital world whereby a country distributes its critical data and information systems in co-operation with other countries to ensure its continuity and security. This innovation also represents the first bilateral agreement to expand the Vienna Convention on Diplomatic Relations, which provides the framework for international diplomatic relations, to the hosting of data and information systems. As such, Estonian officials describe it as a unique case study in international law and relations. It may also support a new concept of the free movement of data, in addition to people, across the European Union.

The data embassy is also innovative in terms of technical design and implementation. Novel thinking is required to design a system that keeps the data of the two sites in sync, while preventing data loss. To achieve this, new technological solutions will be developed including, for example, the use of blockchain technology to ensure data integrity.

RESULTS AND IMPACT
The data embassy is still very new and not yet fully developed and implemented. Much of the initial impact has been intellectual and political, with innovative conceptions of cross-border storage and use of data spearheading a new phase in international law. Over time, the world's first data embassy will validate the importance of ensuring digital continuity of the state and the possibilities of building distributed systems with the assistance of technologies such as blockchain to help increase a country's security.

CHALLENGES AND LESSONS LEARNED
The data embassy project encountered legal challenges which primarily revolved around guaranteeing the confidentiality and security of critical data lying within the jurisdiction of another state. To overcome these challenges, the governments of Estonia and Luxembourg signed a bilateral agreement that established immunity for the data embassy. This agreement is the first of its kind. The project has also encountered technical challenges (e.g. how to protect the integrity and confidentiality of critical data outside Estonia, how to redesign information systems to work reliably in globally dispersed environments, etc.), which require new technological solutions. These solutions and the tools to overcome the outlined challenges are currently under development.

One of the key lessons learned according to Estonian officials is the importance of finding partners who think similarly and are eager to innovate, and with whom mutual trust exists or can be cultivated. Luxembourg is a good partner for Estonia as the government understands the importance of digital continuity and is ready and willing to make efforts to secure this future. The project was made possible by Luxembourg's support for the project and readiness to host the world's first data embassy within their government-owned data centre, thereby providing legal immunity for the data and server hosting.

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84. See https://e-estonia.com/estonia-to-open-the-worlds-first-data-embassy-in-Luxembourg.

Trend 2:
Systems approaches and enablers

The complexities of today's problems require systemic change rather than simple, incremental responses. Technology, environmental challenges and citizens' dissatisfaction with "business as usual" are all putting pressure on governments to change their working methods and reach beyond simple solutions and linear equations of cause and effect. This marks an innovative paradigm shift in governance. Rather than layering interventions on top of one another, the public sector should repack policies in ways that allow them to get to the real purpose of change and deliver value to citizens. Human wants, needs and desires are complex, and the systems created to satisfy them are even more so. If simple models are used to analyse them, they will produce simple answers. As human lives and the problems that affect them are intertwined, innovative working methods are needed that take this complexity into account and provide solutions that actually work. One way to address these challenges is to apply a more systemic approach to innovation. Systems approaches can have a transformative effect across the board in the public sector:

● They identify the real purpose behind the change process.

● They help to analyse the interlinked determinants behind complex problems.

● They help to design systemic innovations that work in specific contexts.

INNOVATORS ARE EMBRACING COMPLEX SOLUTIONS FOR A COMPLEX WORLD

Systems approaches have a long history in engineering, ranging from constructing cities to planning traffic. Increasingly, they are being applied to social problems (see Box 7 for definitions). However, until recently they did not receive adequate attention in the public sector, largely because systems approaches do not offer simple solutions, 10-point guidelines or toolkits (or at least they should not). Instead, they focus more on applied expertise, holistically analysing how to reach a purpose, selecting tools and methods that fit the problem, not vice versa.

Box 7: DEFINITIONS OF SYSTEMS AND SYSTEMS APPROACHES

Systems are interlinked elements bounded and created to achieve a specific purpose.

Systems approaches are a set of processes, methods and practices that aim to affect systems change. Systems approaches focus on the impacts and outcomes of policies and their purpose, going beyond the linear logic of "input-output-outcome" of traditional policy design. They emphasise the involvement of all affected actors inside and outside government, as well as the importance of leaving room for iterative processes to account for the uncertainty associated with wicked problems.

Source: OECD (2017c).

In complex systems, change occurs due to the interplay of diverse factors that can be very loosely connected to one another. It is important not only to identify the different elements of the system, but also how they influence and interact with each other, in order to be able to reach positive results in complex settings. For example, is it possible to attribute why citizens distrust[85] the government to one cause? Citizens conflate their personal experience at the doctors, police or post office with the broader functioning of government. Furthermore, trust is interpersonal: if a government does not trust its citizens, can citizens be expected to trust their government? Can the loss of confidence in government (Figure 25) be linked purely to the effects of the financial crisis when these effects vary across countries? Addressing these issues means going beyond piecemeal policy interventions that address only part of the problem.

The Observatory of Public Sector Innovation (OPSI) at the OECD is continuously updating its tactics for systems change (Figure 26). Getting to the heart of the problems in systems is difficult, and sometimes involves making sense of huge datasets (e.g. mobility planning in cities), thus, governments need expert help. But knowing what kind of help is needed is a skill in itself. OPSI is now familiarising countries with systems approaches by working with

85. In a recent Pew survey, only 18% of Americans said that they trusted the government always or most of the time. See www.people-press.org/2017/05/03/public-trust-in-government-1958-2017.

Figure 25: **Confidence in national government in 2016 and its change since 2007**
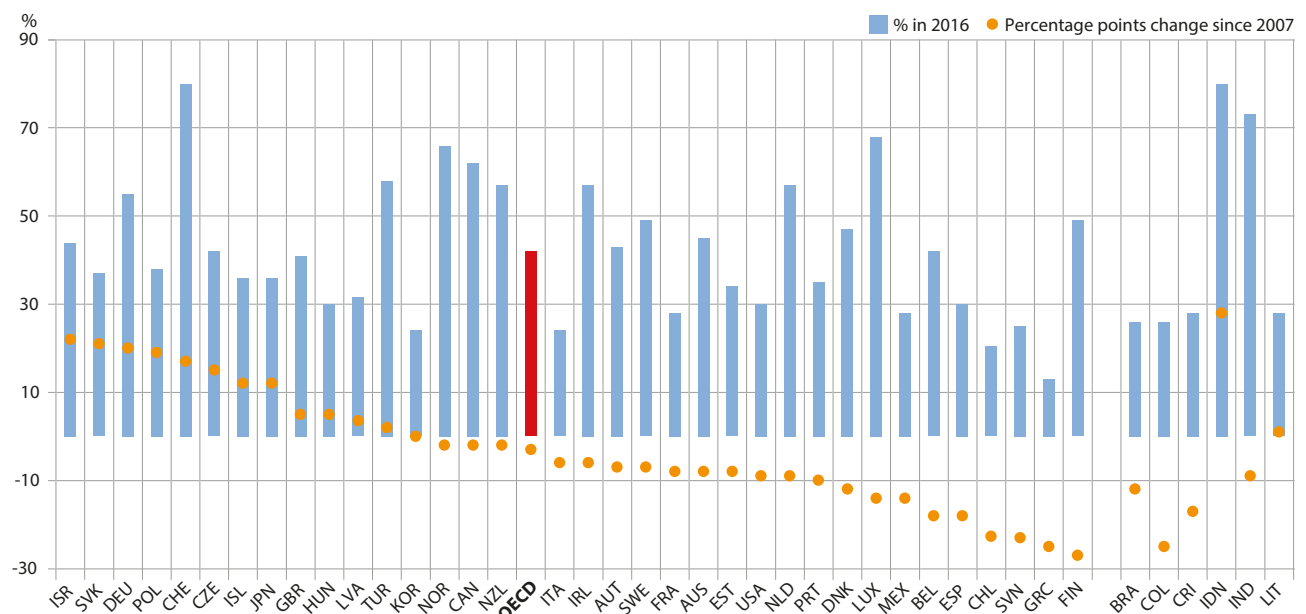
Source: OECD (2017b).

Figure 26: Systems tactics for public sector challenges

Systems Approaches to Public Sector Challenges
WORKING WITH CHANGE

OECD

PEOPLE
Combining a diverse set of people: "If you know everyone in the room: you will fail".

PLACE
Creating the neutral space to deliberate and set back from the everyday system.

DWELLING
Creating the time and conditions to think and deliberate on the end purpose.

CONNECTING
Connecting to all stakeholders to both inform the process and form advocacy coalitions.

FRAMING
Framing the issue based on the outcome/purpose (public value) not existing system structures.

DESIGNING
Based on the analysis before, designing solutions that may have systemic effects.

EXPERIMENTING
Reducing uncertainty by experimenting on a smaller scale with different solutions and clear action plans.

PROTOTYPING
Creating a prototype for scale that can be tested by diverse populations.

STEWARDING
Guiding and supporting the process by both creating the resources and political backing for change.

MEANINGFUL MEASUREMENT
Measuring the effects based on the outcomes wanted to achieve, not proxies.

Source: OECD (2017c).

them on specific complex issues. This work is intended to empower public sector innovators to look beyond their immediate silos and the systems of today and envisage the systems of the future. In this effort, the OECD is not alone. The World Bank has been introducing systems approaches iteratively to issues of development (Bauer, 2017), while the United Nations is analysing environmental problems at the "ecosystems" level, and futures experts in international organisations have tied strategic foresight to anticipatory systems frameworks (Miller, 2017).

Beyond advocacy and the work of international organisations, several trends linked to systems approaches are taking shape:

- First of all, innovators are increasingly transcending administrative silos to deliver real value to citizens.

- Second, innovators are using more advanced diagnostic tools to get to the root causes of problems.

- Third, innovators are debating and analysing value trade-offs and unintended effects of systemic innovations. This means that delivering public value to citizens is being put back at the heart of change efforts.

- Fourth, innovators are searching for levers of change to move from incremental to radical transformation in the public sector.

- Last, but not least, innovators are looking to provoke systemic change in the public sector itself, by exploring how to make public institutions function in ways that allow them to work differently and experiment with far-reaching ideas.

INNOVATORS ARE TRANSCENDING ADMINISTRATIVE BOUNDARIES

The first trend in emerging practice is the move to transcend traditional administrative silos. Technology, as touched on in the previous section, is having a profound

effect on the core concepts and operating practices of the public sector. Data are no longer bound to one department or agency, but can be interlinked, made interoperable and used for different purposes. This approach produces not only whole-of-government, but also whole-of-society solutions. Solutions like APEX from Singapore (see later in this section; page 62) open up and unify data-operating practices across sectors, producing systemic effects. With regard to data security and privacy concerns, Justice Data Lab[86] in the United Kingdom is the first service to evaluate the impact of rehabilitation interventions, by providing secure access to sensitive data and technical analysis for the third sector and beyond. It demonstrates how data security obstacles can be overcome and how statistical techniques have enabled innovation through the use of administrative datasets above and beyond their original purpose.

Knowledge is power, and sharing information means that governments, to some extent, have started to share their power as well (Tõnurist, 2015). The traditional boundaries (political mandates, working with citizens, partnerships, etc.) of the public sector are changing (Figure 27). Through digital transformation, services can be personalised with individual life-events and context taken into account, and solutions cocreated with citizens. On one level, the automation of simple bureaucratic tasks is releasing more resources to core responsibilities. For example, Trelleborg municipality in Sweden[87] uses a case handler robot to automate certain parts of social support processes that concern financial assistance. This has resulted in large efficiency gains (90% of social assistance processing time was saved), and also opened up more time and resources in government to undertake important work relating to individual citizen's needs. In a similar vein, the Estonian Tax Authority automated data analysis, cutting down on employees and investing heavily in new digital services making it more difficult to work in the shadow economy (Lember, Kattel and Tõnurist, 2017). Major gains can also be achieved through GaaP (government as a platform) (Tõnurist, Lember and Kattel, 2016).

On another level, new platforms linking people and their complex needs play a key role in re-shaping boundaries. In this context, breaking down administrative silos is

Figure 27: **The changing boundaries of the public sector**
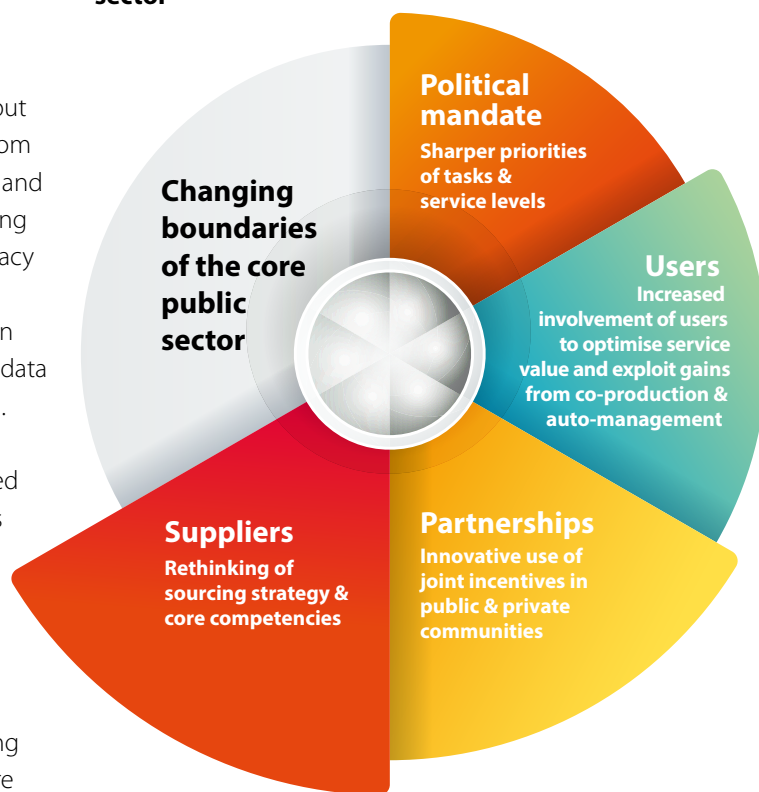
Source: OECD (2017d: 21).

not a goal in itself – the real aim is the value from new systematic solutions for people's complex needs. For example, in New Zealand data integration is used to model critical life events (see Box 8), making all necessary services available to people in one place when they encounter a change in their life and require assistance. This approach also prompts more considered responses from citizens, who are now better informed, because government has anticipated their needs rather than requiring them to assemble information from diverse sources. In another example, the less data-heavy, yet very innovative, One-Stop-Guidance Centres for youth in Finland (see Box 9) bring together various service providers across sectors to avoid duplication of activities. This approach simplifies matters for users who no longer need to familiarise themselves with internal government structures in order to receive services. Hence, a unified response to the needs of a specific target group is cocreated across sectors. Other examples of this approach include the Seoul 50+ Policy and the Asker Welfare Lab, both outlined in detail in the next section of this review (pages 89 and 98, respectively).

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86. See www.gov.uk/government/publications/justice-data-lab.

87. See www.trelleborg.se/en/english.

SmartStart is a cross-agency online life event service in New Zealand linked to the birth of a child. This is the first of a number of integrated digital services based around critical life events. Through SmartStart, New Zealanders can learn about having a child; navigate, access and engage with government services; and consent to having information provided to one agency reused by another agency.

SmartStart integrates 55 services (e.g. birth registration, financial assistance, child health services) and shares data between departments with minimal effort required on the part of the customer. Integrated web content and service access means that citizens no longer have to complete forms and provide the same information multiple times.

Source: "There is a baby on the way", 2017 brochure produced by SmartStart, Government of New Zealand.

To Do List

Pregnancy weeks 0-14
☐ Choose a lead maternity carer

Pregnancy weeks 15-30
☐ Check what parental leave you can get
☐ Check what financial help you can get
☐ Verify your identity with RealMe

Pregnancy weeks 31 to birth
☐ Get a car seat ready
☐ Choose a Well Child Tamariki Ora provider

New baby weeks 1-6
☐ Register the birth
☐ Apply for an IRD number for your child
☐ Add your child to your Working for Families application
☐ If you're on a benefit, tell the Ministry of Social Development your child has been born
☐ Order a birth certificate

Baby 6 weeks to 3 months
☐ Check if the financial help you can get has changed

Baby 3 months to 6 months
☐ If you get Working for Families payments, let Inland Revenue know if your income changes
☐ Check if you can get help paying for childcare

SmartStart
The one place to go for step-by-step information to help you and your baby get off to the best start

smartstart.services.govt.nz

Ohjaamo is a One-Stop-Guidance Centre that serves as an easy-access service point for young people below the age of 30. It brings stakeholders together from diverse sectors, provides services to young people in new ways and encourages them to work together, creates new operating practices and develops skills in multi-sector management.

Ohjaamo's core function is to provide personal advice and guidance, support in life management, career planning, social skills and capacity building, as well as education and employment. The professionals working at Ohjaamo examine the situation and service needs of each young person individually, with the objective of helping young people to take charge of their lives.

In 2016, 429 employees worked in 40 Ohjaamo centres. Their services reached 69% of Finnish youth from ages 15 to 29. Across Finland, 80 000 young people used Ohjaamo services in 2016. By 2025, Ohjaamo services will reach all young people below the age of 30.

Source: Government of Finland.

Adding another layer of complexity, people nowadays live more mobile lives. It is not uncommon, for example, for individuals to live in one city, or even country, and work in another. This is the main principle of the free movement of labour in the European Union – making mobility a right in itself. However, this raises the question: are public services sufficiently mobile to meet the needs of citizens? Should citizens have to contend with different government administrations at different levels for their rights to be ensured and their needs met? OECD countries use various mechanisms to co-ordinate action from the national to the regional level (see Figure 28), but the scope of this co-ordination differs in terms of content (Figure 29). New, emerging challenges are pushing for quicker co-ordination across traditional administrative silos. One such example is Co-lab Sweden (described in more detail Chapter 3, page 84), which has introduced new working methods to work across sectors in order to address the needs of unaccompanied minors among refugees.

Trend 2: Systems approaches and enablers

Figure 28. **Vertical co-ordination instruments in OECD countries** (total number of respondents is 30)

National level regional development agencies	14
National representatives in regions	18
Contracts or other agreements	23
Project co-financing	26
Consultation forum or other form of regular dialogue	26

Source: Charbit and Romano (2017).

Figure 29. **Areas with extensive scope in OECD countries' national urban policies**

Number of countries

Economic development	Spacial structure	Human development	Enviromental sustainability	Climate resilience
19	16	11	15	5
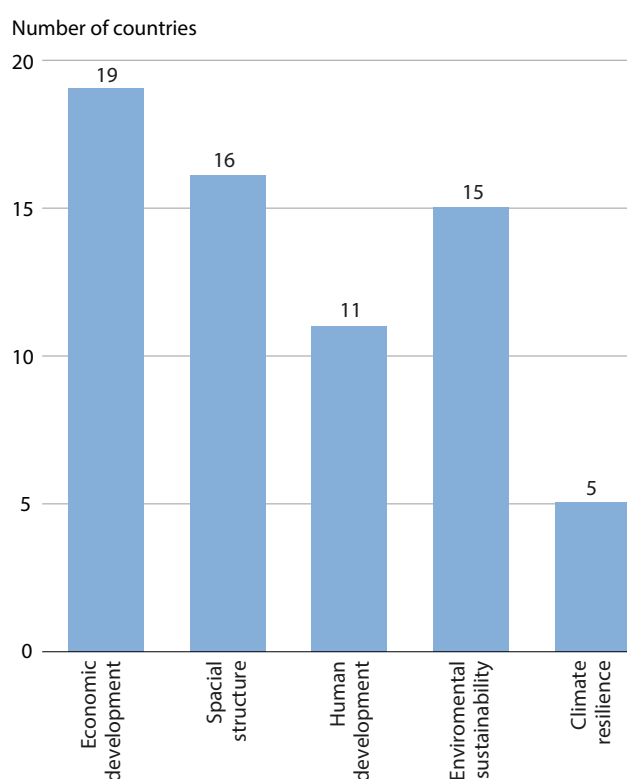
Source: OECD (2017e: 15).

Another example from the Gothenburg region of Sweden (see Box 10) shows how collaborative innovation can be pushed to the fullest. The region starts with the smallest common denominator and builds and extends consensus by collaborating across municipalities. They also see themselves as part of a much larger international context, where the needs of their residents transcend their direct control. Thus, nowadays challenges cross administrative boundaries, often due to globalisation. In some cases, policy problems emerge where causes and effects are difficult to identify, and addressing them requires broader inputs than the efforts of a single actor or policy sector. Lack of adequate answers to people's needs across countries could lead to polarisation and fragmentation.

BOX 10: **INNOVATION SPOTLIGHT: THE GOTHENBURG REGION ASSOCIATION OF LOCAL AUTHORITIES (GR)** (SWEDEN)

GR, a regional association covering 13 member municipalities in western Sweden, has been working to compensate for restrictions imposed by administrative boundaries between the city and the surrounding municipalities since its establishment. The inhabitants of the Gothenburg region want their needs to be met seamlessly, regardless of these imposed boundaries which play no role in their everyday lives.

To this end, GR is enhancing educational collaboration and common employment markets, community care services and transportation, sustainability strategies and competence enhancement in innovative ways. The platform has played a critical role in confronting acute challenges to the region (e.g. the reception of newly arrived refugees in 2015), by helping to cross administrative and sectoral boundaries to find solutions to complex problems.

Source: The Gothenburg Region Association of Local Authorities, Sweden.

Another innovative initiative working to cross broader administrative boundaries is the "Once Only Principle".[88] As a project part of the EU eGovernment Action Plan 2016-2020, it aims to ensure that information from businesses is supplied to public administrations only once, regardless of the company's country of origin. This represents a big push for the Digital Single Market, which is designed to increase the efficiency of business processes, but also possesses huge potential for systemic public sector innovation across countries as well. When data across countries become integrated, the next step is for public services to cross borders. Here, systems approaches are vital to see past existing silos – mental, administrative or thematic – and create value across boundaries and levels.

COUNTRIES ARE GETTING BETTER AT PROBLEM DIAGNOSTICS TO INITIATE SYSTEMS CHANGE

The second trend leading to systemic change is the use of more advanced problem diagnostics. Problem framing is the main key to the use of systems approaches and their impact. The end result will depend on the choice of aspects, relationships and values for inclusion in the debate, as well as how the problems are named and defined. For example, a recent systems approach in Iceland reframed domestic violence as a public rather than a personal matter, enabling the use of different tools and interventions to address the problem (OECD, 2017c). Systems approaches are also necessary to understand new information patterns and to use analytics in a meaningful way, especially taking into account the abundance of available data and enhanced data-processing capabilities (OECD, 2017c). Transformation does not come from big data alone, but from the ability to model interactions between data sources and analyse them in ways that provide greater insight into systemic problems. It is therefore promising to see new initiatives emerging that help to combine data for better problem diagnostics. For example, GovLab's "data collaboratives" project[89] identifies innovative uses of private (often corporate) data to meet public challenges.

Another area contributing to systemic change is the increased use of behavioural approaches in policy making. The study of behaviours helps to examine the complexities and contradictions of human actions and allow the use of behavioural insight initiatives to nudge behaviour. The

OECD recently published a collection of case studies on the application of behavioural insights, including cases from 23 countries (OECD 2017f: 27) in various policy areas such as consumer protection, education, energy, environment, finance, health and safety, labour markets, public service delivery, taxes and telecommunications (OECD, 2017f). One such example is Predictiv, outlined in depth later in this section (see page 67), which allows for the testing of various (behaviour-dependent) policy solutions iteratively on large-scale online panels. These kinds of initiatives help governments understand which solutions would work in practice, much quicker than normally possible, and then scale accordingly. Furthermore, the use of behavioural insights can provide empirical evidence of the complexity and interconnectedness of the personal choices people face every day. This will improve understanding among policy makers of the factors influencing behaviour, thereby allowing for better defined systemic solutions. However, care must be taken to ensure that the tools used to analyse problems do not draw attention away from substance and problem framing. Behavioural insights initiatives have been critiqued (Figure 30) for tweaking around the edges and playing to the mantra of "changing more by doing

Figure 30. **Type of opposition/criticism to applying behavioural insights** (total number of respondents is 60)
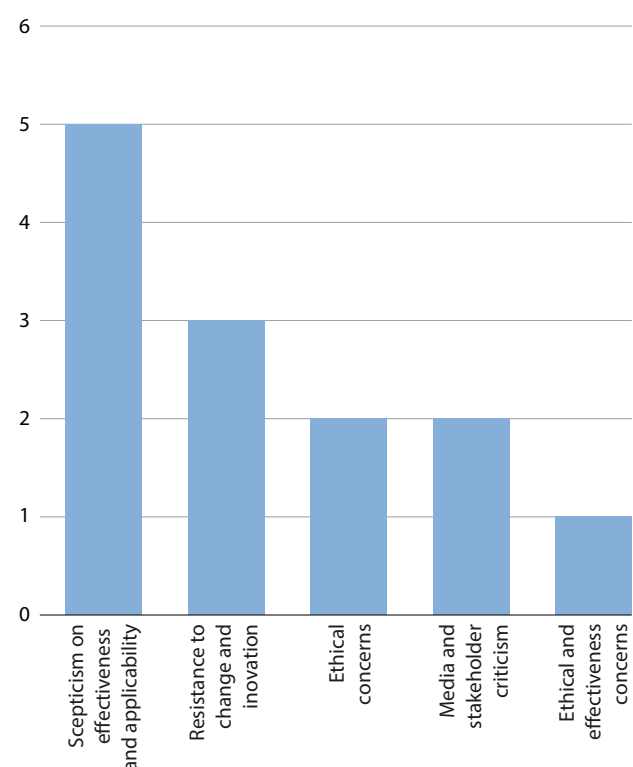
Source: OECD (2017: 34).

less", and in the process holding back fundamental change and innovation. Behavioural insights have been left on their own for too long in government, and should be incorporated into the toolboxes of systems thinkers and public sector change makers.

Nevertheless, systematic use of data in smarter ways for problem diagnostics and potential solutions can lead to better outcomes and also substantial financial savings. In the Netherlands, CBS (Statistics Netherlands) combines its considerable data expertise with real-life urban problems and city policy knowledge (see Box 11). As a federal body, CBS works to support cities through the provision of expertise that cities often lack. The resulting jointly developed Urban Data Centres help to better understanding the current situation and problem dynamics in a city. The centres create location and problem-specific data-driven input for local policy making that can lead to transformative change. In the United Kingdom, the Ministry of Housing, Communities and Local Government (MHCLG) has put in place a data strategy bringing together all data projects under a single programme to promote innovation and a clear and common vision.[90] This holistic approach allows the department to identify interdependencies and efficiencies across the department, consolidating data collection in a single electronic system, setting common data standards and promoting open data. For example, for the evaluation of the Troubled Families Programme, administrative data from 150 upper tier local authorities and three central government departments have been

linked for the first time, creating a uniquely rich dataset. The department has also used algorithms and open data to develop a prototype tool for automating fact sheet briefing.

However, data are not the solution to everything and sometimes existing data are not enough. New ways of analysing and diagnosing problems are needed. The next section of this review outlines the example of the Asker Welfare Lab (page 98) and their transformative diagnostic tool. Other countries have developed similar needs-based methodologies. For example, the MY LIFE initiative in Finland (see Box 12) created a self-assessment methodology to evaluate the life situations and goals of young adults, so as to address them systematically.

Box 12: **INNOVATION SPOTLIGHT: MY LIFE (CITY OF KUOPIO, FINLAND)**

The MY LIFE project (2015-16) worked to develop a comprehensive self-assessment methodology – 3X10D Survey – for evaluating the comprehensive life situation and goals of young adults. The methodology provides professionals with broader information about young people's lives and helps them to assemble the services young adults actually need. The approach enables services to be prioritised and facilitates the division of work between professionals and young adults towards reaching common goals. The initiative also introduced an integrated approach to well-being for young adults.

Source: City of Kuopio, Finland.

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90. See http://opendatacommunities.org.

Box 11: **INNOVATION SPOTLIGHT: URBAN DATA CENTRES (THE NETHERLANDS)**

In 2016, CBS (Statistics Netherlands) started to develop Urban Data Centres (UDC) by combining national data and data expertise with smart, data-driven city needs. The Dutch city of Eindhoven jointly developed an UDC with CBS. The centres are built around the city's interests and needs – smaller towns and big metropolises variably have different interests – by combining national survey, administrative and big data with city data. After launching the first CBS Urban Data Centre, seven additional centres were established in just one year. The concept can also be adapted to and implemented in developing countries, and can contribute to the realisation of the SDGs.

Source: Statistics Netherlands.

4 Advantages of an **URBAN DATA CENTRE**

01 Unique collaboration CBS and The Hague
02 Combining data
03 Rich data sources
04 Quality, privacy security and ISO certification

SYSTEMS APPROACHES INVOLVE TRADE-OFFS WHICH MUST BE EVALUATED

No innovative approach is perfect. All changes have unintended effects, some positive, others negative. This is even more the case with systemic change. An important part of using systems approaches is analysing the value trade-offs connected to different issues, and looking at their unintended effects. One example might be thinking about economic growth in the context of climate change, globalisation and quality of life. Growth is connected to multiple indicators that can be very complex to interpret, and thus must be placed in a broader context (Figure 31).

Figure 31: **Socio-economic context and characteristics of growth**

GDP per capita

Composition of value added, 2015

Income inequality (Gini coefficient)
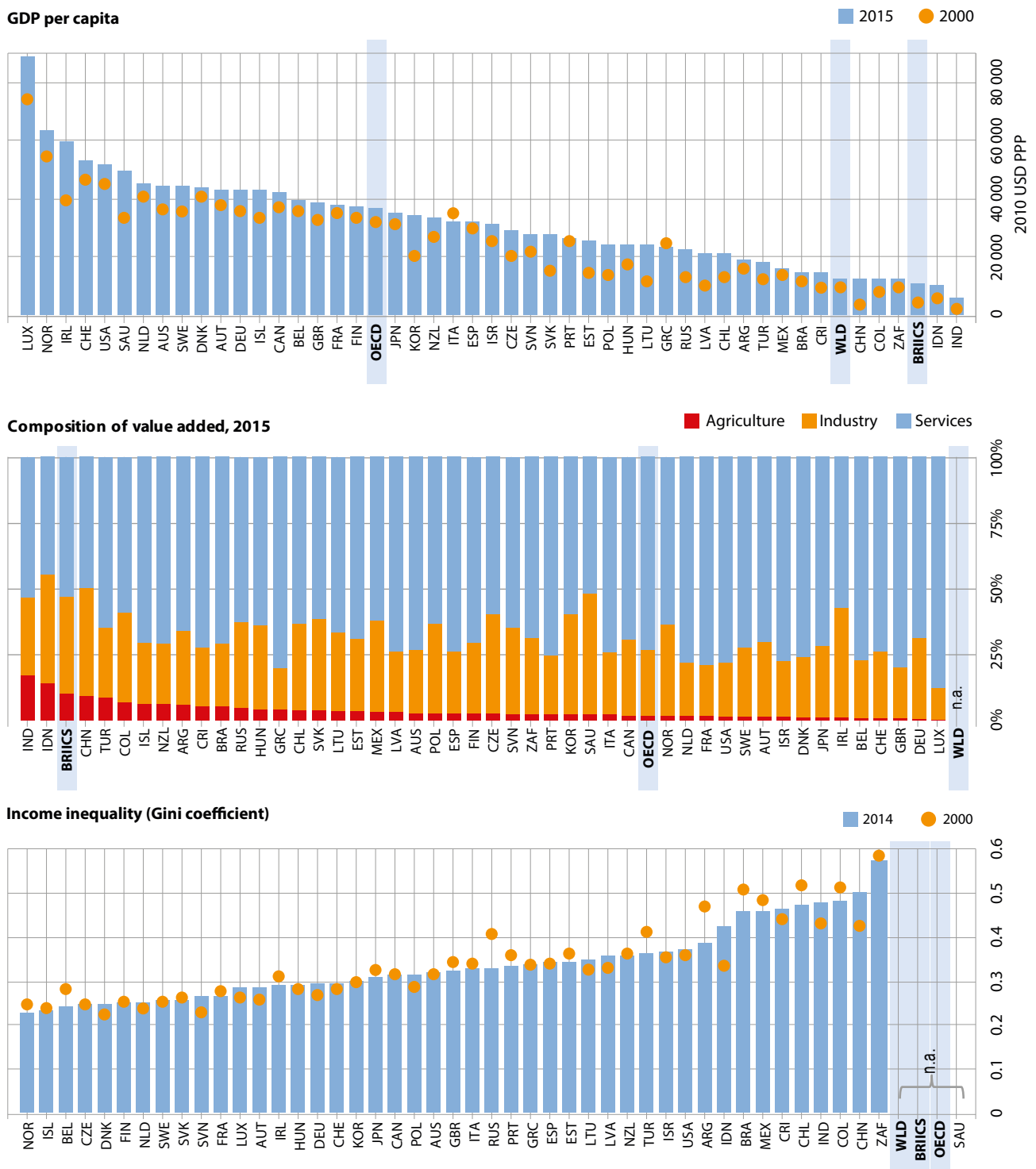
Source: OECD (2017g: 25).

While growth in some circumstances can have positive impacts on air pollution, land consumption and income inequality, in most cases potentially difficult trade-offs are present (OECD, 2017g). This raises the question – which values should prevail and who gets to decide?

Understanding the nature of problems and their interconnectedness also facilitates informed debate about public value trade-offs connected to innovations with systemic effects. For example, what are the trade-offs in an ageing society when a government is working to ensure high labour market participation in later life, while grappling with rising youth unemployment? (Read more about these issues in the case study on Seoul 50+ Policy, page 89.)

The problem with systemic innovation is that, in many cases, societies face proximate failure with distant impacts:

interventions and systems are delivering inadequate results today, but the more detrimental effects are felt only in the future. Climate change is the most obvious example here, but health prevention can also be used as a good analogy. Only a small fraction of all health spending in OECD countries goes towards prevention (Figures 32 and 33), and while countries have made headway with some behavioural risk factors (e.g. consumption of alcohol, smoking), others such as obesity resulting from poor diet and physical inactivity are on the rise (Gmeinder, Morgan and Mueller, 2017). These contribute to chronic illnesses that cost countries far more in the long run than prevention campaigns in the present. The challenge is to change the system while ensuring its continued operation: hospitals and services need to function today, even if governments want to invest in future savings. It is vital, therefore, to determine how to motivate politicians trying to get re-elected today to work on outcomes only visible decades later.

Figure 32: **Spending on health prevention**

Only a small fraction of the health spending goes on prevention activities

...with a large proportion allocated to healthy condition monitoring programmes

9%	Immunisation
7%	Early disease detection
44%	Healthy condition monitoring
27%	Information, education, counselling
13%	Other collective services

2.8%
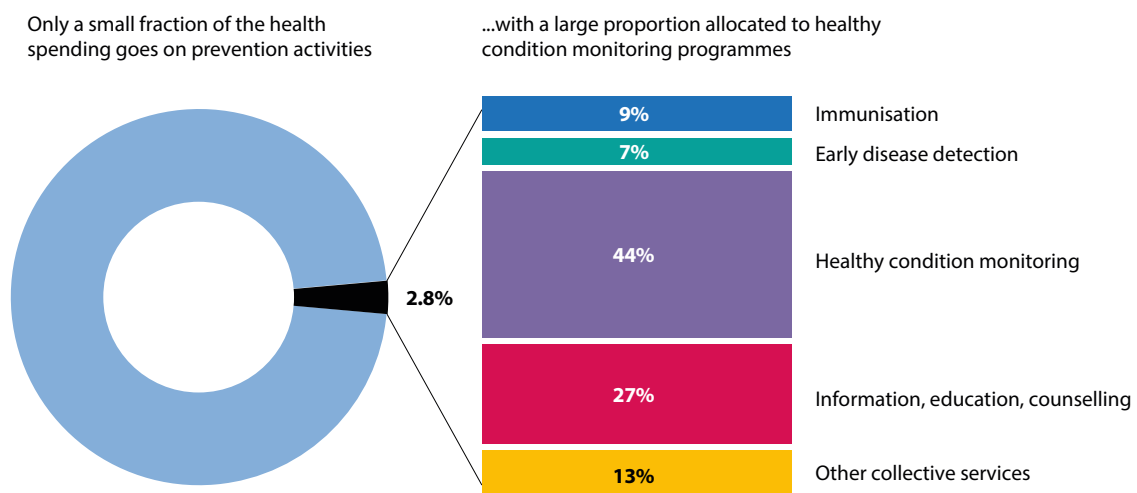
Spending on prevention was particularly affected following the economic crisis

Growth rate (%) in real terms, per capita
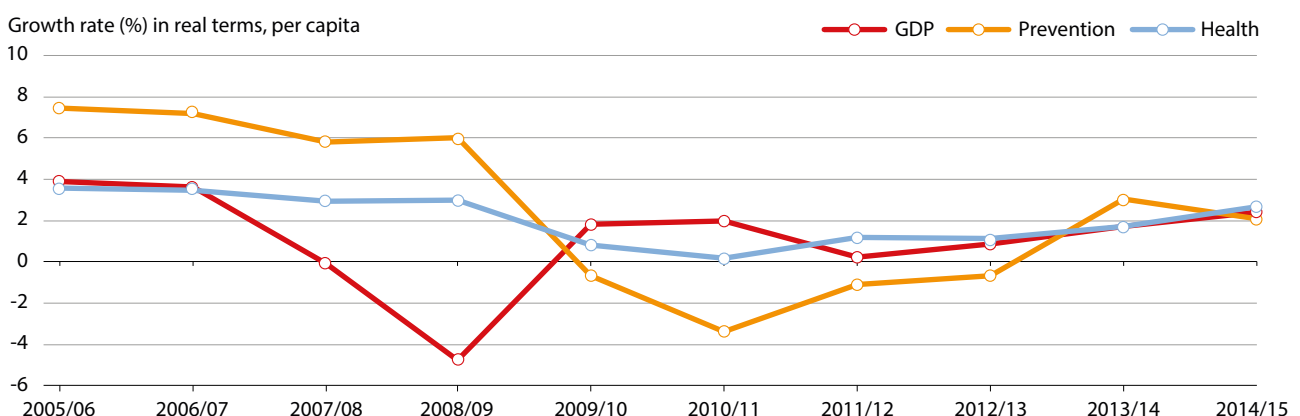
Source: Gmeinder, Morgan and Mueller (2017: 6).

Figure 33: Prevention expenditure per capita and as a share of current health expenditure, 2015
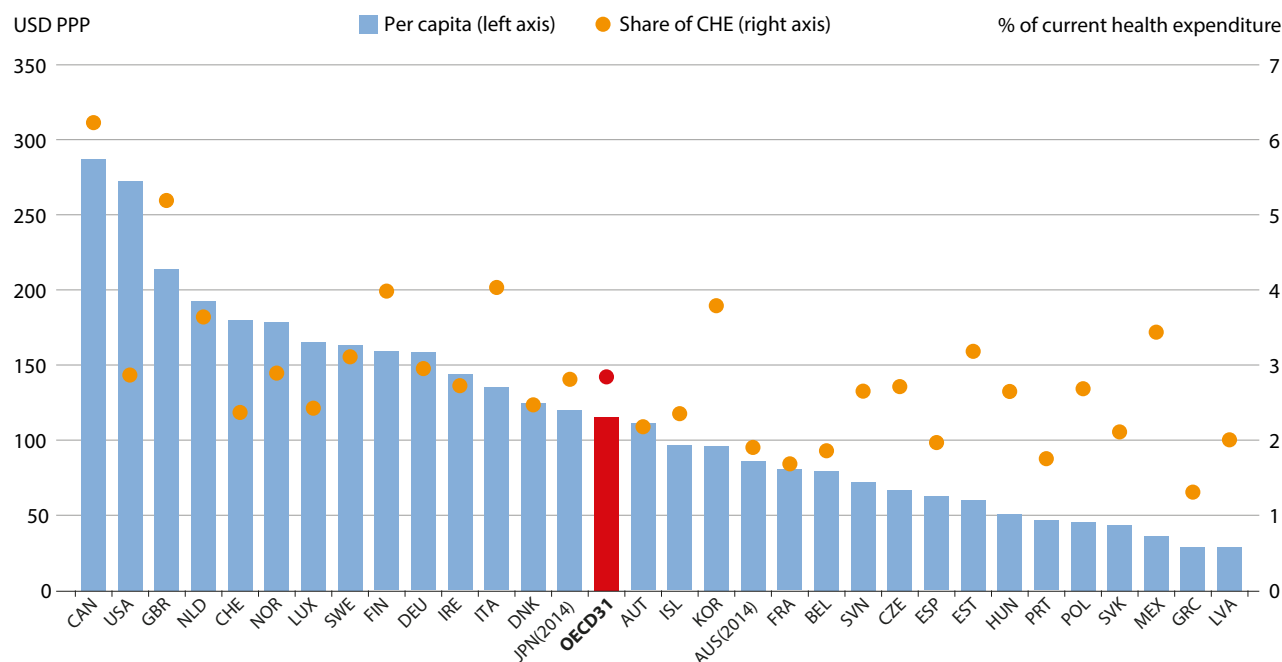
Source: Gmeinder, Morgan and Mueller (2017: 15).

Another complex example is the case of the sharing economy, specifically regulating Uber and other ride-sharing platforms (OECD, 2017c). While such platforms are changing perceptions of the mobility experience for the average consumer, the outcome for cities can include more cars on the streets, destruction of jobs, a rise in precarious employment and possibly economic value being directed away from cities. Thankfully, public sector innovators have started to think about creating spaces for these difficult "value conversations" as part of systems change. These spaces, like ARENA A-Lab in Australia which tackles energy transformation (see Box 13), make it possible for different stakeholders with conflicting interests to come together and discuss different notions of "public value", with a view to finding common ground. The Fusion Point in Sweden (see Box 14) brings together urban planners, developers and academics to discuss and inform action around the biggest urban development in Northern Europe. The City Hall adopted a vision for development defining RiverCity Gothenburg as "inclusive, green and dynamic". However, policy makers did not define, for example, what inclusiveness meant in practice. Is it a mixture of diverse communities living together, more affordable housing or just open access to the new region of the city? Such a large expansion will also affect other parts of the city. Can these changes be planned, anticipated and managed? The Fusion Point debates these issues together with all stakeholders concerned and

informs policy makers about the emerging practice and value trade-offs with the help of leading urban scientists.

Box 13: **INNOVATION SPOTLIGHT: ARENA A-LAB (AUSTRALIA)**

The Australian Renewable Energy Agency (ARENA) is a federal government body that funds new technologies, facilities conversations and shares knowledge about renewable energy. ARENA created the A-Lab in 2016 to break down barriers to renewable energy in Australia.

A-Lab draws on a network of people with a wide range of expertise and passion to make systemic change in the electricity sector. In A-Lab, stakeholders can design and deliver solutions to the most complex challenges of integrating renewable grids, combine their respective strengths and build momentum for change.

A-Lab's innovation frames tangible and tactical programmes of work that aim to solve future energy issues. The approach allows for a diverse group of people with opposing views to explore opportunities and find new and creative solutions.

Source: Government of Australia.

Box 14: INNOVATION SPOTLIGHT: FUSION POINT (SWEDEN)

The Fusion Point practice-based research programme brings together cutting-edge research and urban planning practice to inform the largest urban development project in northern Europe – RiverCity Gothenburg. Twenty years from now, central Gothenburg will be twice its current size. The aim of the programme is to strengthen the exchange between research and practice in architecture and urban design, and to create meeting spaces where different theoretical and practical perspectives fuse in productive ways. The focus is on developing a design methodology for urban development, in which academic knowledge is more efficiently integrated into various decision-making processes of public institutions.

Source: City of Gothenburg, Sweden; http://alvstranden.com/stadsutveckling/fusion-point-gothenburg.

Public value is not a constant, it is a changing variable. The understanding of value should be shared by society, and thus cannot be an elite-led discussion. It is therefore important that a broad base of stakeholders – especially citizens – understand the shifts and trade-offs of planned changes. This means that public engagement is also changing in a systematic way. There has long been dissatisfaction with traditional town hall meetings and public consultations, which tend to be shallow and regressive in nature. One way forward is to increase the volume of engagement. For example, in Korea, the Ministry of the Interior and Safety, with the co-operation of five other ministries, undertook a large-scale experiment entitled "Gwanghwamoon 1st Street" or the "People's Transition Office" to collect ordinary citizen's ideas for the transition to a new government.[91] The initiative was launched after only two weeks of preparation following the new President's inauguration day. People's suggestions were gathered through a variety of platforms including through temporary offices (see Figure 34), local branches installed in every municipality, website, telephone, text message and email. Over 49 days after its launch in May 2017, the initiative collected 180 705 suggestions, 99 of which were reflected in the national agenda and 1 718 were reflected in the policies of individual ministries.

Figure 34. Citizens providing suggestions to government staff at Gwanghwamoon 1st Street temporary office

Source: Government of the Republic of Korea.

New initiatives also aim to deepen community engagement and cocreate solutions with citizens. For example, in Italy, Laboratori di Quartiere (Neighbourhood Labs)[92] aim to shift away from the paradigm of a "smart city" towards a collaborative "Augmented City", requiring citizens not just to collaborate on the use of urban spaces, but to also become part of the ongoing transformation. In Canada, reference panels, citizens' assemblies and commissions (see Box 15) have been used to address complex problems, where different values can be in conflict or the self-interest of decision makers may undermine the legitimacy of their decisions. This is an in-depth, time-intensive format of engagement that can unearth new perspectives to policy problems and make clear what communities actually value.

91. See https://gwanghwamoon1st.go.kr (in Korean).

92. See www.comune.bologna.it/laboratoriquartiere.

MASS LPB has been helping the Canadian government to organise reference panels, citizens' assemblies and commissions for government at various levels since 2007. These have helped to tackle some of the toughest and most divisive issues in public policy, in which complex value conflicts or ingrained political self-interest are involved (e.g. amalgamating municipalities).

As part of its work, MASS has introduced the Civic Lottery process in co-operation with Canada Post. MASS mails tens of thousands of Canadian households each year inviting residents to volunteer to participate in a reference panel or commission. Civic Lotteries produce random-representative cohorts for the communities involved around a specific issue under discussion.

For the deliberative work, MASS has developed the Reference Panel Playbook. Panels typically comprise 36 randomly selected residents who meet over several days to advise government on a specific policy issue. With an explicit mandate, the panels allow citizens to learn about a complex issue from leading experts and deliberate the value trade-offs involved with the help of trained facilitators. Going deeper than traditional consultation techniques, Reference Panels shed light on community perspectives and public policy choices.

To date, MASS has helped to organise 25 reference panels, citizens' assemblies and commissions for governments involving more than 1 000 Canadians, and reaching 250 000 households.

REFERENCE PANEL PLAYBOOK
How to run a deliberative process based on broader social value

Define the task	Ensure independence and balance	Create a curriculum	Host and facilitate
1	**3**	**5**	**7**
2	**4**	**6**	**8**
Plan your response	Who should be in the room	Involve the wider public	Time and money
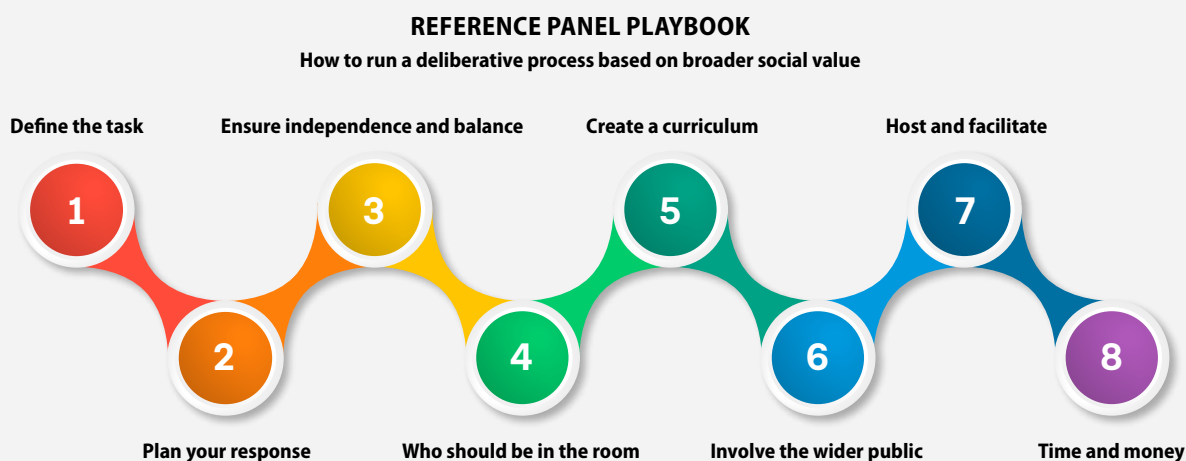
Source: Image based on MASS LBP; Government of Canada. See www.masslbp.com/the-reference-panel-playbook.

SYSTEMS INNOVATORS ARE LOOKING TO SCALE: FROM INCREMENTAL TO RADICAL

Not all systemic innovations are planned in advance. New concepts and approaches emerge from bottom-up experimentation, innovating by doing and technological developments outside the sector. However, governments need to apply solutions at scale, not just to discrete communities. Thus, experiments also need to be applied at the whole-of-government level, to ensure innovations benefit the whole user base equally (e.g. all students within the education system). This raises the question of how to foresee the systemic effects of incremental changes.

The section on identity highlighted the need to be aware of big technological developments, such as AI, blockchain and biometrics. However, many innovations start small or concentrate on a small process segment, but can have lasting ripple effects. For example, open standards and joint operating protocols (e.g. APEX) may have a continuous influence on how partnerships are forged and the kind of cross-sectoral innovations that emerge from the system. Identifying smaller issues within a system can become a source of legitimacy to work with larger problems. Roskilde Kommune has implemented an innovative complaints management system (see Box 16) where faults are used as a way to reach new solutions, some of them quite fundamental. Consequently, it is important to both identify potential levers for systems change – by looking for adequate scale and scope – but also remain open to potential from bottom-up developments.

Trend 2: Systems approaches and enablers

Box 16: INNOVATION SPOTLIGHT: INNOVATIVE COMPLAINT MANAGEMENT (DENMARK)

In 2015, Roskilde Kommune developed an innovative complaints management system. It works by changing an organisation's understanding of complaints, by looking at complaints as errors and faults as a potential for new solutions. The aim is to improve the services offered by the municipality, by perceiving complaints as an opportunity to become a learning organisation.

Traditional complaint processing

Innovative complaint management

Theory of change: Creating new experience and learning with the employees will create the change
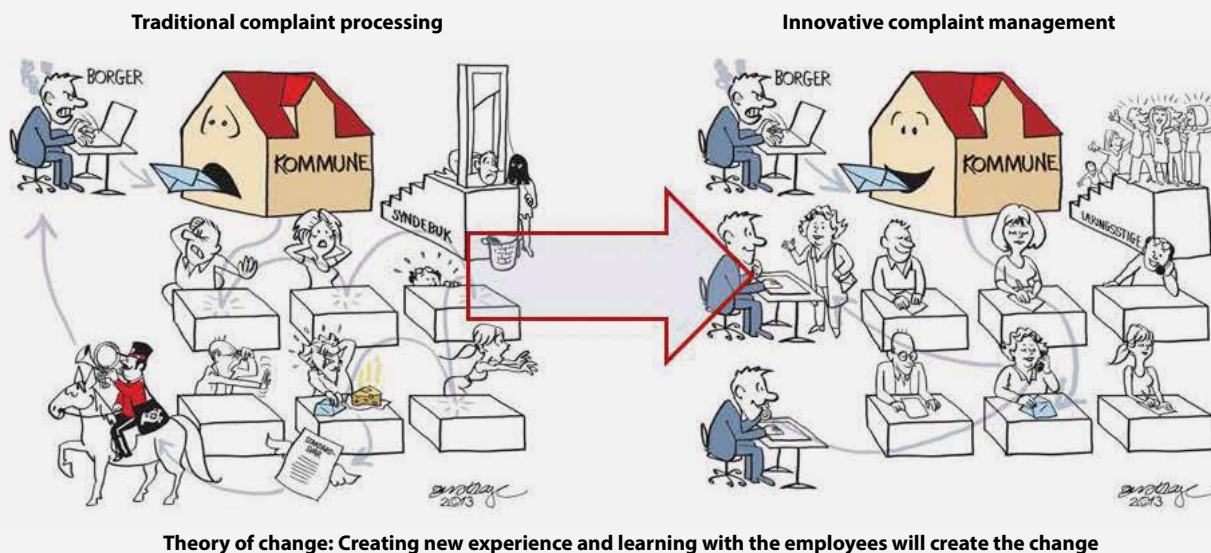
Source: Roskilde Kommune.

Many major systemic upheavals in government can come from things that may at first not seem innovative at all. One example would be to upgrade normal government operation protocols by making them more transparent. As systemic change often entails working across sectoral boundaries, one major lever of systemic change within the public sector is linked to public procurement and demand-based innovation. Governments in-source products and services on a daily basis, but their innovative and transformative nature (i.e. how they enable change for positive outcomes) is only rarely manifested in these transactions. Could governments in-source systemic change within a policy field?

Many OECD countries have developed procurement strategies for innovative goods and services at the central government level, while some have also used them at the agency level (see Appendix 1). However, OECD's survey on public sector innovation enablers (2017b) highlighted the significant confusion that still surrounds funding for innovation. Consequently, many policy makers do not explore demand-based strategies for public sector innovation in practice. This hinders the ability to systematically connect actors outside the public sector with government innovation efforts. Nevertheless, innovators across countries are searching for ways to understand this area better and generate better information about public procurement in general. For example, Code for Australia[93] has worked in sprint cycles for several Victorian Government agencies to find, manage and communicate data in relation to public construction and infrastructure procurement. In Finland, Hansel OY has developed a real-time view of government spending.[94] Here, transparency has become the vehicle for innovation. When suppliers have access to current government spending, they may propose cheaper and more efficient alternatives. Greater clarity around spending not only makes transactions more transparent, it allows governments to work with outside partners towards a common, systemic purpose. Consequently, a simple operational upgrade can lead to a transformative "butterfly effect" within the public sector.

On the whole, governments should keep an eye on radical innovation projects, but also work to encourage bottom-up experimentation and change on the ground that may become a force for transformation in the future. Public sector innovators need to learn to see the systemic effects of incremental innovations.

93. See https://github.com/CodeforAustralia/dtf-genesis.

94. See www.tutkihankintoja.fi.

INNOVATORS USE SYSTEMS APPROACHES TO TRANSFORM THE PUBLIC SECTOR ITSELF

One of the most difficult topics facing innovators is how to incorporate change into government functions. Ensuring today's governments are ready to tackle 21st-century challenges means addressing issues such as the speed of change, technological upheaval and persistent wicked problems, among others. OPSI is currently conducting the first-ever review of a country's public service innovation system – in this case, Canada.[95] The process and results may also provide lessons learned for other countries. The aim is not only to offer public sector innovators in Canada static solutions (e.g. how to make innovation flourish in the country here and now), but also to design an innovation system that is adaptable and robust enough to cope with continuous change.

One of the major topics of concern for public sector innovators in Canada and elsewhere in the world is how to retain talent within the public sector that would enable broader systems change. Innovation is still an emerging topic in many traditional

HR management frameworks, strategies and programmes, and as measures become more concrete – directly influencing civil servants' performance and enhancement – innovation becomes noticeable by its absence (see Appendix 2). However, governments are facing the same challenges as other sectors: jobs are disappearing due to automation and digitalisation which require altogether different mind-sets and skillsets.

These skills may not always be digital, although awareness of technological potential is necessary. Skills that are becoming hardest to substitute with machines – including innovation and creativity – are the most difficult to recruit (see Figure 35). These are the skills most needed also for systems change. For example, some innovators that possess these abilities today are used to working with challenges in a "gig economy" (i.e. working on a challenge-basis rather than in government silos). They expect transformative leadership with autonomy, efficacy and affective commitment. They are attracted to governments due to their civic drive, but are driven away by the inability to apply it in pragmatic ways for better results. Hence, it can be difficult for governments to retain or attract upcoming talent. The Free Agent and GC Talent Cloud case (see page 71) works to address this issue.

95. OPSI will be publishing a review of the public sector innovation system of the Government of Canada in mid-2018.

Figure 35. **The hardest skills to find are those that cannot be performed by machines**

Q: How difficult, if at all, is it for your organisation to recruit people with these skills or characteristics?
Q: In addition to technical business expertise, how important are the following skills to your organisation?

Difficulty in recruiting people with skills
Respondents who answered
"somewhat difficult" or "very difficult"

Importance of skill
Respondents who answered
"somewhat important" or "very important"

Skill	Difficulty
Creativity and innovation	77%
Leadership	75%
Emotional intelligence	64%
Adaptability	61%
Problem solving	61%
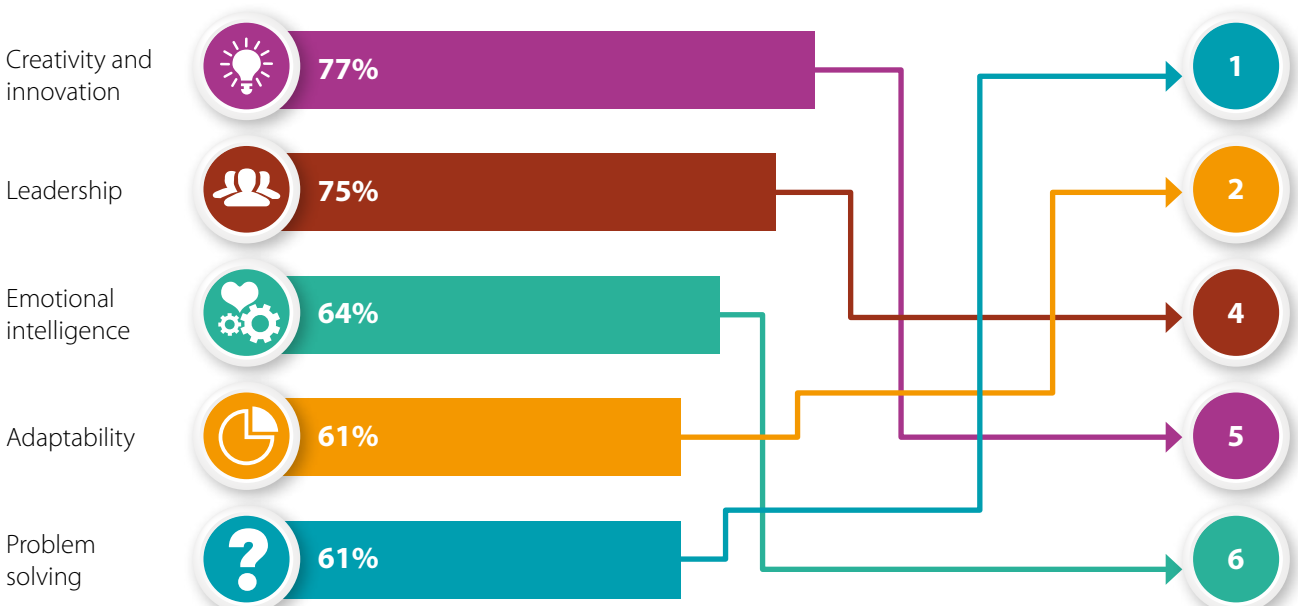
Source: OECD (2017h: 34).

These initiatives recommend that governments refrain from tinkering around the edges of existing HR systems, and instead experiment with more systematic solutions for the mobility of talent across the public sector.

Other governments are trying to build momentum for change from within to help ensure existing civil servants are not ignored by a focus on new teams – a frequent criticism of organisations such as innovation labs, digital service teams and other similar entities. For example, in 2015, the Government of Korea introduced the Personnel Management Diagnosis system with an index to diagnose the level of personnel management innovation in each agency. Using existing structures is a way to internalize the core value of innovation and secure it as a driving force behind management change. The Wicked Lab in Australia has taken an even more granular approach, by developing an Online Tool for Systemic Change (Box 17). The connected tool supports community transitions in real time. It takes an ecosystem approach and increases the coherence of all initiatives in a community that underpin a wicked problem, thus aligning actions and goals.

Box 17: **INNOVATION SPOTLIGHT: WICKED LAB ONLINE TOOL FOR SYSTEMIC CHANGE** (AUSTRALIA)

In 2017, the Wicked Lab developed a tool to help communities and governments address wicked problems (all types) by creating the enabling conditions for systemic change. It focuses on assisting communities to transition to more coherent and effective ways of working. It also assists governments to undertake the unplanned exploration of solutions with communities and the planned exploitation of community knowledge, ideas and innovations. The whole product solution includes apps, education programmes and forums, and was developed to support use of the tool by governments and communities.

Source: Wicked Lab.

HOW TO START USING SYSTEMS APPROACHES?

OPSI has identified five different trends emerging in the field of systems approaches: (i) embracing complexity, (ii) transcending administrative boundaries, (iii) using better problem diagnostics to initiate systems change, (iv) looking for ways to move from incremental change to radical transformation; and (v) using systems approaches to transform the public sector itself. Systems approaches are becoming increasingly popular with public sector innovators who want to deliver real value to citizens, in order to address their complex needs. In so doing, innovators are using new tools and methods to get to the heart of the problems – not only "nudging" citizens, but really understanding what is causing their behaviour and the consequences it will deliver in the future. Meanwhile, citizens are expecting more from their governments. A variety of innovations have been developed that are breaking silos, using new ways to analyse data in systemic ways, discussing the value trade-offs associated with innovations and approaching the scale of change needed in government. The following case studies explore these trends in more depth.

The last of these developments – using systems approaches to transform the public sector itself – is probably the most difficult and raises a number of questions: Where to get started? What is the best way to counteract push-back from the current system, established norms and culture that are not addressing the challenges of today and tomorrow? How can implementation of innovation for systems change avoid becoming destructive (change for the sake of change)?

The following three case studies highlight different strategies. The first starts with a non-threatening technical solution and then approaches the core business (APEX), the second takes the innovation slightly outside the current system (Predictiv), and the third adopts a portfolio approach – implementing a step-by-step proof-of-concept case while advancing the transformative innovation on the side (Free Agents and GC Talent Cloud). While these are not the only options, their practises and the challenges they face provide a variety of lessons.

The route OPSI has taken is to develop a service for governments to help them initiate and push forward systems change processes. The nature of the problem itself determine the way that OPSI introduces governments to systems approaches – even to the level of problem framing. In this way, it has become an objective unifier of different stakeholders connected to complex problems, and a facilitator of discussions in interactive workshops designed to unpack issues and re-examine problem definitions, knowledge gaps and potential solutions. OECD does not have to be the sole architect of these processes; countries can launch these activities themselves with the assistance of systems thinkers. However, OPSI advises all governments to bear some key recommendations in mind.

Recommendations

The time for piecemeal solutions in the public sector is over. Governments interested in successful innovative solutions need to take into account the complex nature of problems in the real world. Systems approaches can help governments tackle cross-cutting issues and analyse problems by focusing on the objectives the public sector wants to achieve, redrawing organisational boundaries based on those objectives, and bringing together different stakeholders able to transcend public sector capacities. To make the most of systems approaches, OPSI recommends that governments:

1. Focus on a problem, not a method. There are a variety of available systems methods ranging from the very quantitative to the very qualitative. It is important to diagnose the problem and the knowledge gap before choosing a method to apply. Systems approaches and methodologies are multifaceted for a reason – they deal with complexity – so there is no shame in asking for expert help. In fact, governments should also seek non-expert help, as the problem cannot be fully defined without input from all those involved. It is better to take more time in the beginning to understand the problem at hand, and define it well, rather than becoming locked into a solution from the outset.

2. Apply new problem diagnostic tools. The more interoperable data become, the more they can shed light on real time practice. New problem diagnostic tools – digitally or ethnographically co-created – can be a great way not only to obtain a different perspective on complex issue, but also to break down silos. Connecting the dots numerically, or creating a persona that speaks volumes, can create more legitimacy to push for more transformative changes organisationally.

3. Analyse potential systemic effects and value trade-offs of innovations. Nothing is perfect. The more systemic innovations become, the more they create winners and losers. Part of adopting a systems thinker mind-set is to analyse which public values innovations are actually trying to address, what are the trade-offs, and what is actually happening in practice (the butterfly effect).

4. Stay open to emergent, bottom-up change. The levers of systemic change may not always come from top leadership pet projects, but from the corner of the desk of a civil servant or coder. Perceiving the potential in small things and creating room for them to grow is a skill in itself. Become a catalyst and a sponsor for home-grown innovators.

5. Experiment with transformative change inside government. Governments have to lead by example. Experiments with systems approaches in back-office government functions can ripple horizontally across government and outward to other sectors and citizens. Governments may not always know the best way, but they should have the courage to experiment.
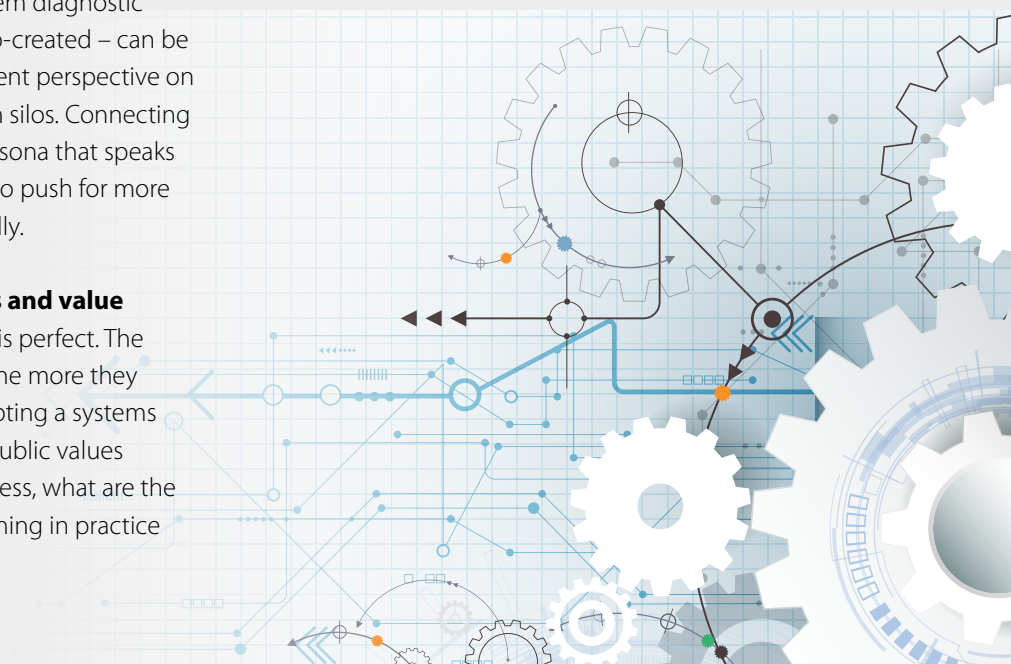
CASE STUDY

APEX – Singapore

APEX[96] is a whole-of-government platform which establishes common application programming interfaces (APIs) (see Box 18) that allow public agencies to share data and services with other agencies and private entities. APEX simplifies the communication protocols by which different government programmes can talk to each other, providing uniform governance, consistency and reliable performance. It enables innovation through a central catalogue and self-service portal where innovators can select common protocols to create new services and experiences for citizens. APEX thus addresses one of the biggest systemic challenges facing governments in the pre-era of machine-to-machine learning and AI – data and system interoperability.

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96. https://portal.apex.gov.sg (only accessible via intranet). The APEX Introduction Video can be downloaded here: https://drive.google.com/file/d/0B84-8GIFcQYKNVdmVVFMWHRVeWs/view?usp=sharing.

THE PROBLEM

In today's fast-paced and digitalised world, government agencies need to evolve quickly to stay relevant. Old methods of data acquisition and transfer are now too slow to satisfy citizen's needs. Consequently, there is a desire for innovative and integrated government services through which data can be shared seamlessly between public agencies. Equally appealing are the potentially more tailored and citizen-centric products businesses can offer if given access to selected agency data. Government agencies therefore need technological solutions to efficiently share data and systems, in order to provide more complete and citizen-centric services. However, data and systems interoperability is not easy. Data-sharing standards are often inconsistent and fragmented, while security needs and privacy concerns frequently dissuade governments from attempting whole-of-government platforms. With the exception of the most technologically competent, the majority of civil servants will encounter difficulties in implementing these new processes and solutions.

AN INNOVATIVE SOLUTION

In 2017, the Government Technology Agency of Singapore (GovTech) launched APEX, a centralised whole-of-government platform designed to allow all government

agencies to share data among themselves and with private enterprises through APIs. Prior to the launch, APEX was a small feature within a platform-as-a-service (PaaS) product that allowed hosted services to expose APIs to external services. However, it became evident that the API-hosting technology could be extended to meet a wider need across government agencies, providing a simple way to share data. The government spun off APEX as a separate project with a much more ambitious scope – to secure data-sharing, make API management user-friendly and increase the visibility of available APIs.

Figure 36. The difference in data sharing through traditional methods and through API gateway

Source: Government of Singapore.

APEX provides a secure data-sharing environment where agencies' APIs are protected by authentication policies that conform to the latest security standards (see Figure 36). Round-the-clock monitoring and transaction logging also ensure high system availability and access tracking. Most importantly, APEX allows data to be shared between the government intranet and the public internet by providing a bridge between the two networks in a safe and secure setup. This makes it possible for government agencies to publish APIs in order to share data hosted in the intranet with commercial entities deploying services on the internet. For example, one of the pilot projects, myInfo, was developed to share basic citizen data hosted on agency databases with banks to make it more convenient for citizens to set up bank accounts. This allows the private sector to build businesses using open government data. It also reduces substantially the number of times citizens need to register their information with the government – from multiple occasions to just once.[97]

97. See www.singpass.gov.sg/myinfo/intro.

Importantly, APEX simplifies API management by providing a user-friendly portal for both experts and ordinary users within the public sector (see APEX design principles in Figure 37). This is a rarity in government – the creation of user-friendly systems inside the public sector is often overshadowed by the prioritisation of intuitive solutions on the front-end for citizens. Yet, making such systems work inside the public sector – where IT skills remain scarce – is the foundation for future innovation. In addition, APIs served through APEX are registered in an API catalogue that can be freely browsed by other users. This encourages sharing and avoids the creation of digital silos or duplication of efforts. Users can browse and search the catalogue for relevant APIs, which may spark ideas for collaboration with other agencies or combining data in creative ways. The ability to perform self-registrations and request access to other agencies' APIs, enables agencies to begin using the data they need without significant administrative overheads. The portal also provides a repository of information to guide users in on-boarding as data consumers or providers. APEX professional services also assist agencies to improve their general standards of API design and security.

Figure 37: **APEX design principles**
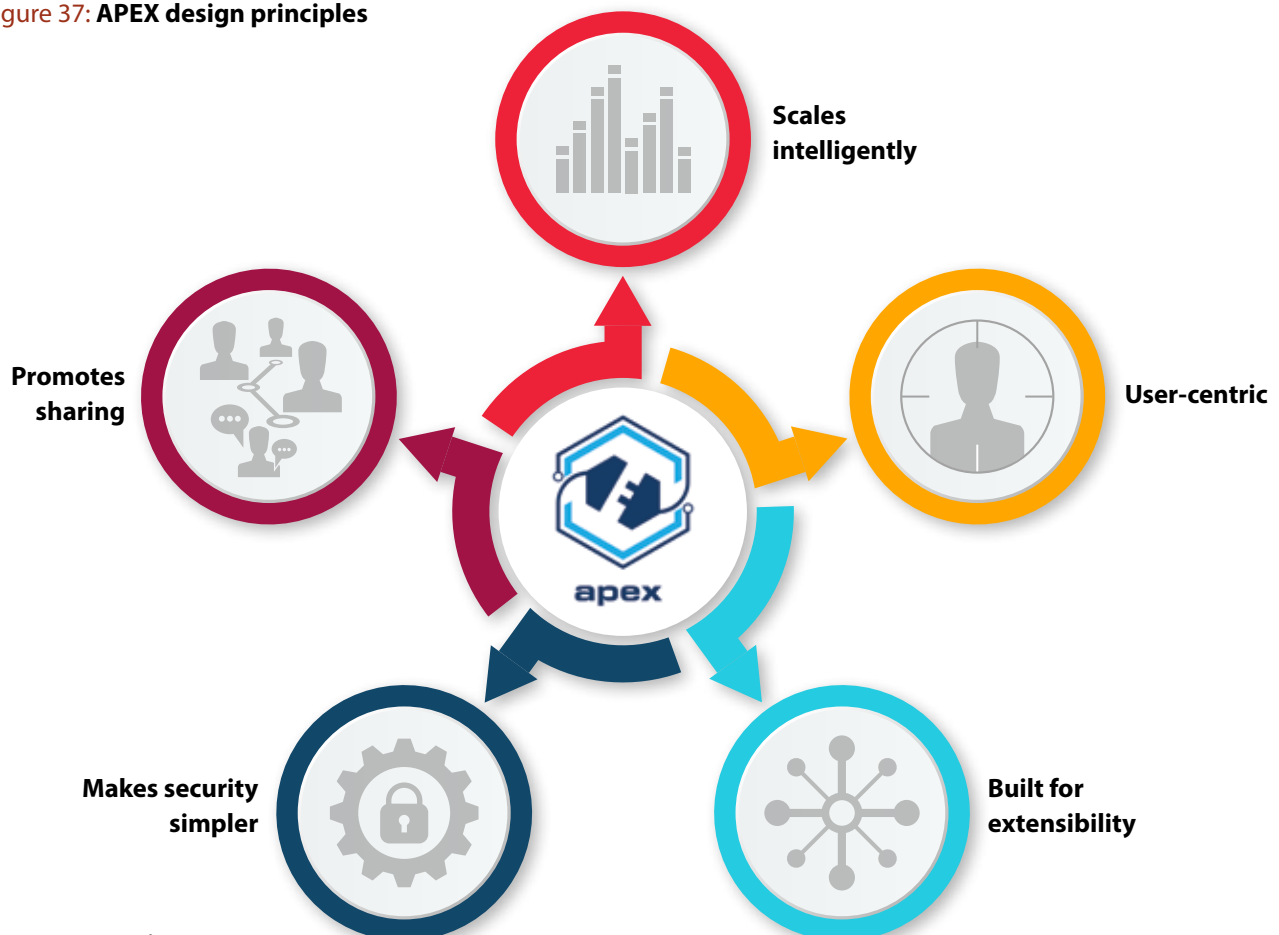
Source: Government of Singapore.

APEX was built by an in-house engineering team around the concept of agile development, thus allowing the rapid addition of new features to the platform. Further modularity was ensured by building the platform on micro-services architecture powered by RESTful APIs.[98] This allows APEX to easily integrate with new systems both upstream and downstream.

NOVELTY

APIs and API gateways are no longer new or innovative technologies. The innovation and value of APEX stems from making these technologies more accessible and increasing their adoption in government. Interconnection and interoperability projects are currently receiving the greatest attention. For example, in Europe the ongoing Once-Only Principle Project[99] is working to pilot solutions for 50 organisations from the European Union and Associated Countries. When technology supports secure and seamless data exchange, the possibilities are endless.

98. Learn more here: https://restfulapi.net.

99. See www.toop.eu/about.

RESULTS AND IMPACT

APEX removes the need for users to handle many of the security challenges involved in serving APIs to a large consumer base. Since its launch in July 2017, APEX has steadily acquired new users, and on-boarded nine projects from across five agencies. These projects served a total of more than 625 000 API calls in a month. These figures are growing rapidly as APEX gains traction as a reliable API platform. For its success in this area, APEX recently received an award from ASEAN (see Figure 38).

USER PERSPECTIVE

The APEX team (see Figure 39) was deeply involved in the on-boarding of its initial users, many of which have become trusted partners. Their positive experience with APEX has spurred them to readily suggest new features to improve their services. APEX's professional services team regularly engages users in dialogue to better understand their needs. This enables them to identify and develop high-value, new user-centric features that can be added to APEX.

Figure 38. **The APEX team receiving the silver award at the 2017 ASEAN ICT Awards Ceremony under the public category**

From left to right: Dr Yaacob Ibrahim, Minister of Communications and Information, Singapore; Johnson Koh and John Tng of the APEX team; and H.E. Mr Masahiko Tominaga, Vice-Minister, Ministry of Internal Affairs and Communications of Japan. *Source*: Government of Singapore.

CHALLENGES AND LESSONS LEARNED

APEX is a model of innovation within tight restrictions that has succeeded in holding on to its vision. The team has navigated extensive government procedures and standards to redefine what it means to share data securely. APEX is reliant on a dedicated team with diverse skill-sets able to provide a clear vision and the impetus to deliver it with speed. Starting small as an in-house project, they had the freedom to self-manage, experiment, fail fast and regroup quickly.

As APEX's success depends on getting partners on board, the platform had to be built with the user in mind. APEX needed to remove barriers to entry for agencies using the platform based on user feedback. As such, the APEX team followed the agile methodology to iteratively and incrementally design, build and validate features of the platform. This helped the team to break down large problems into incrementally deliverable parts and empowered them to respond promptly to user feedback, as well as experiment with new, high-value features. The team was thus able to focus on releasing a minimal viable

product early for testing. This drove a virtuous cycle of testing, iteration and extension, which allowed the team to release regular updates with enhanced features, bug fixes and the latest security patches.

There are, of course, obvious trade-offs between adhering to government security standards and providing seamless data-sharing between agencies which APEX needs to balance. Project challenges identified during the planning phase included the need to bridge an internet–intranet separated infrastructure and comply with strict security standards. These constraints shaped the architecture and design of APEX.

Continuing challenges include scaling APEX's systems to adapt to demand and maintaining system stability as the user base grows. The team has automated the deployment and configuration of most subsystems to quickly and reliably scale-up to meet demand. In order to maintain system stability, monitoring capabilities are continuously enhanced to ensure any system issues are noted and addressed in a timely manner.

Figure 39. **The APEX team**

Source: Government of Singapore.

CASE STUDY

Predictiv – United Kingdom

PREDICTIV

Predictiv[100] is an online platform for running behavioural experiments. It enables governments to run randomised controlled trials (RCTs) with an online population of participants, and to test whether new policies and interventions work before they are deployed in the real world. After a short design phase, the tests take one to two weeks to complete, enabling policy makers to obtain responses to questions that would otherwise have taken many months (or years) to answer. As such, it has the potential to profoundly change governments' working methods. While time constraints and political realities sometimes make it hard to run "field trials" on live policy, Predictiv makes experimental methods more accessible. However, it remains to be seen whether Predictiv will initiate a wider cultural shift in government departments and regulatory offices regarding the ways policies and processes are changed and implemented.

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100. See www.predictiv.co.uk.

THE PROBLEM

Evidence is becoming increasingly important in policy making (OECD, 2016b). Even the best ideas can fail during implementation, because human behaviour is hard to predict, especially in different contexts. However, the policy-making process itself is not always conducive to producing or making use of available evidence. The speed of change is increasing and reacting to new problems on a daily basis does not leave sufficient time to review existing evidence for informed decision making. Parliamentarians or officials drafting a law do not always have six months to wait for their questions to be answered.

Governments possess tools to decrease uncertainty in policy making, but almost no time to use them in practice. For example, RCTs allow policy makers to evaluate what does and does not work in terms of changing behaviour and improving public policy outcomes (see Figure 40). However, they can take a long time to set up correctly and often need to be repeated in different contexts. It can take months or even years to run a research study or to put an RCT into the "field". Furthermore, traditional research methods (e.g. focus groups) are often bound by their size and, in many cases, reveal more about what a small number of people "say they do", rather than what they "actually do" in practice. Practical constraints – both time and money – limit the number of RCTs or focus groups that can be run and the different versions of a policy that can be tested. These complexities inevitably hold back the spread of experimental culture in government.

AN INNOVATIVE SOLUTION

Predictiv was launched in 2016 by BI Ventures, a team within the Behavioural Insights Team (BIT) (see Box 19) that builds scalable digital products that address social issues.[101] Predictiv was built on the premise that running RCTs with an online pool of participants is a quicker, cheaper and easier method to test for isolated behavioural triggers.

Inspired by academic "lab experiments" run through platforms such as Amazon's Mechanical Turk,[102] BIT started to question if a similar approach could be used by policy makers. Effective use of existing platforms such as Amazon

101. See www.behaviouralinsights.co.uk/ventures.

102. See www.mturk.com. MTurk is a marketplace for work that requires human intelligence and enables customers to access an on-demand workforce.

Box 19: WHAT IS BIT?

The Behavioural Insights Team was created by the Prime Minister's Office in 2010 to apply behavioural science to public policy. In February 2014, BIT became a social purpose company, owned by the UK Government, Nesta (an innovation charity) and its employees.

BIT aims to make public services more cost-effective and easier for citizens to use; improve policy by introducing a more realistic model of human behaviour; and wherever possible, enable people to make "better choices for themselves".

Source: www.behaviouralinsights.co.uk/about-us.

Figure 40: **Randomised controlled trials method**

Population is split into 2 groups by random lot

Intervention

Positive change

No change

Outcome for both groups are measured

Control
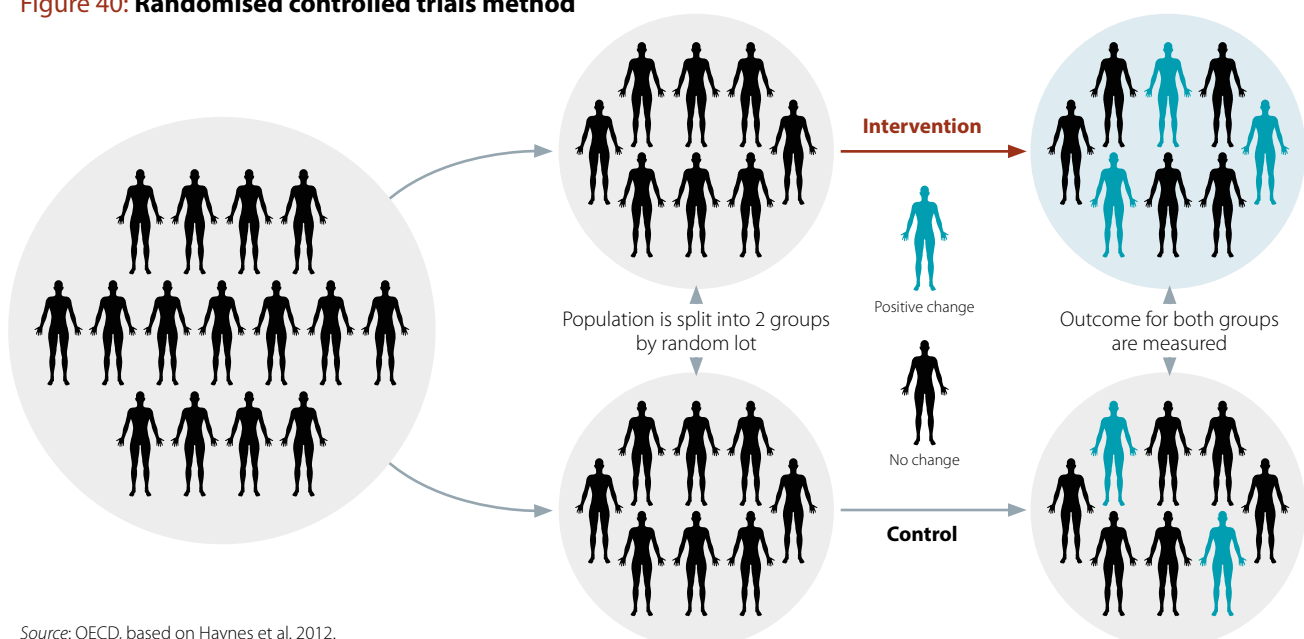
Source: OECD, based on Haynes et al. 2012.

Practical

By drawing on a large online panel of participants, Predictiv avoids many of the practical constraints of traditional research and can run research programmes that wouldn't be possible in the 'real world'.

Rapid & robust evidence

Predictiv recruits participants, runs the online research and summarises findings, generating quantitative evidence fast. We can create nationally representative samples or target specific groups, e.g. men 18-25, in work, with incomes <£20k.

Test a range of ideas

Predictiv tests different versions of a new policy, programme or communication campaign at lower cost vs. traditional research. For example, Predictiv can evaluate many versions of a letter for recipient comprehension.

Source: www.predictiv.co.uk/governments.html.

Mechanical Turk (MTurk) required substantial technical expertise, which represented a major barrier to entry for everyday users. Accordingly, BIT decided to develop its own more user-friendly platform, leveraging its team's technical expertise in behavioural end experimental economics to design and test interventions. The key question was how to reach large numbers of people. In an effort to address this issue, BIT partnered with organisations with experience in using online panels for simple survey-type research. The biggest technical challenge involved randomly allocating different "arms" of a trial to different participants in ways that maintained scientific rigour. Once this challenge was solved, BIT validated the platform through a series of tests to ascertain whether the results were consistent with equivalent, rigorous academic research.

Since its launch, Predictiv has enabled policy makers to obtain answers quickly, within critical time frames, allowing changes to policies as they are being developed. Predictiv makes it easier for a policy team or organisation to run an online RCT from start to finish, without requiring a team of behavioural scientists (see Figure 41). Users can choose from a selection of experiments designed by BIT and based on robust behavioural science and experimental economics methodologies. The platform then recruits the participants, runs the online research and summarises findings, generating quantitative evidence fast.

Predictiv also draws participants from a high-quality and large-scale online pool of adults across the United Kingdom (up to 4 million people) who have consented to taking part in online research. This allows Predictiv to target research by demographics such as gender, age, income and education. This approach avoids many practical constraints of traditional research and enables Predictiv to conduct tests that would not be possible in the "real world". The online platform also allows testing of different versions of policies, programmes or communication campaigns at a lower cost compared to traditional research. This helps to identify which iteration is most effective at achieving the desired outcome.

Government departments are using Predictiv to tackle a wide range of policy questions. These include testing whether citizens understand new policies and processes (interpreting risk, knowledge of actions they need to take, and data consent and sharing); the effectiveness of new ways of working (e.g. how the new online component of a government programme will function); and responses to different choices (e.g. the impact of changing the way prices are presented). For example, Predictiv has been used to test, among others, whether changes to the presentation of credit card statements will increase the size of monthly payments consumers are prepared to make, whether changes to the way consent is sought will increase the number of citizens who agree to share their data with public service providers; and whether changes to an online tax form will increase the accuracy of the information provided by users. In each of these cases the answer was "yes". Apparently small changes can have a big impact on the choices people make.

BI Ventures plans to increasingly automate the platform by building and making available standard "templates" that cover the full range of questions policy makers might want to answer. It is also possible to use Predictiv outside the United Kingdom, as the platform already has links to international online panels.

NOVELTY

While Predictiv was inspired by academic online experiments running on private platforms, it is the first initiative of its kind to make RCTs accessible to policy makers. Policy makers can perform rigorous experiments online in a fraction of the time normally taken, without the need for a PhD in experimental economics. This enables them to test policy suggestions in a matter of days to ascertain whether they have the desired effect.

RESULTS AND IMPACT

More than 30 trials have been conducted via the Predictiv platform to date and the results are already shaping government policy. For example, the Government Equalities Office and the Department for Work and Pensions are using the results of one trial to change government communications around Shared Parental Leave. In addition, the Greater Manchester Combined Authority is rolling out a version of simplified Privacy Notices following another trial. Predictiv is only getting started and many other trials are in the pipeline.

USER PERSPECTIVE

User experience with Predictiv has been positive. The initiative has helped the Money Advice Service run a range of online RCTs as part of its Financial Capability Lab, which was created to test a large set of initial ideas to address financial challenges affecting people in the United Kingdom. "Predictiv enabled us to economically generate robust evidence of whether the ideas could help people overcome some of the key barriers to building a savings buffer, managing credit use and seeking financial help" (Money Advice Service).

The United Kingdom's Office of Gas and Electricity Markets (Ofgem) used Predictiv to optimise a letter targeting disengaged energy customers: "We were delighted with the efficiency of the setup process, the helpful advice provided by the team and the speed at which we obtained results – the whole thing was turned

around in a matter of days. We are definitely hoping to use this service again in the future."

CHALLENGES AND LESSONS LEARNED

In general, BIT takes a portfolio approach to supporting innovations. Some innovations will fail, while others succeed. With Predictiv the main challenge was to identify a technological solution for the interface between the experiment and the online panels. As the platform is not restricted to a defined set of trials, the team continuously develops the platform to keep up with government interest.

Predictiv as a whole has great potential, as it makes robust experimental techniques more accessible to policy makers, who in many cases lack the skills or time to set up larger experimental trials. However, once this "low-hanging fruit" has been captured, the challenge will be to design increasingly complex experiments that closely mirror decisions in the "real world", and then integrate this approach with the full policy cycle (Figure 42). Moreover, digital platforms that permit the inclusion of near real-time user perspectives in policy development indicate a more systematic change in the making – the advent of real-time digital governance, where the public sector can iterate, test and change policies instantaneously in the present.

Figure 42. **Behavioural insights and the policy cycle**
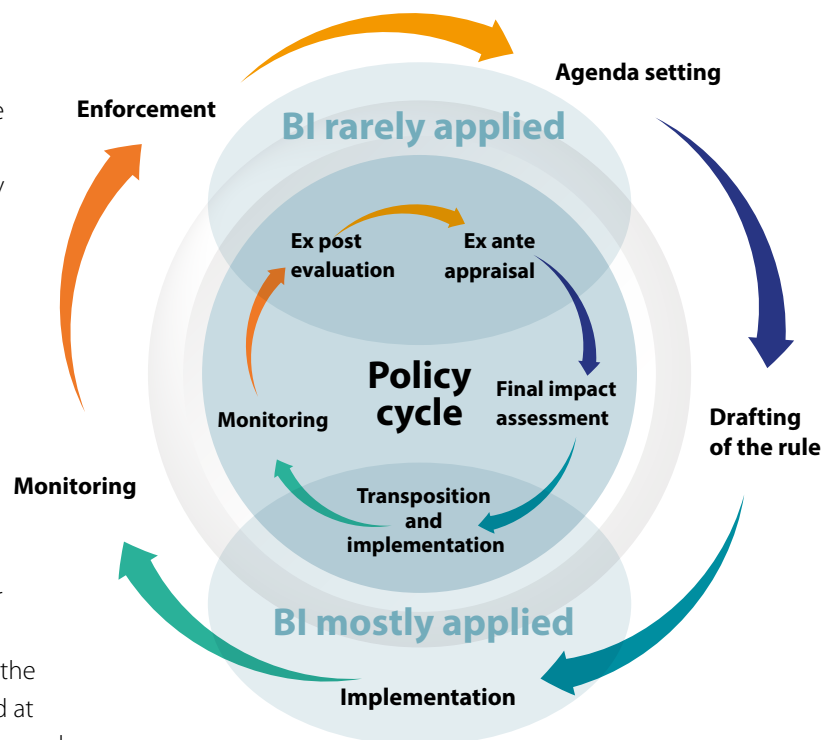
Source: OECD (2017f: 53).

CASE STUDY

Free Agents and GC Talent Cloud – Canada

The Government of Canada (GC) has been testing several models for recruiting and mobilising talent in the Public Service in the digital age. The most ambitious of the projects is the GC Talent Cloud, which aims to become a validated, searchable repository of cross-sector talent. It envisions a digital marketplace where workers have access to rights, benefits and union representation, while retaining the flexibility to choose work inside and outside government, as offered. It represents a departure from the permanent hiring model in the Public Service, organising talent and skills for project-based work. Still at the visionary stage, it has produced several spin-off projects that are becoming successful in their own right. One of these is the Free Agent model, which was originally created as a pre-GC Talent Cloud test of its core design elements. While the Free Agents Model has become a scalable programme, GC Talent Cloud is still getting up to speed and is currently in the design phase. This study looks to Canada to see if governments can lead paradigmatic shifts in a digital age or only innovate in incremental ways.[103]

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103. Canada's Free Agents and GC Talent Cloud are also featured in the 2018 World Government Summit's *Edge of Government* exhibit.
See https://edge.worldgovernmentsummit.org.

THE PROBLEM

In the face of increasingly complex and rapidly evolving challenges, policy makers have to work across silos, bring in new skills and capabilities, and adopt a more horizontal, fast-paced working style. Managers have to mobilise diverse skill sets rapidly to meet shorter project timelines. In parallel, the digital transformation is calling for much flatter organisations, with significant numbers of jobs in the knowledge and service sector likely to be made redundant in the coming decade due to machine-to-machine learning and AI. In the face of this new reality, OECD has identified a need for new leadership styles, working methods and innovation skills in the Public Service (OECD, 2017d, 2017i). However, most governments still rely on workforce models built for a different era.

In Canada, this scenario centres on indeterminate hiring[104] with a temporary workforce complement, which is poorly suited to deliver on the aforementioned challenges. Such employer-driven hiring models result in inefficiency: recruiters have to contend with high application rates to process, high levels of duplication, low visibility for employee skills, low levels of autonomy in choosing work and low retention rates for top talent. All of this is cost and time intensive, with mixed results in terms of "best fit" hiring, particularly for evolving jobs. It currently takes between 90 working days and one year to hire new people.[105] This timescale is inadequate for project-based work, an area of increasing demand in a rapidly evolving digital world.

A hierarchal culture and outdated work systems compromise the Public Service's ability to recruit top talent, and contribute to the loss of public sector "innovators" to the private sector. The Public Service must become faster at bringing in new talent and better at maximising existing talent and accessing new skills. However, it is not enough to invest in piecemeal solutions and streamline existing systems to peak efficiency, as such approaches address only a fraction of real needs.

AN INNOVATIVE SOLUTION

Inspired by the 2012 Deloitte GovCloud concept (Tierney, Cottle and Jorgensen, 2012), the Government of Canada proposed to restructure government workforces to meet the changing needs of citizens in complex environments. In this context, Natural Resources Canada (NRCan) set out to test a new form of workforce planning – the GC Talent Cloud. The central idea was that the GC Talent Cloud would become a new digital platform of pre-qualified talent with a competency validation process and easy searchability. Free Agents was one of its earliest pilots to test out the feasibility (including market viability, efficiency savings, psychological stress on workers in the gig economy, competency modelling and screening design) of a new type of workforce (see Boxes 20 and 21). The objectives of the pilot were threefold:

1. Demonstrate the benefits of the cloud-based free agency model for human resources.

2. Support, develop and retain talented public servants.

3. Increase the capacity of the Public Service to innovate and solve problems.

As many different types of work could benefit from the model, NRCan's Innovation Hub chose to forego the choice of a specific background or skill-set for Free Agents. Instead, the Innovation Hub developed a set of attributes and behaviours that the Public Service innovation community considered valuable for innovation and problem-solving in their organisations. These attributes formed the basis for the pilot's screening process. Candidates who successfully
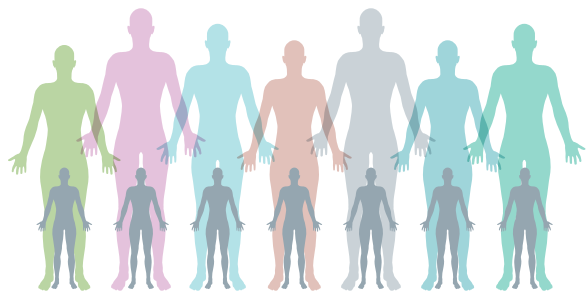
**Ask NOT *"What types of work are being done?"*
BUT *"What is your talent force capable of?"***
GC Talent Cloud project proposal

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104. Hiring people within certain specific brackets of skills and competences.

105. Information drawn from the Talent Cloud Proposal (2017).

Box 20: **WHAT ARE FREE AGENTS?**

"Free Agents" are individuals who possess successful innovation and problem-solving attributes and wish to work in a project-based manner. They are able to choose their work and undertake project-based opportunities across the Public Service. They have the freedom to select work that matches their skills and interests, which allows them to make a contribution that they find meaningful.

Source: Government of Canada

TALENT CLOUD AND FREE AGENTS MODELS

The GC Talent Cloud model

This model represents a vision of a digital repository of pre-qualified talent, where the curation and distribution of talent is optimised for fast placement for project-based work.

Talent is pulled from the repository using a term hiring mechanism, ensuring the protection of workers' rights.

The credentials of those in the GC Talent Cloud are validated and preserved in a way that reduces duplication, increases credential integrity and vastly heightens the scope of talent available to hiring managers.

Source: GC Talent Cloud project proposal from Government of Canada

Free Agents GovCloud model

This programme screens and selects public servants for their attributes and behaviours rather than their traditional educational credentials.

It functions as a pilot test to assess whether these attributes will be valuable for project-based work and will have an impact on problem solving and innovation in the Public Service.

The speed and convenience of the model provides a unique opportunity for managers to rapidly staff their projects with little risk.

Source: Free Agent case description.

demonstrate these core attributes are offered lateral deployments to positions in a special unit of the NRCan Innovation Hub. Because of the lateral deployment model, there is flexibility in the selection process and assessment methodology. Deployments do not need to have clear priorities or undergo a competitive process for appointment.

The Free Agent pilot tracks performance, project outcomes, costs, risks and benefits in order to make broad, data-driven recommendations about the long-term viability of the potential full-scale GC Talent Cloud model (see Figure 43). Work is underway to develop a profile of skills and competencies useful for innovation in the Public Service. Once developed, this profile will provide the framework for

Figure 43: **Benefits of the Talent Cloud model**

BENEFITS

GET THE SKILLS YOU NEED
Talent Cloud sees people, not boxes, allowing managers to hire for cross-classification skills sets, validating candidates for work in multiple classifications simultaneously.

INCREASED OPPORTUNITY FOR DIVERSITY
With an increased rate of turnover in project work and more porousness, there is an opportunity to bring more diversity to the Public Service.

FASTER HIRING
The Talent Cloud design is expected to dramatically reduce hiring manager time in the HR process, reducing risk through better credential verification and "best fit" matchig tools.

RISK MITIGATION

REVERSIBLE
If the Talent Cloud model proves undesirable or not viable, it can be taken apart without damage to people or the current HR system.

COMPLIANT WITH EXISTING POLICIES
The Talent Cloud design is compliant with all existing HR legislation, classification, and collective bargaining agreements.

SUPPLEMENTAL TO EXISTING HR SYSTEM
There is no requirement to replace the exisitng HR system in order to test the Talent Cloud model.

Source: GC Talent Cloud project proposal from Government of Canada.

Free Agents to pursue training and learning opportunities. This profile will draw from existing research undertaken by groups such as the OPSI (OECD, 2017i) and Nesta.[106]

NOVELTY

While Deloitte's GovCloud paper created significant enthusiasm, globally the closest any government has gotten to testing the idea in practice is the NRCan Free Agents model. Other pre-GC Talent Cloud tests in Canada include the micro-missions platform, open badges (verifiable digital micro-credentials), learning pathways and upward feedback.

RESULTS AND IMPACT

The Free Agents programme has now outgrown the single department in NRCan and is scaling, having identified a partner department to hire the next 30 Free Agents.

The pilot is currently undertaking a formative evaluation, but initial feedback surveys show that both the Free Agents and hiring managers have benefitted greatly from the programme's activities. In the first year of the pilot, the programme staffed 42 projects in 20 departments. The projects spanned a broad range of business lines including policy development, communications, science and research, and computer programming. Projects ranged between 2 to 18 months in length; however, the majority (76%) were between 6 and 12 months.

Before candidates enter the programme, many have acted temporarily in positions above their substantive level for long periods. They are frequently encouraged to be innovative; however, during competitive processes many feel they cannot demonstrate their innovation capacity and believe that doing so actually reduces their chances of career advancement. Once in the programme, job satisfaction and enjoyment are considerably higher for Free Agents compared to the rest of the Public Service. Furthermore, the vast majority of Free Agents report new opportunities to apply existing skills and develop new skills, greater access to the innovation community and a higher likelihood of remaining in the Public Service.

Though still higher than the general Public Service, Free Agents reported relatively low levels of agreement with questions of diversity, balancing work and personal life, and mental health. Data from monthly surveys and

journals showed that Free Agents felt some pressure to perform at a consistently high level and ensure that there was no downtime between assignments. The pilot will use the discussions and insights from these workshops to inform the programme's approach to diversity, inclusion, and workplace wellness and mental health. It will also investigate how best to address the unique characteristics and stressors of free agency and put in place safeguards to minimise the potential to overburden the Free Agents.

USER PERSPECTIVE

User perspectives are gathered through surveys both of hiring managers and Free Agents. Based on the results from a survey of hiring managers, the speed and convenience of hiring a Free Agent represent the greatest value provided by the programme. Overall satisfaction among managers with the pilot was very high (90%) and the vast majority would hire a Free Agent again (84%).

CHALLENGES AND LESSONS LEARNED

In the beginning, senior management support was crucial to start experimenting with the Talent Cloud model and piloting the Free Agent test in NRCan. For the Free Agent programme, leadership coverage has become less important since it has demonstrated significant results and the model is scaling. Going forward, the model's success will depend upon staying true to the user-centred, iterative design process that is responsive to changing developments.

Nevertheless, building a paradigm shift in talent management systems takes time, especially in government. There are many legacy systems in hiring, job classification and advancement that require attention. Thus, the more radical GC Talent Cloud initiative is still getting off the ground. The team behind the initiative has left NRCan to go to the Treasury Board Secretariat,[107] where they should be better placed to run the more far-reaching, cross-sectoral experiment. They have laid out a comprehensive, iterative project proposal to build the experimental platform and simultaneously work on the main issues of the gig-economy (including workers' rights, labour relations, rights and benefits, stress on mental health and financial support). However, it remains a grassroots project that will need to rapidly show results to continue to attract funding and support for its mandate.

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106. See www.nesta.org.uk/blog/what-are-skills-and-attitudes-successful-public-problem-solving.

107. See www.canada.ca/en/treasury-board-secretariat.html. The Treasury Board of Canada Secretariat provides advice and makes recommendations to the Treasury Board Committee of Ministers on how the government spends money on programmes and services, and how they are regulated and managed. The Secretariat helps ensure tax dollars are spent wisely and effectively for Canadians.

PEACE, JUSTICE AND STRONG INSTITUTIONS

Inclusiveness and vulnerable populations
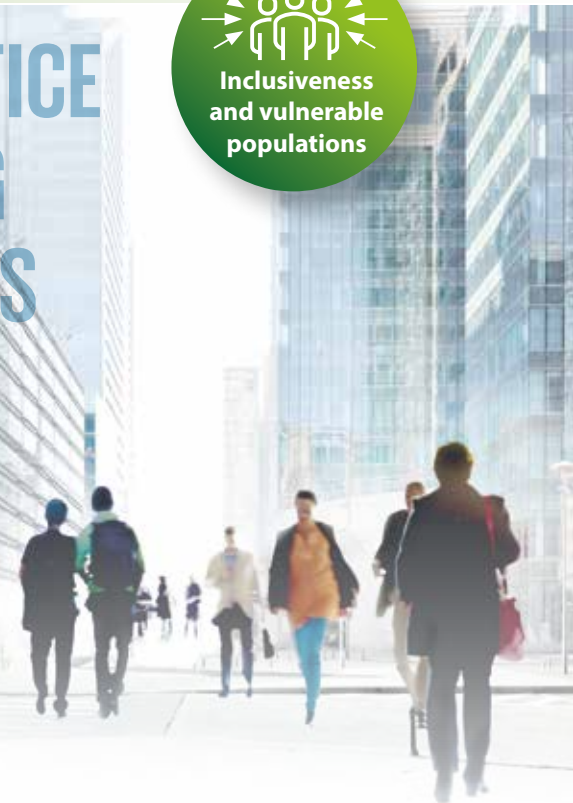
Trend 3:
Inclusiveness and vulnerable populations

In the face of migration and ageing populations, uncertainties about the future of work and job automation, and continued gender and economic inequalities despite decades of attempted reforms, world governments are turning to innovation to help create more inclusive societies where no one is left behind – especially those who are most vulnerable. Many countries have rallied behind global initiatives such as the Sustainable Development Goals (SDGs), while some have acted on their own initiative when confronted with unexpected threats to the well-being of their people. The last few years have seen record levels of people displaced from their homes due to violence and conflict and environmental factors such as climate change, as well as global waves of nationalism that limit the ability of these migrants to integrate well into their new communities. The same period has witnessed targeted gender-inclusion initiatives and a reckoning for gender-based mistreatment, as well as continued disparities in pay and political inclusion. Other major issues are visible on the horizon, such as ageing populations and the displacement of jobs through automation. The world is at a crossroads with governments challenged to acknowledge new realities and create new solutions through innovation.

GOVERNMENTS AND ORGANISATIONS ARE INNOVATING TO MEET THE SUSTAINABLE DEVELOPMENT GOALS

With the adoption of the 2030 Agenda for Sustainable Development, every nation committed to a set of universal, integrated and transformational goals and targets, known as the Sustainable Development Goals (SDGs) (see Figure 44). The 17 goals and 169 targets represent a collective responsibility and a shared vision for the world by 2030. Obtaining unanimous consensus among 193 heads of state and other top leaders was a historic accomplishment, and the SDGs have catalysed a global movement for inclusiveness to improve the lives of the world's most vulnerable populations, among other aspirations. Each country committed to building enabling environments for sustainable development at all levels with the involvement of all actors. This implies new ways of doing things through whole-of-government, whole-of-society and transnational approaches. Such approaches are essential to achieving real transformation in the years to come. This necessitates innovation.[108]

108. See www.un.org/sustainabledevelopment/blog/2015/12/sustainable-development-goals-kick-off-with-start-of-new-year.

"The 17 Sustainable Development Goals (SDGs) are our shared vision of humanity and a social contract between the world's leaders and the people… They are a to-do list for people and planet, and a blueprint for success."
Ban Ki-moon, United Nations Secretary-General, 2007-16

A recent OECD survey[109] found that, in most countries, the centre of government either leads or coleads implementation of the SDGs (see Figure 45). This approach supports innovation and cohesive, cross-cutting implementation, as the centre usually possesses the co-ordination expertise coupled with the necessary political sensitivity to help implementation thrive. It also has an overarching view and convening power, both of which are vital to laying foundations for new paths to success. Line agencies, on the other hand, may have more limited experience in driving cross-disciplinary policies such as the SDGs. The same survey found that countries have identified a number of positive outcomes from rallying around the SDGs (see Figure 46).

109. The Survey on Planning and Coordinating the Implementation of the SDGs was answered by 28 OECD countries and 3 OECD accession countries in 2016. Respondents were predominantly senior officials at the centre of government.

Figure 44: **The 17 Sustainable Development Goals**

Source: www.un.org/sustainabledevelopment/sustainable-development-goals.

Figure 45: Leadership and co-leadership of implementation of the SDGs, 2016

Leadership by the centre of government: 31%

Leadership/co-leadership without centre of government: 31%

United States, Slovenia, Mexico, Japan, Greece, Finland, Estonia, Czech Republic, Colombia, Chile, Slovak Republic, Lithuania, Latvia, Korea, Italy, Ireland, Iceland, Germany, France, Costa Rica, Austria, Australia, United Kingdom, Turkey, Switzerland, Sweden, Norway, Netherlands, Luxembourg, Hungary, Denmark, Belgium

Co-leadership between centre of government and line ministries: 38%

Source: OECD (2017b).

Figure 46: Most positive aspects of implementing the SDGs cited by centres of government

Source: OECD (2017b).

Implementation of the SDGs began in 2016 and has served as a rallying force and a global action plan. It is helping to break down silos both within countries and on an international scale. With a united agenda, countries and cities are innovating to achieve the most ambitious, diverse and universal initiative in the history of humankind. The United Nations has called on countries and their partners in other sectors to foster dialogue and partnerships between governments and innovators, in order to build innovation hubs to transfer knowledge and skills and engage minds around the world.[110] This is encapsulated in a key cross-cutting goal – SDG 17: Partnerships for the Goals. The results of this call to action can be seen in several innovative initiatives that support the full SDG agenda, such as the examples shown in Boxes 22 and 23.

This review found that governments are working to overcome significant challenges and innovating to drive progress towards the SDGs, while instituting broader efforts to foster inclusiveness and support vulnerable populations. Many of these innovations address cross-cutting challenges that can contribute to broad progress among a large swathe of SDGs. The review also identified one area in particular where additional efforts may be needed.

110. See www.un.org/pga/72/2017/09/18/sdg-innovation.

Box 22: GLOBAL PULSE

Global Pulse,[1] the UN's flagship initiative on big data, is a network of innovation labs that serves as a testbed for data-driven innovation. Global Pulse is working to identify ways to use data to push progress in every SDG, such its Haze Gazer[2] tool, which tracks forest fire hotspots in Indonesia in real-time to enhance crisis management, or its use of speech-to-text analytics on local radio content to help understand local sentiments regarding inflows of refugees.[3]

Source: www.unglobalpulse.org/projects/understanding-perceptions-refugee-influx-through-analysis-radio-content.

1. See www.unglobalpulse.org.
2. See http://hazegazer.org.
3. See www.unglobalpulse.org/projects/understanding-perceptions-refugee-influx-through-analysis-radio-content.

Box 23: UNLEASH

UNLEASH,[1] a non-profit initiative developed by core partners from a variety of difference countries and sectors, was launched as a global innovation lab and talent platform. Its objective is to convene people from across the world in networks around the SDGs. UNLEASH aims to disrupt the status quo in order to create a better, more sustainable world, and help incubate and support innovative ideas.

Source: https://unleash.org.

1. See https://unleash.org.

GENDER EQUALITY IS AN UPHILL BATTLE, BUT INNOVATIVE COUNTRIES ARE NARROWING THE GAP

Gender equality is one of the most significant cross-cutting issues in the SDGs. It is formalised in SDG 5: Achieve gender equality and empower all women and girls, but constitutes a necessary platform to achieve progress in every one of the SDGs. Gender equality is not only a fundamental human right, it is also a keystone of a prosperous, modern economy that provides sustainable inclusive growth, and results in the kinds of diverse ideas and perspectives that fuel innovation. Gender equality is essential to ensure that women and men can contribute fully at home, at work and in public life, for the betterment of societies and economies at large.

Unfortunately, in the past five years, countries have made little progress in reaching gender equality goals. Gender gaps persist in all areas of social and economic life and across countries, and the size of these gaps has not changed significantly. Women are less likely to study in lucrative science, technology, engineering and mathematics (STEM) fields, or engage in paid work. Once in the labour market, they are also less likely to advance to managerial positions and generally earn almost 15% less than their male counterparts (see Figure 47). Women also remain under-represented in political and business leadership positions (OECD, 2017j). Furthermore, the proportion of women who choose to run a business has not increased substantially in most countries for many years (OECD, 2015a). Most scientific research does not consider sex or gender as variables and treats male as the

norm, resulting in different health and safety outcomes for women and men (EU, 2013). These inequalities should have long been resolved. There is no reason for women to trail behind men in social, economic and political outcomes. These disparities also cripple innovation by allowing dominant thinking to persist.

However, there are some positive signs that the gaps are narrowing. Although still lagging, women's involvement in politics is growing, enrolment rates in higher education are rising, and participation in the labour market has increased. Gender equality is making significant inroads at the higher education level: in most OECD countries, women already account for at least 50% of higher education enrolments. There is a good deal of optimism that by the mid-century, global gender gaps at the primary school level will have largely disappeared (UK Ministry of Defence, 2014). Many countries have recognised that the status quo is inadequate to achieve meaningful change within an acceptable timeframe, and have instead implemented innovative policies and initiatives.

Many of these initiatives are found in developing countries and emerging economies, which often lag behind advanced countries in terms of gender equality. For example, the "Kanyashree Prakalpa" ("adolescent girls project"), launched by the Government of West Bengal, India, in October 2013, is now demonstrating impressive results.[111] Each day, child marriage affects 41 000 girls

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111. See https://wbkanyashree.gov.in.

Figure 47: **Gender wage gap by country, 2012 and 2015**
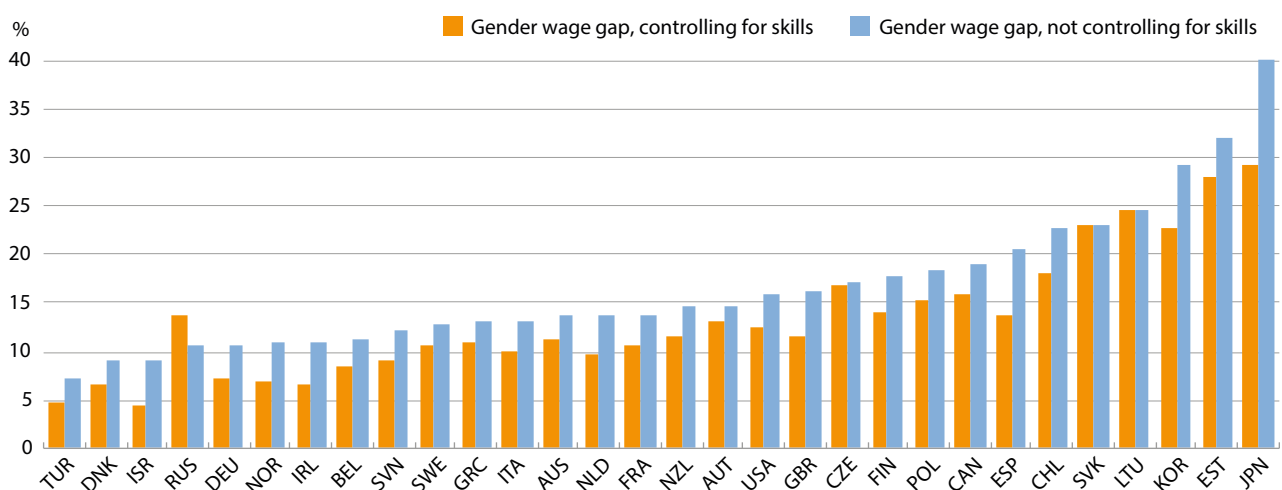
Source: OECD (2017a: 50).

Figure 48: Kanyashree beneficiaries wearing specially designed bangles.
Source: www.wbkanyashree.gov.in/readwrite/notice_publications/000227.pdf.

globally, and India has the highest number of child brides in the world despite the practice being banned decades ago. This unique, tech-driven Conditional Cash Transfer programme aims to improve the lives of millions of low-income adolescent girls through educational, social, financial and digital empowerment. Established on the basis that "education is the cornerstone of an empowered life", the programme's core objective is to ensure girls stay in school and delay marriage until at least the age of 18. It provides an incentive of INR 750 (EUR 10) to girls aged 13-18 for each year that they remain unmarried and in education, with a one-time grant of INR 25 000 (EUR 327) to be paid after a girl turns 18, as long as she is unmarried and engaged in an academic or vocational pursuit (see Figure 48 for a photo of Kanyashree beneficiaries). Girls use this stipend to pay for higher education or start a business. The entire process from enrolment to bank transfer is managed through a single app, which includes a facial-recognition component to prevent misuse of funds.

The programme also works to enhance the social power and self-esteem of girls through events, competitions and the endorsement of strong female role models. In addition, the programme provides career counselling, and financial literacy and parental counselling courses. Since launching, the programme has enrolled 4.3 million girls aged between 13 and 19. Approximately 1.2 million girls have achieved the goal of delaying marriage to 18. Each of these girls now has a bank account in her name. Government data report that the average annual school drop-out rate for girls has reduced from 3.5% in 2012 to 2.9% in 2015. An independent assessment by the Pratichi Institute, India, also shows that enrolment of girls aged 13-18 has grown 11% from 80% to 91% between 2014 and 2016.[112] The initiative has won numerous awards including the UN's highest public service award (Banerjie, 2017).

In another example, the United Nations Development Programme (UNDP) partnered with Microsoft and the National Council of Egypt to launch the Aspire Social Innovation Hub. In Egypt, 78% of women are unemployed and very few undertake entrepreneurial ventures. The Hub seeks to close this gender gap by enabling young women

112. National Informatics Centre, Ministry of Electronics and Information Technology, Government of India submission to the OECD Call for Innovations crowdsourcing exercise, 30 August 2017.

to launch businesses, providing them with training and resources in computer science. At the Hub, young women come together to codesign business concepts that can promote social good, for example, in the fields of health care and refugee aid (UNDP, 2017).

Innovative entrepreneurship efforts are also emerging in Nepal, where female entrepreneurs create cloth from the Himalayan giant nettle plant for products such as carpets and clothing. The extraction process is very difficult and results in health issues. Seeking to make these women's lives better and to improve the efficiency of their businesses, UNDP partnered with the Nepalese Department of Foreign Affairs and Trade to launch a USD 20 000 challenge to develop new technologies for this task. Four recent engineering graduates won the challenge with an innovative solution that simplified multiple stages of the process, reducing creation time from several days to just a few hours. The government is now providing funding to scale up the new approach in 22 districts (UNDP, 2017).

Developed countries have also recognised the need for proactive action. In 2017, the Government of Australia launched the Australian Public Service Diversity and Gender Equality Awards to shine a light on outstanding contributions to workplace diversity. Among the award recipients was NEWinIT (Network of Employment Women in IT), an employee network for Women in IT, based inside the Department of Employment. The goal of the network is to provide inspiration and support to women working in IT by building inclusive spaces, challenging subtle biases and hosting a mentorship programme.[113]

Many countries are looking to drive gender equality through innovative budget programmes. The budget process is central to national policy making. Accordingly,

113. See www.apsc.gov.au/publications-and-media/networks-events-and-seminars/aps-diversity-and-gender-equality-awards-2017/finalists.

Box 24: WHAT IS GENDER BUDGETING?
"Gender budgeting is a way for governments to promote equality through fiscal policy. It involves analysing a budget's differing impacts on men and women and allocating money accordingly, as well as setting targets –such as equal school enrolment for girls – and directing funds to meet them."

Source: OECD (2017b); *The Economist* (2017).

more and more countries are viewing gender budgeting – an innovative application of gender mainstreaming in the budgetary process – as an increasingly important tool for promoting gender equality and inclusiveness (see Box 24). This involves the integration of a clear gender perspective within the budget process, through the use of special processes and analytical tools, to promote gender-responsive policies that aim to address gender inequalities and disparities. A 2016 OECD Survey on Gender Budgeting showed that over one-third of OECD countries (12 countries) have introduced gender mainstreaming in their budgetary process. However, the majority have no such plans (see Figure 49). Gender budgeting practices vary in those countries where they have been introduced, and there appear to be three broad categories of gender budgeting systems:

1. Gender-informed resource allocations, where gender assessments inform individual policy decisions and/or funding allocations.

2. Gender-assessed budgets, where the budget as a whole is subject to gender assessment.

3. Needs-based gender budgeting, where a gender needs assessment forms part of the budget process.

Big data analytics is another innovative approach being used to address gender equality issues. Recent research by

Figure 49: **Status of gender budgeting**
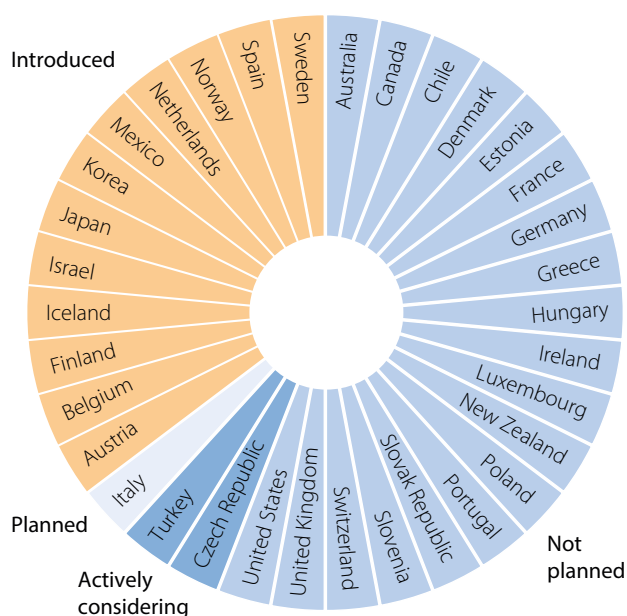
Source: OECD (2017b: 131).

Figure 50: Data visualisation of gender disparities in childhood stunting
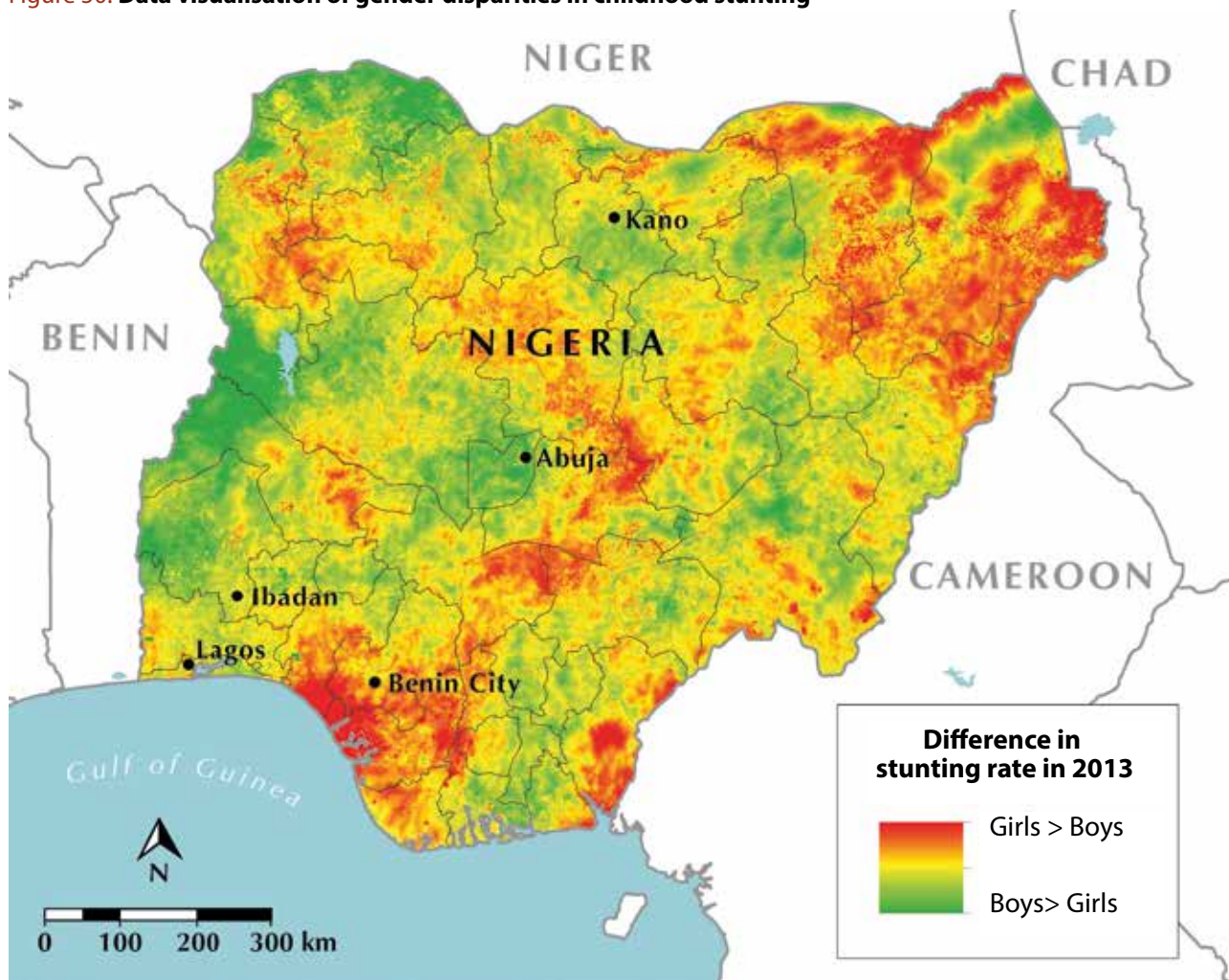
Source: Bosco et al. 2017. WorldPop Program, Flowminder Foundation, University of Southampton; Data2X (2017).

Data2X[114] – a joint effort of the UN Foundation, the William and Flora Hewlett Foundation, and the Bill & Melinda Gates Foundation – has surfaced a number of innovative big data projects aiming to better understand the social and economic status of women and girls (Data2X, 2017).[115] Such knowledge is a necessary foundation to solving inequality challenges through innovation. The following are just some of the fascinating applications of data analytics for gender equality:

● The use of anonymised credit card and mobile phone data to understand women's purchasing and mobility patterns, in order to help understand their needs and priorities. This can help governments better target services.

● Analysis of tweets and the use of machine learning to identify symptoms of depression in women and girls. This approach accurately detects mental illness 96% of the time, and could, for example, enable automated responses that provide information on seeking help or counselling.

● The use of geospatial data and satellite imagery to identify gender disparities in areas such as girls' stunting or women's literacy, which can help target services (see Figure 50).

More certainly needs to be done to achieve gender equality and to make the necessary (and long overdue) progress. However, these innovative initiatives are promising and it appears that the SDGs are accelerating progress in this area.

114. See http://data2x.org.

115. See http://data2x.org/wp-content/uploads/2017/03/Big-Data-and-the-Well-Being-of-Women-and-Girls.pdf.

GOVERNMENTS MUST ADJUST TO AGEING SOCIETIES

The challenges posed by ageing populations cut across the SDGs on poverty eradication, good health, gender equality, economic growth and decent work, reduced inequalities and sustainable cities. A combination of low fertility rates and longer life spans will lead to future ageing in all major regions of the world. At current rates, there will be almost the same number of people over-60 as the number of children by 2050 (see Figure 51). This represents a radical change from the past and present. Currently, the global population includes approximately 900 million people aged over 60. This number is projected to increase to 1.4 billion by 2030 and to 2.1 billion by 2050. Europe is expected to have the largest proportion of over-60s (34% in 2050 compared to 24% in 2015). But rapid ageing will occur in other parts of the world as well, particularly in Asia (UN, 2015a). Almost 80% of the world's older population will live in (what are currently) less-developed regions. By 2050, China will have about 330 million citizens aged 65 or more, India will have about 230 million, and Brazil and Indonesia will each have over 50 million (UN, 2011). Globally, the number of over-80s is expected to multiply threefold by 2050 (from 125 million in 2015 to 434 million

in 2050 and 944 million in 2100). The proportion of people aged over 80 accounted for just 1% of the OECD population in 1950, but had increased to 4% in 2010 and is projected to rise to almost 10% by 2050 (OECD, 2016a: 30).

Ageing implies changes in lifestyle and consumption patterns, which will have significant implications for demand for types of products and services. High old-age dependency ratios, together with more prevalent non-communicable diseases and increased disability among the elderly, will place considerable burdens on healthcare and other services. Ageing-related illnesses, including cancer and dementia, may also increasingly dominate government focus areas, such as health agendas (OECD, 2016a). Governments today must prepare for the challenges of tomorrow's ageing population. Some countries have already launched innovative programmes to address this issue.

The Seoul Metropolitan Government (SMG) in Korea is addressing these challenges head-on through its "Comprehensive Plan for 50+ Assistance", or more simply known as the "50+ policy", as profiled in the case study on page 89. While other countries anticipate a time when their young and old populations have equal numbers,

Figure 51: **Global parity between seniors and children**

The older population (80+) will be predominantly female by 2050
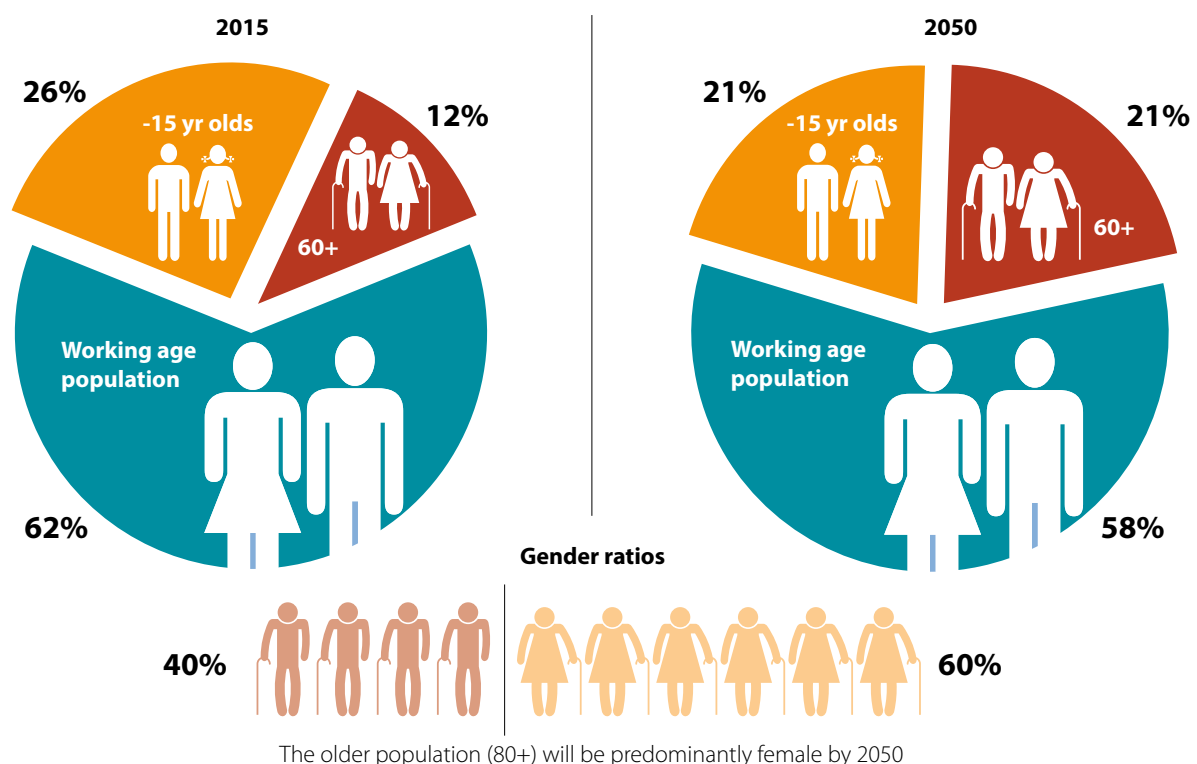
Source: OECD (2016a: 28).

Korea already has more old citizens than young, and is ageing faster than any other developed country (Steger, 2017). The innovative 50+ policy creates new, systemic social innovation models for Koreans in their 50s and 60s transitioning to later life. These include life training, emotional support and retraining for continued employment and engagement with society.

The UK-based innovation foundation NESTA[116] and the European Commission-backed Active and Assisted Living Programme (AAL Programme)[117] are also working to support ageing populations. Their joint initiative, the "Smart Ageing Prize", promotes the use of innovative technologies to help older people build stronger social bonds. It also encourages community involvement to help improve well-being and quality of life among the older generation. The programme has an open application period and provides mentoring and support to a handful of semi-finalists. In September 2016, the partnership awarded the first prize of EUR 50 000 to "Activ84Health",[118] which gives residents of nursing homes the ability to virtually tour the world via video projection while cycling on exercise bikes. The call for entries for the second prize is now open.[119] NESTA is also halfway through a five-year project to track a number of innovative ageing initiatives,[120] such as efforts to provide digital badges to encourage running and an app to activate nearby individuals trained in first aid in case of need. This type of longitudinal tracking and reporting from lessons learned is rare, and the findings may prove very useful to governments.

The Australian Centre for Social Innovation (TASCI) is working to support ageing populations by focusing on carers. Their Weavers initiative[121] is a peer-to-peer programme designed to support carers, who often bear a hidden burden that can affect their wellbeing. The programme connects carers with trained individuals, who also have caring experience, in order to help equip them with tools and ways of thinking to improve their own wellbeing and better enable them to care for others. It was co-designed with carers and uses evidence-based practices to help participants overcome the significant challenges of caring for loved ones. In 2016, they open sourced the programme to allow others around the world

to adapt and replicate Weavers at no cost. Open sourcing the programme also allows others to improve on the model and share the improvements with the Weavers community for everyone's benefit.

WAVES OF MIGRATION HELP SOLVE SOME CHALLENGES BUT CONTRIBUTE TO OTHERS

Migration is one of the signature challenges of the 21st century and cuts across at least half of the SDGs, including those on education, gender equality, work and economic growth, and peace and justice.[122] Countries around the world have seen massive rates of migration in the last few years, whether by choice for individuals who seek new jobs or experiences in countries other than their own, or by force for refugees pushed from their homes due to conflict or disasters. While the causes and experience of migration can be traumatic, this trend may have some positive outcomes. As discussed previously, many countries are facing major problems related to ageing populations, with the size of the working-age population insufficient to provide for the dependent population (those younger than 15 and older than 64). International migration may help to reduce anticipated labour and skills shortages in receiving countries (see Figure 52). The central scenario in the OECD's long-term growth projection assumes that inflows of migrant workers will be an important factor in mitigating ageing in most OECD countries (Westmore, 2014).

Many migrants bring qualifications and skills with them. In 2011, there were 31 million highly educated migrants in OECD countries, with high-skilled migration increasing by 72% over the last decade (OECD, 2015b). This can represent

122. See https://unofficeny.iom.int/2030-agenda-sustainable-development.

Figure 52: **Population and migration, OECD, 1990-2060**
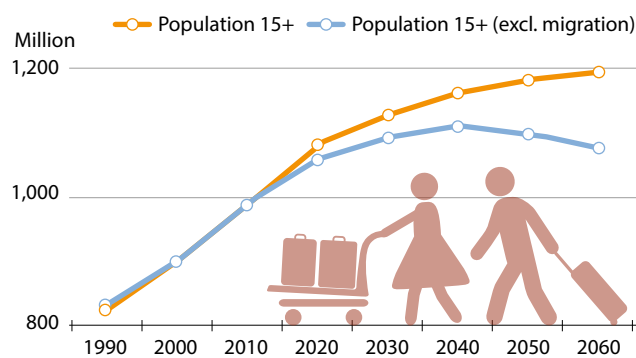
Migrant workers will be an important factor to mitigate the effects of ageing in most OECD countries

Source: OECD (2016a: 29).

116. See www.nesta.org.uk.
117. See www.aal-europe.eu.
118. See www.activ84health.eu.
119. See http://aal.challenges.org.
120. See www.nesta.org.uk/blog/three-scaling-insights-accelerating-ideas-fund.
121. See http://tacsi.org.au/project/weavers.

tremendous value for receiving countries. However, migrants' skills are often not fully utilised in the labour markets of destination countries, and close to 8 million migrants with tertiary education in OECD countries are working in low and medium-skilled jobs (OECD, 2015b). This, in part, can be caused by a lack of services that help migrants adjust to and establish themselves in their new environment. However, governments have developed innovative programmes to help migrants build prosperous lives in their new homes. For example, Mexico's National Savings and Financial Services Bank (Bansefi), a development bank created by the federal government, launched mobile branches in 2017 for Mexican citizens migrating from the United States (see the case study on page 94). The initiative was a response to the uncertain futures of approximately 600 000 Mexican "Dreamers" and other Mexican citizens in the United States, many of whom went to the United States as children. Dreamers also usually have higher-skilled and higher-paying jobs than other undocumented immigrants (Parlapiano and Yourish, 2018). To date, 11 mobile branches have opened along the border and one at the Mexico City airport, providing bank accounts, insurance and other services for migrants coming from the United States.

In another example, the Swedish Association of Local Authorities and Regions (SALAR) launched Co-Lab Sweden in 2016.[123] This innovative, cross-sectoral innovation lab for user-centred creation of solutions was set up to address the complex challenges faced by approximately 50 000 unaccompanied minor refugees arriving in Sweden as refugees. These young people have to interact with numerous public and non-governmental organisations that do not necessarily communicate well and tend to work in silos. The massive influx of unaccompanied minors created an urgent need for new forms of interaction between support organisations to better address the situation of this particularly vulnerable group.

Co-Lab Sweden brings together the target group, unaccompanied minors, with a host of organisations from public, private and civil sector organisations to cocreate solutions designed to ease the transition process and better integrate the refugees. It has enabled the development of a common platform and a common understanding among users and a diverse set of stakeholders of the situation and the everyday lives of unaccompanied minors. The cocreation process has produced ideas, which are currently being tested,

on how to empower the minors and how to enable different types of stakeholders and organisations to build capacity to collaborate in new ways and develop more effective means of working with unaccompanied minors (see Figure 53).[124]

Many challenges for migrants arise from the lack of a formal identity. The absence of an official identity locks them out of numerous government and private services, as well as the broader economy. The Identity section of this review discusses the ambitious and innovative ID2020 initiative, which aims to provide an official identity to the 1.1 billion people who live without one – many of whom are migrants (see page 22). ID2020 is a direct response to SDG 16.9: to provide legal identity for all by 2030.[125]

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124. SALAR submission to the OECD Call for Innovations crowdsourcing exercise, 31 August 2017.

125. See https://sustainabledevelopment.un.org/sdg16.

Figure 53: **Co-Lab Sweden co-creation session**

Source: Co-Lab Sweden.

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123. See www.fornyelselabbet.se.

The recent humanitarian refugee crisis seems to have receded over the past year, following unprecedented high inflows during the second-half of 2015 and early 2016 (OECD, 2017k). However, all signs point to a further strengthening of factors pushing and pulling migratory flows in the decades to come. Youth bulges in some parts of the developing world are creating conditions ripe for outward migration. A likely lack of employment opportunities and growing risks of internal conflict will force many to seek better lives and safety elsewhere. Climate change may also have an influence on future international migration flows (European Environment Agency, 2015). Countries and cities around the world must continue to innovative in order to cope with migration as an ongoing reality and to take advantage of the positive contributions migrants can make to their communities.

SYSTEMS APPROACHES ARE SUPPORTING THE MOST VULNERABLE

The previous section of this review focused on systems approaches to tackling public sector challenges, as well as examples of technologies and tools that connect information and services in ways crucial to making true systems transformation a reality. By their very nature, systems approaches are cross-cutting and affect many areas of policy and society. Thus, governments are undertaking innovative systems initiatives to help their most vulnerable populations. As discussed in the following case study (see page 98) the Asker Welfare Lab in Norway is applying innovative systems approaches to help their most vulnerable citizens, including refugees, vulnerable youth (e.g. dropouts) and families with children with disabilities. Multi-disciplinary, citizen-centred "investment teams" are assembled with representatives from all

Figure 54: **Investment team training to use the "Mapping Tool" to map a client's life situations**

Source: Asker Municipality.

relevant social services working together, as opposed to the typical fragmented ways in which services are often provided (see Figure 54). These investment teams receive specialised training in investment thinking and work with clients to identify areas in their lives where service investments can have the greatest impact.[126]

Innovative systems approaches are also being used to tackle domestic violence. The Iceland Government has launched the United Against Violence programme to address violence against women. The programme introduced a new, integrated support system for victims based on the concept that domestic violence is a social (and not private) harm that affects everyone. The programme is grounded in a radical systems-change concept that centres support around the victim and concentrates on stabilising the family, rather than focusing on providers and authorities (lawyers, police, social services, etc.). The police, social and child protective services (and increasingly schools and healthcare providers) now work in a co-ordinated fashion to detect and respond effectively to domestic violence across Iceland (OECD, 2017c).

In another example, since 2016, Portugal has been linking data from sources across the public sector, with a view to easing the financial burden for over 800 000 economically vulnerable households, by providing them with affordable electricity and gas services. Data from the Social Security department, Tax Authority, Department of Energy and all energy suppliers are connected and automatically apply a discounted rate based on criteria such as income, or reductions for the beneficiaries of social programmes such as family allowances, or disability and unemployment benefits, among others. The key to this innovation is that all processes are automated, removing the need for the beneficiary to take any action. Before the process was automated by linking up data, many vulnerable residents were reluctant to take advantage of the programme, as they had to request it manually and often encountered difficulties in providing the many forms of documentation needed to demonstrate eligibility. The key enabling component of the automation process is the Integration Platform developed by the Administrative Modernization Agency (AMA).

These are just a few examples of cities and countries beginning to employ systems approaches that are custom designed for their most vulnerable citizens. The OECD has seen a significant rise in the establishment and implementation of these programmes in recent years, and expects this trend to grow in the foreseeable future.

GOVERNMENTS NEED TO INNOVATE IN THE FACE OF JOB AUTOMATION

Governments are experimenting with new, inspiring and innovative approaches to promote inclusion and protect their most vulnerable citizens and residents. However, in conducting this research and reviewing the cases received through the OECD's Call for Innovations, it became apparent that less attention was being paid to a cohort of the next generation of vulnerable people: those whose jobs may be replaced through automation by robots, AI, and other technologies. New production technologies are reshaping the availability and nature of work. It is therefore important that strategies for inclusion understand this process (OECD, 2017l: 5). Out of the 276 cases received this year, none focused on or considered the increasing number of people who risk losing their jobs and perhaps

Figure 55: **Growing precarity of employment, % employment growth, 2007-2013**

(%)

Non-standard workers   Standard workers

One in ten
jobs in the OECD area could be automatable over the next decade

1995–07   2007–13
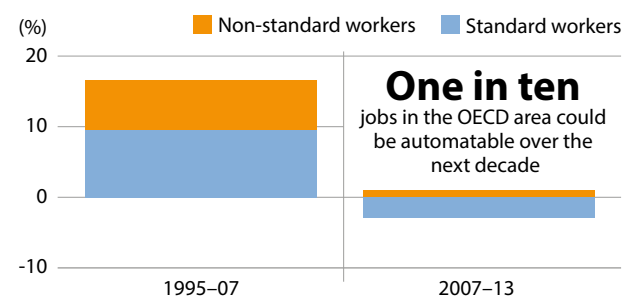
More than half
the jobs created since 1995 are non-standard, i.e. part-time, temporary or self-employment arrangements

Less manufacturing jobs
% total employment

China   OECD

1982   1992   2002   2012

More jobs in R&D-intensive industries
% of manufacturing employment

China   OECD

1982   1992   2002   2012
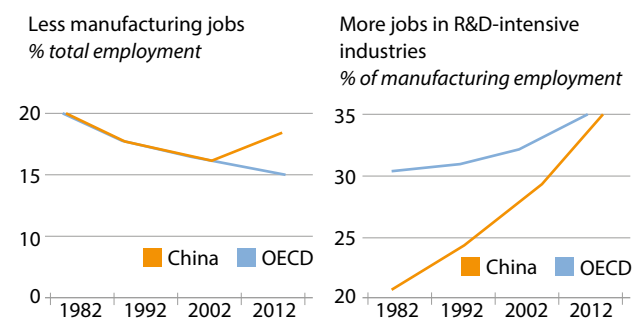
Source: OECD (2016a: 55).

126. Asker Municipality submission to the OECD Call for Innovations crowdsourcing exercise, 31 August 2017.

even what they consider to be their purpose in life. At the same time, a number of cases that concerned the automation of government services with bots and self-service options, while innovative, did not to seem consider the potential human side effects. The research identified only a few efforts to address this problem.

OECD research has found that 10% of jobs in OECD countries may be automated in the near future, while many jobs are shifting to non-standard positions that may provide less security and stability (see Figure 55). Depending on the ability of economies to react quickly and create new jobs to replace those lost (alongside the change in wages), the number of jobs could decline, perhaps permanently. Greater work-sharing and a reduced working week could help distribute work more evenly, but this approach would need to guarantee a living wage – possibly through some sort of "universal basic income" (Skidelsky, 2013) (see Box 25). The concept of a basic income is the key exception to the lack of focus on job automation, with a small number of countries exploring or in the early stages of conducting basic income pilots.

In 2017, Finland launched the world's only national pilot on basic income. From January 2017, the government has paid EUR 560 per month to 2 000 unemployed citizens selected at random, in order to establish whether a basic income has an impact on employment outcomes

BOX 25: **WHAT IS UNIVERSAL BASIC INCOME?**

A universal basic income is an unconditional cash benefit of a fixed amount provided by a country or city – or some non-governmental organisations (NGOs) – to all citizens, regardless of their employment status, current income or any other factor. Universal basic income is designed to help eliminate poverty, provide a baseline income security for all citizens and eliminate the stigma of receiving public financial benefits.

Some believe that basic income can spark creativity and entrepreneurship, which can help mitigate the worst effects of job automation. However, others believe it could provide a disincentive to holding a job or might negatively impact government budgets. OECD research shows that universal basic income may necessitate large tax increases and reductions in other benefits.

Source: https://futurism.com/images/universal-basic-income-answer-automation/, https://www.oecd.org/els/soc/Basic-Income-Policy-Option-2017-Presentation.pdf.

(e.g. whether individuals who receive the guaranteed basic income are more likely to take up new jobs compared to individuals receiving traditional unemployment benefits).[127] Several months into the experiment, early anecdotal results indicate that basic income recipients have already experienced less stress in their lives, which can help improve the mental capacity to seek work or take on entrepreneurial ventures (Raphael, Angell and Hall, 2017). However, some critics believe the sample size might not be adequate to provide a concrete understanding of the effects, and are concerned that economic variables could muddy the results (Ward, 2017). The formal results will be released once the pilot concludes at the end of 2018.

In addition to the Finland pilot, a number of basic income experiments are taking place in Kenya, where the NGO GiveDirectly launched a USD 30 million experiment involving 120 rural villages in November 2017. The full experiment will last over 12 years, with intermediary results provided along the way.[128] The scope and scale of the project has the potential to provide significant insights and evidence into the concept of universal basic income, which may prove integral to helping others decide how and whether to implement the project themselves.

Despite these interesting and innovative examples, the potential ramifications for automation and the future of work seem to eclipse current efforts to prepare for it, which signals that further work is needed in this area. This is one area where governments will want to be proactive and not reactive.

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127. See www.kela.fi/web/en/basic-income-objectives-and-implementation.

128. See www.givedirectly.org/basic-income.

Recommendations

Building a more inclusive society and ensuring the protection of the most vulnerable are among today's most significant challenges. As can be seen in this section, countries are taking innovative actions, often in a globally united way, to make this happen. Although ensuring equity for all individuals requires many actions and an ongoing focus, the following recommendations can help build the foundation and linkages needed to address the problems of today and tomorrow.

1. Connect with international communities to drive united progress. The world has never been so interconnected, and its challenges have never been so complex. Global initiatives such as the SDGs cannot be solved by each government acting on its own. These challenges and goals necessitate a unified, international response. Governments at all levels should connect with and actively participate in the international communities that have existed for some time, such as the OECD and United Nations, as well as new communities that are being activated to help address unmet needs, for example, by better convening non-government actors such as civil society and industry. Only by working together can governments "enhance policy coherence for sustainable development" – SDG commitment 17.14.

2. Ensure all members of society are considered and consulted in policy making and service delivery. The voices of the excluded and vulnerable are too often drowned out by members of society who have long had their say in the functioning of government. Governments at all levels must seek to understand the opinions, experience and conditions of all members of society for which their policies and services touch. This can be done through major formal mechanisms, such as gender budgeting, or through user-centred services such as in the Asker Welfare Lab case study. If governments develop policies and services without a solid understanding of all the types of people they will impact, they are not doing enough.

3. Begin preparing today to support the next generation of vulnerable populations. There are so many issues to deal with today that it can be easy for governments to lose focus of the challenges of tomorrow. Governments can start innovating today to build a foundation of support for the vulnerable populations of the future, including those whose jobs and livelihoods may be automated. This can help soften the blow later down the line. Innovative foresight and horizon-scanning activities can help identity where challenges are likely to arise, and help illuminate the actions countries can take today to prepare.[129]

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129. See www.oecd.org/naec/reflection-and-horizon-scanning.htm.

CASE STUDY

Seoul 50+ policy – Republic of Korea

50○+ 서울시50플러스
Seoul 50 Plus

Technological progress, globalisation and demographic changes have a pronounced effect on labour markets.[130] Ageing and the automation of jobs – megatrends of the next decade – will create great opportunities, but also daunting challenges. How will life-long learning and continued labour market participation work when jobs are disappearing? Furthermore, the needs of newly retiring urban populations are markedly different from those of previous generations. These trends challenge labour markets, pension systems and social policy, in general, and place a heightened fiscal burden on welfare states. The Seoul Metropolitan Government (SMG) is trying to address these challenges with its Comprehensive Plan for 50+ Assistance (hereafter, Seoul's 50+ policy). Seoul's 50+ policy provides life training, emotional support, cultural experiences and also retraining for continued social opportunities for newly retired populations. As part of the initiative, Seoul has redefined what "work" in the 21st century means.

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130. See the OECD Future of Work project: www.oecd.org/employment/future-of-work.

THE PROBLEM

Korean society is rapidly proceeding towards the centennial society, with the elderly demographic of the population soaring. The country has experienced both sharp declines in fertility and substantial gains in longevity (United Nations, 2015). In 2000, Korea became an ageing society with 7.2% of the population over 65+, and an aged society (14.02%) in 2017, and will become a super-aged society by 2026 (20.8%) (Kim and Jane, 2017). The nation's rate of ageing is three times faster than that of countries that entered an ageing society phase before Korea. As the working-age population continuously decreases, potential intergenerational conflicts emerge due to the growing fiscal burden on healthcare, social welfare and pensions. A 100-year life in the context of 25-30 years of pre-pension economic activity is not feasible under current socio-economic structures.

Simultaneously, a large post-war demographic group, which constitutes the main labour force behind Korean economic growth, is reaching retirement age. This wave of retiring baby boomers is creating a serious social problem – one that is also a personal crisis. Retirees may live up to 50 years following retirement: what should they do with the second half of their lives?

These baby boomers are highly educated professionals from previous generations with differing values. They have also been the main force behind the economic development and democratisation of Korea. Their experiences, capabilities and participation in the labour market are seen as the solution for an aged society. However, the 50+ generation is insecure about their future and quality of life, as opportunities for employment and social interaction decrease after retirement.[131] Retirement benefits for many do not permit recipients to enjoy the same living standards as before, or worse, place them at risk of falling into lower-income strata. Few baby boomers have made adequate financial preparations for retirement (Kim, 2012). Furthermore, those retiring in their 50s and early 60s – the 50+ generation (an age group between 50 and 64) – are excluded from various welfare policies, placing them in an especially vulnerable position. Currently the 50+ population comprises 11.5 million people, representing 22.4% of the entire population of Korea. In Seoul alone, this age group accounts for 2.19 million people (Figure 56).

Figure 56. Ages of South Korea population
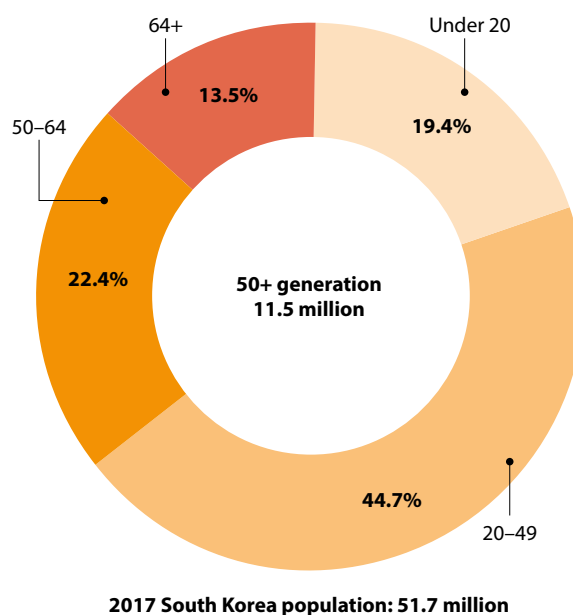
2017 South Korea population: 51.7 million

Source: Presentation made by the Seoul 50+ Foundation of the Seoul Metropolitan Government, Seoul, 2017.

In Europe and elsewhere in the world, the standard reaction to this demographic shift has been to increase the retirement age, keeping older people in the labour market for longer periods. Korea has also recently amended existing legislation on retirement, raising the minimum normal retirement age to 60 in 2013. At the same time, older workers continue to work well beyond their retirement. The effective age of labour force exit is, on average, around 72 for both men and women,[132] which is higher than many other OECD countries. Yet, it is common practice in Korean companies to set a mandatory age of retirement well below the age of 60, often as low as 55. Consequently, the average age of actual retirement, particularly in the private sector, stands at 53. To make matters even more complicated, job availability is constantly shifting due to automation and globalisation, while Korea also works to tackle high youth unemployment. In other countries with similar issues, the trend to ensure "continuous employment" makes older workers accept lower wages – often significantly lower (Ujikane, Kuwako and Schneider, 2016).

AN INNOVATIVE SOLUTION

Originating from civil society and brought to the public sector by the current Mayor of Seoul, Park Won-Soon, the Seoul 50+ initiative stems from the idea that the retirees

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131. Data taken from a 2015 needs assessment of the 50+ generation.

132. See www.oecd.org/els/emp/older-workers-scoreboard-2016.xlsx.

Figure 57: A 50+ campus

Source: Seoul 50+ Foundation of the Seoul Metropolitan Government, Paris, 2017.

need support to create new life models for themselves (see Box 26). While ageism is rife in Korean society, the initiative has taken an innovative and bold approach by embracing the older generation as an active social actor.

In 2016, after more than two years of preparation and pilots, the city announced its "Comprehensive Plan for 50+ Assistance". In 2015, the city had conducted a needs assessment of the 50+ generation, and found that the three main concerns were feelings of insecurity, lack of work and nowhere to go. Thus, the 50+ policy focused on providing a platform for "Learning and Exploration", "Jobs and Social Engagement" and "Culture and Infrastructure". The main mission of Seoul's 50+ policy was to create a new life vision for Seoul's 50+ generation. This entailed improving the life quality of the generation, producing a shift in perception among older people, and enhancing social participation and sharing in society. As a whole, the initiative tried to prepare the city and its inhabitants for a new model of an aged society.

The nucleus of the innovation is a comprehensive 50+ infrastructure planned across Seoul. This includes the establishment of the Seoul 50+ Foundation (the coordinating body), and several 50+ campuses

and centres built on multi-sectoral collaboration.[133] Nineteen 50+ centres are planned for city districts by 2020 and four centres are currently in operation. As each city district has different characteristics – ranging from densely populated neighbourhoods to university or office areas – the centres will reflect specific, local features and needs. The campuses (see Figure 57) are bigger one-stop-shops offering tailor-made services including counselling, education and new job models, and

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133. Seoul alone cannot provide all the services needed, even with the help of the 50+ community. The Seoul 50+ Foundation has signed MoUs with more than 30 organisations to develop a variety of programmes and create quality 50+ opportunities through partnerships.

Figure 58. The 50+ policy service model
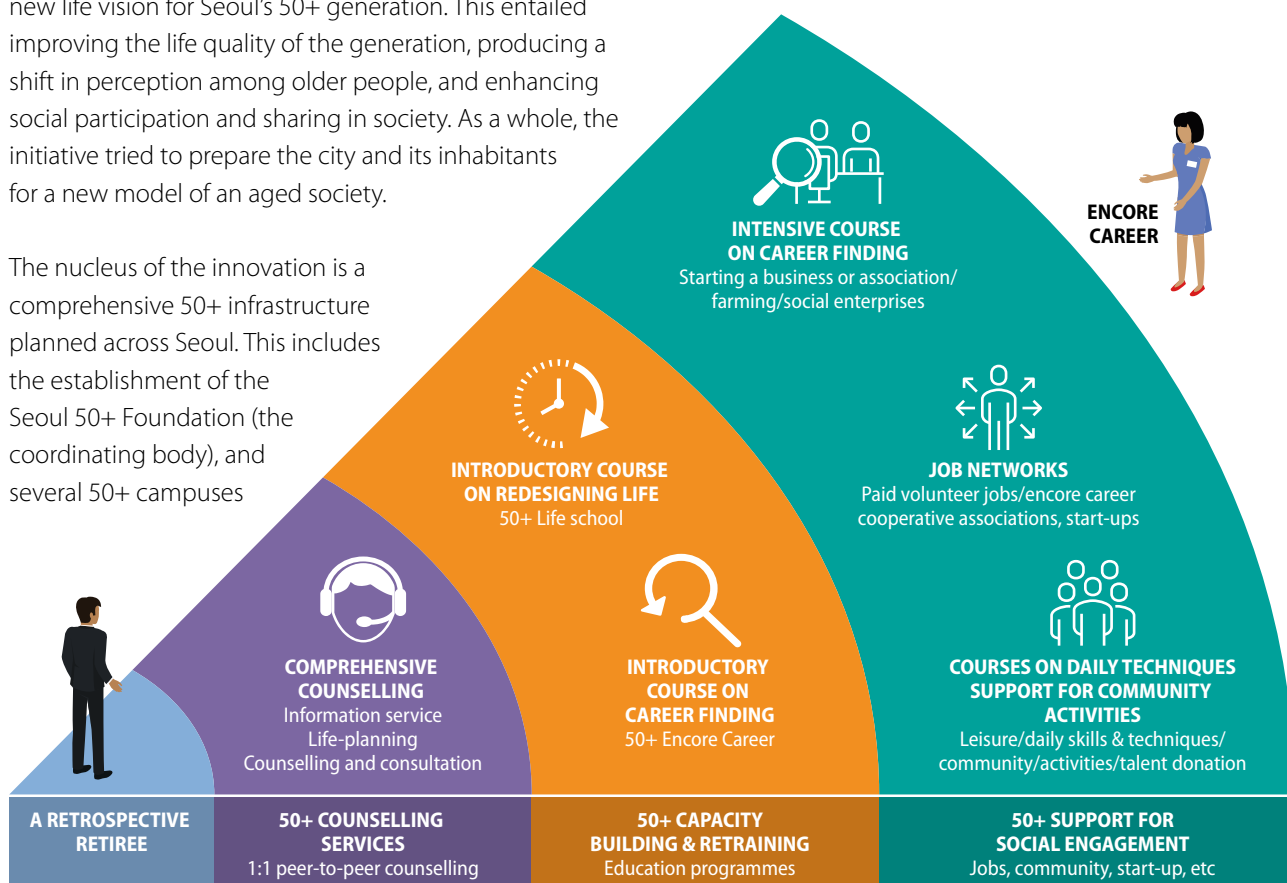
Source: Presentation made by the Seoul 50+ Foundation of the Seoul Metropolitan Government, Paris, 2017.

promoting intergenerational exchange. Six 50+ campuses are planned by 2020 and three are currently in operation.

This infrastructure provides support and cultural spaces for the 50+ generation to interact among peers, drive changes and generate needs-based services for one other (see Figure 58). It goes beyond traditional policy interventions, providing more comprehensive support and dealing with the practical and emotional side of life transitions (e.g. offering cooking classes for retired men or overall life-transitions courses for the newly joined). Half of the courses offered at the campuses are initiated and designed by the 50+ generation and the target group also provides peer-to-peer counselling (see Figure 59). As the older generation becomes a large market segment for services, Seoul's 50+ policy helps the demographic group locate demand and generate self-initiated projects and work opportunities. In essence, the social capital of the target group is used to cope with ageing issues in society.

Furthermore, Seoul 50+ tries to redefine what work in Korean society means for an entire generation that has dedicated itself to rebuilding the country after the Korean

War. The initiative tries to connect the population's broader interests and social aspirations with job opportunities and new types of employment in the form of an "encore career". This implies continued work opportunities across projects, not just "belonging" to a single employer. This approach also enables the 50+ demographic to build social connections and find new ways to serve their communities. It allows them to make the most of this time of life, while also continuing to earn an income, acquire new personal meaning and have a social impact. The Seoul 50+ policy creates and promotes new 50+ job models for the public and private sectors, by expanding socially meaningful job models through paid volunteer jobs ("Boram jobs") and operating 50+ start-up venture competitions, incubation and encore out-placement programmes.

NOVELTY
The comprehensive nature and scale of the Seoul 50+ policy is unique. Other countries have initiated similar projects, such as Germany's Bundesprogramm Perspektive 50plus[134] (2005 to 2015), but not to the same level or extent.

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134. See www.perspektive50plus.de.

Figure 59: **Peer-to-peer counselling**

Source: Seoul 50+ Foundation of the Seoul Metropolitan Government, Paris, 2017.

178,032
2016-2017 CAMPUS VISITORS

1,825
SOCIAL SERVICE VOLUNTEER JOBS

70
COUNSELLING CASES PER DAY

Figure 60: **50+ statistics as of November 2017** *Source:* Seoul 50+ Foundation of the Seoul Metropolitan Government, Paris, 2017.

RESULTS AND IMPACT

As of August 2017, 50+ programmes have registered more than 15 000 people, the 50+ generation has organised 112 communities, 600 people have participated in 13 different "Boram Jobs" streams and 50+ campuses have provided more than 303 courses (see also Figure 60). While these numbers are not large compared to the size of the target group, years remain before the full institutionalisation of the programme. However, the initiative is already scaling. Other local municipalities are benchmarking 50+ campuses and centres of the Seoul Metropolitan Government, and the national government has announced a cross-ministry plan to establish social infrastructure for the third act of life. Success will depend on the ability of national ministries to operate across fragmented interventions in an effective manner.

USER PERSPECTIVE

Prior to launching the Seoul 50+ initiative, the city conducted a needs assessment of 1 000 residents aged over 50 in Seoul. This was followed by a series of consultation processes with stakeholders to clarify roles and responsibilities among existing welfare entities. As the programme evolves and develops, with input from the 50+ generation itself, feedback from users is integrated into the approach. At the end of August, the OECD team met with a selection of 50+ peer-to-peer counsellors, community leaders and programme participants, all of whom saw great value in the initiative.

CHALLENGES AND LESSONS LEARNED

Vulnerable groups rarely carry a voice within the political system, so strong political proponents are needed. The Mayor of Seoul had to defend the initiative in its early days, with opponents of the programme stating that investments should go instead to those currently facing poverty.

As the current 50+ generation differs from prior retiring cohorts, a user-centred approach was essential. However, not all user needs are resolved – especially those relating to the long-term financial security of groups entering old age. There is also a disconnect in terms of the services and models people should adopt after they reach the age of 65, with different organisations (i.e. Seoul Welfare Foundations and elder welfare institutes) responsible for the latter in the city.

In general, it is difficult to fit a new policy into existing silos. Whether it concerns employment, lifelong learning or welfare, effort is needed to distinguish a new policy as something different, and to ensure co-ordination with existing policies in order to create synergies. Paradigm shifts take time. The initiative therefore needs space to evolve to ensure a "business-as-usual" mind-set does not take over.

CASE STUDY

Financial Inclusion Programme for Migrants – Mexico

The Financial Inclusion Programme for Migrants is an innovative financial services initiative that provides bank accounts and other support to a unique set of migrants – Mexican citizens repatriating from the United States amid a political climate that has added a great degree of uncertainty to their lives. To help these fellow citizens, the National Savings and Financial Services Bank (Bansefi), a development bank created by the federal government to reach vulnerable populations, has opened 11 strategically located services branches along the US-Mexico border and one at the Mexico City airport to provide them with financial services and education, which is a core requirement of repatriation (see Figure 61).

San Isidro
Tijuana

Calexico
Mexicali

Nogales
Nogales

El Paso
Cd. Juárez

Yuma
San Luis Rio Colorado

Presidio
Ojinaga

Del Rio
Cd. Acuña

Eagle Pass
Piedras Negras

Laredo
Nuevo Laredo

Hidalgo
Reynosa

Brownsville
Matamoros

Figure 61: Financial Inclusion Programme mobile branch border locations

Source: Bansefi.

THE PROBLEM

More than 11 million people who were born in Mexico live in the United States. Repatriation (i.e. moving back to Mexico) affects more than 200 000 Mexicans each year. Repatriates generally arrive without any belongings and also without documents, but usually with some money. A surge in repatriation is a possibility in the near future due to more aggressive US immigration policies. In early 2017, the Mexican government calculated that such policies may affect more than 1 million conationals, as well as a significant number of "Dreamers" (see Box 27).

In Mexico, the migrant population is considered a vulnerable group. Historically, it has had to face a variety of barriers to gain access to financial services, whether due to a lack of knowledge or information, lack of identity documents, their immigration status or simply because of the complicated process of repatriation. These migrants also frequently lack access to financial services, which can result in an inability to access other services. No financial organisations have provided financial services for even the regular flow of repatriates, let alone the potential increase represented by the Dreamers.

Box 27: WHO ARE THE DREAMERS?

In June 2012, the United States issued the Deferred Action for Childhood Arrivals (DACA) immigration policy, which allowed some non-citizens who arrived to the United States as children and remained in the country without documentation to receive renewable two-year periods of deferred action (i.e. meaning the government would delay any actions to remove the individual from the country), as well as a permit to work legally (DHS, 2017). Over 1 million Dreamers – the nickname for residents benefiting from DACA – have been approved for the programme, and live in every state in the United States. Over 700 000 Dreamers are from Mexico. In September 2017, the US government rescinded DACA, which would be phased out and officially ended after six months (DHS, 2017). Unless the US Congress takes action, the future of these residents will be very uncertain once their current deferred action status expires, potentially leading to an increase in the number of individuals repatriating to Mexico. The Mexican government is already seeing an increase in the repatriation of Dreamers and other Mexican citizens.

Source: DHS (2017); www.uscis.gov/sites/default/files/USCIS/Resources/ Reports%20and%20Studies/Immigration%20Forms%20Data/All%20Form%20 Types/DACA/daca_performancedata_fy2017_qtr4.pdf; Bansefi.

AN INNOVATIVE SOLUTION

Bansefi is a social bank based in Mexico that aims to bring banking and financial services to populations excluded or under-served by the financial system. In March 2017, Bansefi launched the Financial Inclusion Programme for Migrants to help empower these conationals by providing financial services and educational programmes specifically designed to meet their needs and help them restart their lives in Mexico. To date, 12 service branches have opened up along the border and at the Mexico City airport (see Figures 62 and 63). Bansefi helps these citizens by providing a number of services including:

- A *bank account and debit card* specifically designed for the needs of these migrants, with incentives encouraging them to save. The bank accounts charge no commission and have no minimum balance.

- *Advisory services and promotional material* to provide conationals with information and advice about personal finances, so they can make good use of and adequately manage their resources.

- Small *life insurance* and other accident insurance policies.

- Facilitated *remittances* to make it easier to receive money from the United States through pre-approved agents and bank transfers from a repatriate's US bank account.

- *Currency exchange* services to help exchange US dollars into Mexican pesos.

Figure 62: **Bansefi staff providing services at mobile branch.** *Source*: Bansefi.

In addition to helping repatriates obtain services at its branches, Bansefi uses tablets to work with citizens to open accounts in the waiting rooms of the immigration office. After activation of the account, users can access Bansefi's network of over 400 branches across Mexico. The main purpose of the programme is to reduce the vulnerability of this segment of the population and improve their quality of life, by offering them tools that enable full financial inclusion, which is a key to accessing countless other aspects of daily life in Mexico.

The Bansefi team leading the innovation believes that such services can be replicated under similar situations or conditions in many countries, as in the case of persons seeking asylum who lack official documentation or knowledge of how to open an account.

NOVELTY

Prior to this programme, there were no public policies or initiatives for financial inclusion for migrants. In addition to the creation of a new type of service, Bansefi

is unique because it represents the first time that the government's National Banking and Stock Commission (CNBV) has authorised a financial institution to use "Certificates of Admission of Repatriated Mexican", issued by the National Institute of Migration (INM), as a means of formal identification and proof of residence for financial services. Holders may also use this certificate to obtain a formal valid identity document, which will enable them to obtain other services and vote. Bansefi is the only bank authorised to allow individuals to open accounts using this certificate as the sole identity document, thus eliminating countless barriers which these citizens would otherwise face.

RESULTS AND IMPACT

The financial services offered at the Bansefi branches have been well-received by conationals undergoing the repatriation process. They have resulted in quicker integration of repatriates into the economy, more productive returns from restarting labour activities to generate income, and improved family well-being by

Figure 63: **Customer at Financial Inclusion Program mobile branch.** *Source*: Bansefi.

helping to provide security for repatriates' financial resources and allowing them to receive remittances. It is believed that the social and financial inclusion of returnees will have a significant impact on family well-being and Mexico's development. Although though the programme is quite new, in its first six months of operation it has already helped 6 962 citizens open bank accounts, exchange currencies and/or receive remittances.

USER PERSPECTIVE

The demand for products has exceeded expectations. Customers state that the services provided by Bansefi's branches reduce barriers of access to resources, provide peace of mind and allow them to reach their destinations with their resources secure. They also state that opening a bank account encourages them to make more efficient use of the available financial instruments.

CHALLENGES AND LESSONS LEARNED

A key challenge for the Financial Inclusion Programme for Migrants was the very limited timeframe. The entire programme had to be rolled out and implemented within four months, as the government wanted to move quickly due to the significant level of uncertainty and speculation. To ensure this could happen, the project had to be prioritised with all available resources focused on the programme. The guiding role of senior leadership, both at the political level and senior levels within Bansefi, was a necessary requisite.

The Bansefi team who implemented the initiative also found that successful and rapid implementation required assembling a team ready to respond to any needs that might arise. They also highlighted the importance of coordinating a series of inter-institutional groups and ensuring that all those involved understood the importance and scope of the project. The team also believes that it is important to leverage existing infrastructure (e.g. offices along borders, operating bank branches, etc.) to minimise overheads and build upon models that are already successful.

CASE STUDY

Asker Welfare Lab – Norway

Asker Welfare Lab[135] is a new concept for service delivery centred solely on the citizen, in which all relevant municipal services, together with external partners – the Investment Team – invest together in a person's welfare (see Figure 64). The lab takes an investment mind-set and treats citizens as co-investors. The aim is to raise the living standards of vulnerable individuals, thereby bettering the quality of life of each person and family in the programme. Most importantly, experts have to partner with the citizens whose lives they want to change, under the motto, "No decision about me shall be taken without me". Public sector investment is closely monitored through a new form of reporting, focusing on the realisation of outcomes.[136]

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135. See www.asker.kommune.no/om-asker-kommune/innovasjon-i-asker/innovasjonsprosjekter.

136. Norway's Asker Welfare Lab is also featured in the 2018 World Government Summit's *Edge of Government* exhibit. See https://edge.worldgovernmentsummit.org.

THE PROBLEM

Public sector services tend to be siloed. Inside national governments, the effects of these silos can be difficult to perceive, but the impacts become clearer closer to citizens, the end users. Municipalities deliver services to citizens "from the cradle to the grave", but the services themselves are often so different that they produce few synergies between them. When public services are layered on top of each other, and designed and delivered in a fragmented fashion, value for citizens falls through the cracks. Yet, the sole reason that public services exist is to benefit citizens at different stages of their lives in a meaningful way. Those in the most vulnerable positions are usually the ones who suffer most from fragmentation, and are usually the biggest service recipients. Consequently, public services can add complexity to already difficult lives (e.g. through tiring application procedures, contradictory intervention aims, etc.), rather than helping people to find sustainable solutions.

Public sector organisations tend to address these co-ordination problems within existing organisational structures through cross-service meetings or arena gatherings. However, the knowledge that results stem from working across all pillars (e.g. welfare, work, health, education and housing) does not mean that organisations will act that way. Looking to address this dilemma, the Asker municipality asked: "What if the municipality starts thinking

Figure 65: **Asker Welfare Lab team and programming**

Source: Asker Welfare Lab.

like an investor – investing in people, instead of just being a case worker, pushing people and paper around?"

AN INNOVATIVE SOLUTION

In 2013, the Asker municipality participated in a project with the Norwegian Centre of Design and Architecture (DOGA)[137] and LiveWork Studio on service design as a method to reshape social housing. The purpose of the project was to create a new direction for social housing

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137. See www.visitoslo.com/en/product/?TLp=15376.

Figure 64: **Principles of the Asker Welfare Lab**

Taking the risk of early investment to achieve long-term socio-economic benefits.

Planning long-term interventions where the municipality is co-ordinated as one unit.

Creating a better experience for the citizen.

Considering the citizen as a "coinvestor" actively contributing to his/her own future.

Source: Asker Welfare Lab.
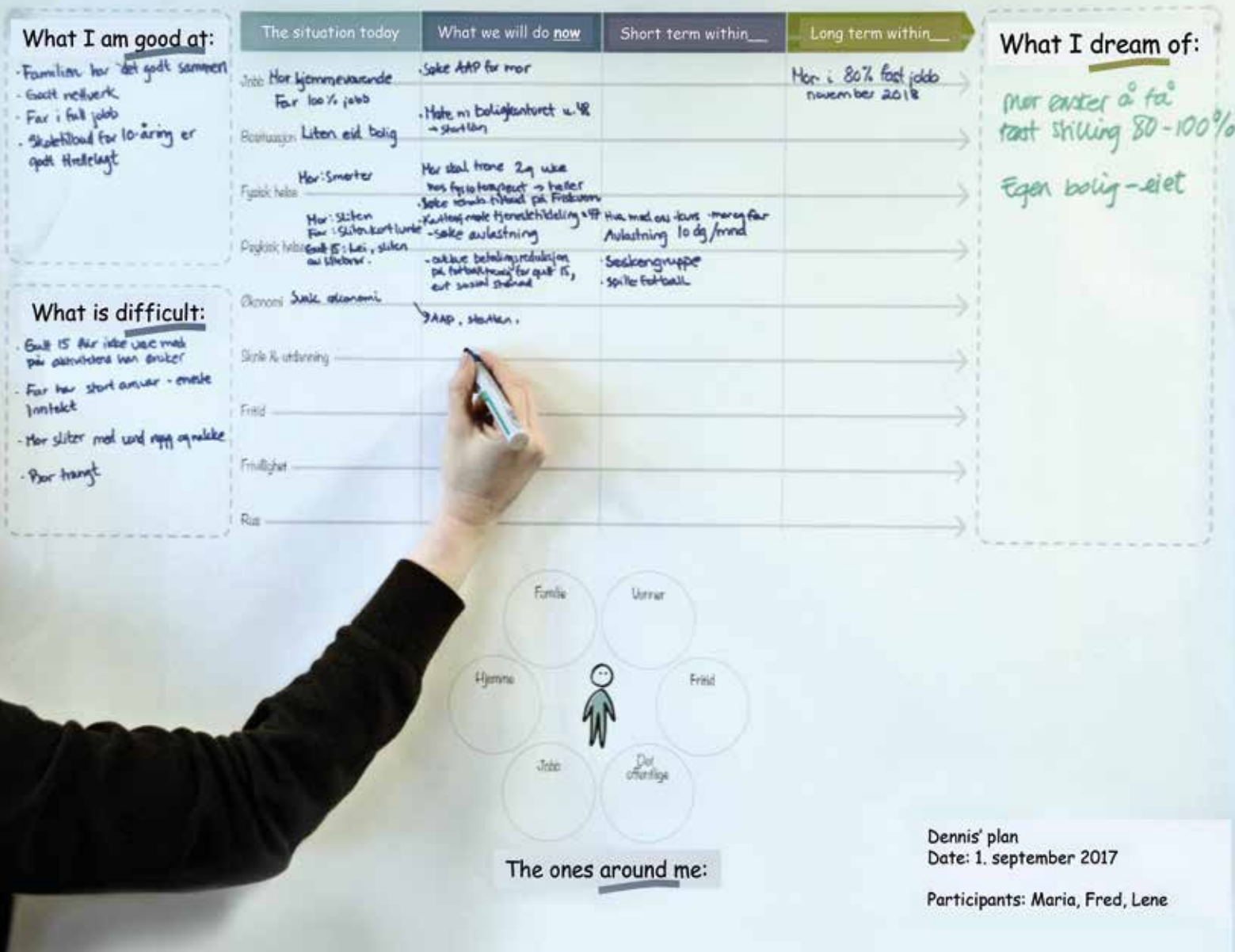
Figure 66: **Asker Welfare Lab mapping tool** *Source*: Asker Welfare Lab.

services under the heading of the "Housing Office of the Future". It quickly became clear that citizens' needs in complex housing and living situations were not adequately met and that the problem was too narrowly defined by focusing on just housing. Municipal workers found that they could not achieve their objective within the traditional service model in an adequate manner. The partners reframed the project and agreed that future services should have a singularly citizen-centric focus and that the public sector should adopt an investor-like mind-set. Before launching the lab, the investment thinking was tested and piloted in 2014 by a new department established within the municipality: the "Citizen Square". With new principles in place, the municipality developed the model for the service concept of the Asker Welfare Lab (see Figure 65).

The lab empowers frontline civil servants, as investors, to work across silos and map and identify citizens' comprehensive needs. To this end, a new planning matrix was designed to allow for structured conversations between the citizen and the investment team. This

approach helps to uncover the real nature of the problem. For example, in one case civil servants were working on a more stable housing situation, while the citizen's need stemmed from the immediate threat of losing a driving licence. While this was not a "municipal responsibility", it was clear that the person's overall situation would greatly profit from more targeted help. Investors therefore need an overview of the issues citizens face and must sometimes take risks and go beyond their usual remits, in the hope of attaining greater rewards. For this, the lab uses innovative tools (see Figures 66 and 67).

Nevertheless, investors, working with the citizen, need to choose carefully what they want to invest in and what would deliver the most value. They need to analyse the possibilities and barriers surrounding the citizen and their networks in depth. The lab helps citizens identify their own assets in order to strengthen the coinvestment with the wider Investment Team at the core of the lab. The teams consist of a variety of stakeholders that can help to pool resources in and outside the public sector and spur

change.[138] These teams are trained in investment thinking and have an extended mandate to make decisions.

Initially, the Citizen's Square was the only gateway to the Asker Welfare Lab. Now, any public service at the municipality can become a way to reach the Investment Team. The Asker Welfare Lab is currently in its second phase of development involving a broader set of services and participants. In 2016-17, a pilot focused on three specific target groups: families with children experiencing "vulnerable living conditions", vulnerable youngsters between the age of 17-25, and families with children with disabilities. The lab's focus switched from after-the-fact assistance to prevention and early intervention.

NOVELTY

While concepts of co-production, co-creation and collaborative innovation are increasingly common, the Asker Welfare Lab represents a totally new philosophy of service delivery, challenging the traditional public sector

mind-set which tends to be expert-focused and, at times, patronising or condescending to citizens. The investor mind-set – "organising the way to a solution" – cuts across organisational silos, empowers frontline staff and gives them budgetary mandates. Furthermore, as citizen and partners have to act as co-investors in decision-making, power is shared with those in need.

RESULTS AND IMPACT

The piloting phase ended in the spring of 2017 and first user engagement shows that citizens experience value from participating. The Asker Welfare Lab model was tested with at least 20-30 citizens/families. Living conditions and quality of life were measured before and after the encounter with the Investment Team showing improvements. The municipal employees involved, who now have greater access to resources and can make investments at an earlier stage, feel that they can effect real change. Common planning also saves time that can be invested in more effective casework.

Investment thinking is further developed in a wider municipal context. Solutions and measures are created through co-operation with the voluntary sector, private

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138. The Investment Team can consist of individuals from health clinics, kindergartens and schools, among others, as well as specialised agencies (e.g. "Special Services for Children, Youth and Families", "Services for Mental Health and Substance Abuse", etc.) and representatives outside the municipal organisation from voluntary and private sector and the family's own network.

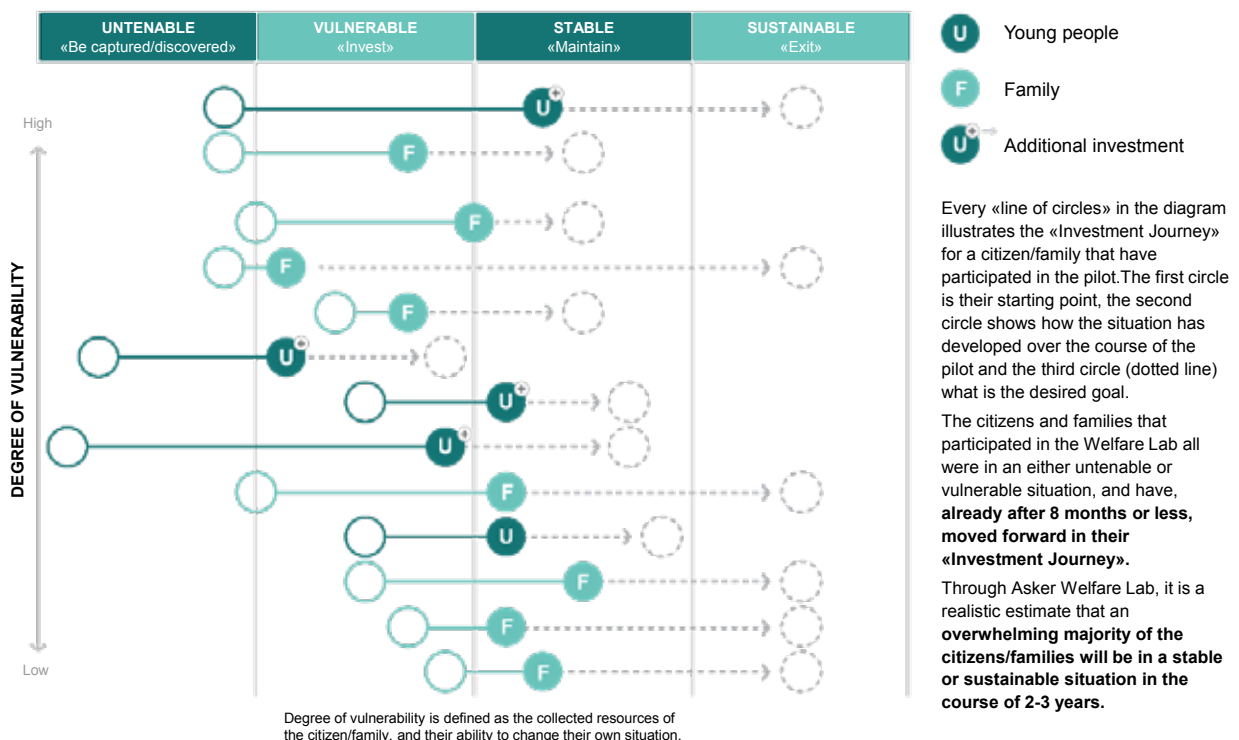**Figure 67: Asker Welfare Lab contributes to an evident improvement of the citizens' situation**

Degree of vulnerability is defined as the collected resources of the citizen/family, and their ability to change their own situation.

Source: Asker Welfare Lab.

businesses and the Asker community as a whole. At the moment, the Asker municipality is working to identify key performance indicators needed to scale and disseminate the model both internally and externally. The municipality does not exist in a vacuum and cannot influence people's lives alone; hence, it is imperative that regional or even state-level interventions co-ordinate with those of the municipality in the future.

The project has been recognised as a National Learning Project in Norway and was one of three projects to receive the annual National Innovation Award from the Ministry of Local Government and Modernisation. It has also been awarded a Best Practice Certificate from the European Public Sector Awards (EPSA) 2017.[139]

USER PERSPECTIVE

User perspectives are central to the Asker Welfare Lab including for problem identification and the lab's approach to working with citizens. Design thinking and cocreation were used throughout the development. While the lab is still developing more sophisticated evaluation tools, there is early evidence that this approach is working for citizens. One citizen explained that: "The mapping tool makes me feel included. It makes me feel that I actually can have an impact on the outcomes."

139. See www.epsa2017.eu.

CHALLENGES AND LESSONS LEARNED

The case of the Asker Welfare Lab highlights the importance of having supporting infrastructure in place for innovation. This includes leadership that allows for piloting, making mistakes and learning quickly from them. It is also crucial to have outside funding to free up the necessary competent workers to pilot new practices. Without this, pushing for change in public organisations becomes very difficult.

From experience, the lab has learnt that putting the family and citizen and their needs at the centre of services is key. This allows the lab to counter expert bias (trying to fit the reality to expert views) and make a real change in people's lives. "We have gone from being insecure about checking with the citizens to being insecure if we have not checked with the citizens first."

Maintaining an overview of problems and their solutions requires better co-ordination of resources, shared mandates and responsibility between public departments, and new models to measure effects. Furthermore, the case demonstrates that the potential results of co-operation between the voluntary sector, private businesses and social entrepreneurs are much greater than anticipated. While not always easy, this approach can deliver results.

Figure 68: **Asker Welfare Lab planning session**

"It is not enough to implement best practices, when the real need lies in creating the next practice."
Asker Welfare Lab submission to OECD Call for Innovations

Source: Asker Welfare Lab.

Conclusion

This review has been conducted at a challenging and demanding moment in history, with disruptive technologies, globalisation and economic inequality combining to make public sector challenges more complex than ever before. This complexity is the core feature of most policy issues today; their characteristics are interrelated in multiple, hard-to-define ways, and new tools are required to help governments respond. However, governments are often ill equipped to deal with these problems. Existing structures, systems, processes and skills are not yet adapted to current realities, and it is clear that the status quo is insufficient to address the nature of today's challenges.

The public sector is in need of a major course correction to cope with this increasing complexity and uncertainty. New ways are needed to examine problems and make decisions that affect billions of people every day. This course correction can only be achieved through innovation. However, no single public sector institution, whether a city or a national government, can or should undertake this transformation in isolation. All governments, as well as their partners in industry and civil society, must work together to drive solutions based on foundational, systems wide and collective perspectives. Innovation must cascade upwards from towns and cities, to states and regions to countries and then across the globe – as well as horizontally across all these levels. It should be driven by dedicated individuals working at all levels from entry-level employees to ministers and CEOs.

As this review demonstrates, governments are viewing today's challenges as a call to action to reconceive the basic underpinnings of how they function, their purpose, and how they engage with and support citizens and businesses. In particular, governments are innovating to:

- build and scale digital **identity** programmes that serve as a foundation for innovative services, while supporting people and businesses to express their unique identities and spur discussions of national identity in an increasingly borderless world;

- embrace **systems approaches and enablers** to lead a paradigm shift in the way they provide services, by innovating to transform and re-align the underlying processes and methods of the business of government in cross-cutting ways;

- foster better conditions for **inclusiveness and vulnerable populations**, in order to address complex current and future problems, and to create a world in which no one is left behind and everyone has access to opportunities for a better life.

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Such trends are part of an emerging movement that views innovation as the new normal of government. Many of the innovations studied in this review prove that remarkable impacts can be achieved by connecting disparate services, systems and people. Based on this principle, OPSI and the MBRCGI are working to fuel this movement by serving as a convener and connector of innovators and innovations worldwide. By conducting this review, OPSI and the MBRCGI seek to diffuse new and interesting ideas and bring together a growing community of innovators to share novel thinking and initiatives to help governments at all levels move forward together.

Appendices

Appendix 1. Development of public procurement strategies/policies to support secondary policy objectives

	Green public procurement		SMEs		Innovative goods and services	
	2016	2014	2016	2014	2016	2014
Australia	■	●	●	●	●	●
Austria	●◆	●	●◆	◆	●◆	●
Belgium	●◆	●◆	●	●	●	●
Canada	●◆	●◆	●	●	◆	●
Chile	●◆	●◆	●◆	●◆	○	●
Czech Republic	–	–	–	–	–	–
Denmark	●	●	●	●	●	●
Estonia	●	○	●	○	●	○
Finland	●◆	●	◆	◆	●◆	◆
France	–	●◆	–	●◆	–	●◆
Germany	●	●	●	●	●	●
Greece	◆	●◆	◆	●	○	○
Hungary	●	◆	●	●	●	●
Iceland	●	●	○	○	○	○
Ireland	●	●	●	●	●	●
Israel	●	–	●	–	○	–
Italy	●	◆	◆	◆	◆	◆
Japan	●	●	●	●	○	●
Korea	●	●	●	●	●	●
Latvia	●	–	●	–	◆	–
Luxembourg	–	●◆	–	●◆	–	◆
Mexico	●	●	●	●	●	●
Netherlands	●	◆	●◆	●◆	●◆	●◆
New Zealand	●◆	●◆	●◆	●◆	●◆	●◆
Norway	◆	■				
Poland	●◆	●	●	●	●	●
Portugal	●	●	●	◆	◆	◆
Slovak Republic	◆	○	●	○	○	○
Slovenia	●	●◆	●	●◆		●◆
Spain	●	●◆	●	●	●	●
Sweden	●	●◆	–	●◆	–	●◆
Switzerland	–	●◆	–	●	●	●
Turkey	●	●	●	●	●	●
United Kingdom	●	●	●	●	●	●
United States	–	●	–	●	–	●◆
OECD Total						
● Strategies/policies developed at the central level	25	26	24	24	19	22
◆ Internal strategies/policies developed by some procuring entities	11	14	8	12	9	11
■ Rescinded	1	1	0	0	0	0
○ Never developed	0	2	1	3	6	4
– No information available	6	3	6	3	6	3
Colombia	●	◆	●	●	●	●
Costa Rica	●	●	●	●	○	○
India	○	–	●	–	◆	–
Lithuania	●	–	●	–	●	–
Russia	–	○	–	●	–	○

Source: OECD (2016, 2014), *Survey on Public Procurement,* OECD, Paris.

Australia's ICT Sustainability Plan expired in June 2015 but Australia's Commonwealth Procurement Rules require that officials consider the relevant financial and non-financial costs of each procurement, including but not limited to environmental sustainability of the proposed goods and services.

In Norway, the first national action plan on, Environmental and Social Responsibility in Public Procurement, was adopted in 2007 and then rescinded.

Appendix 2. Innovation in central/federal government human resource management frameworks, strategies and programmes, 2016

	Competence framework	Training and development programmes	Recruitment strategy / guidelines	Performance assessment	Promotion criteria	Leadership development framework (or programme)	Mobility programmes	Innovation awards
Australia	○	○	○	○	○	○	●	●
Austria	○	●	●	○	○	●	●	●
Belgium	●	●	●	●	○	●	●	○
Canada	●	●	●	●	●	●	●	●
Chile	●	●	○	○	○	○	○	●
Czech Republic	○	●	●	●	●	●	○	○
Denmark	●	●	○	○	○	○	○	○
Estonia	●	●	○	○	○	●	○	○
Finland	●	●	○	○	○	●	○	●
France	○	●	○	○	○	●	○	●
Germany	○	●	○	○	○	○	○	●
Greece	●	●	●	●	●	●	○	○
Hungary	○	○	○	○	○	○	○	○
Iceland	○	○	○	○	○	○	○	○
Ireland	○	○	○	○	○	○	○	●
Israel	●	●	○	●	○	●	●	●
Italy	○	●	●	○	○	○	●	●
Japan	○	●	○	●	●	●	○	●
Korea	●	●	●	●	●	●	●	●
Latvia	●	○	○	○	○	●	○	○
Luxembourg	○	○	○	○	○	○	○	○
Mexico	●	●	○	○	○	○	●	●
Netherlands	○	○	○	○	○	○	○	●
New Zealand	○	○	○	○	○	○	○	●
Norway	○	○	○	○	○	●	○	○
Poland	○	●	○	●	○	○	○	●
Portugal	●	●	○	●	○	●	○	○
Slovak Republic	○	●	○	●	○	○	●	●
Slovenia	●	○	○	●	●	●	○	●
Spain	●	●	●	●	●	○	○	●
Sweden	○	○	○	○	○	○	○	●
Switzerland	○	○	○	○	○	●	○	○
Turkey	●	●	●	●	●	●	○	○
United Kingdom	●	●	●	●	○	●	●	●
United States	○	○	●	○	○	●	○	●
OECD Total								
● Included	16	21	11	14	8	19	9	22
○ Not included	19	14	24	21	27	16	26	13

Source: OECD (2016) *Survey on Strategic Human Resources Management in Central/Federal Governments of OECD Countries*, OECD, Paris.

For mobility programmes the question – "Are there specific programmes to encourage mobility in the civil service?" – was used as, mobility programs in general affect innovation positively.

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Partner organisations

Delivering better outcomes through innovation

MOHAMMED BIN RASHID CENTRE FOR GOVERNMENT INNOVATION

The MBRCGI works to stimulate and enrich the culture of innovation within governments through the development of an integrated innovation framework. The goal is for innovation to become one of the key pillars of the UAE government in line with the vision of H.H. Sheikh Mohammed Bin Rashid AlMaktoum, UAE Vice President, Prime Minister and Ruler of Dubai, which aims to develop government operations and enhance the UAE's competitiveness.

OECD
BETTER POLICIES FOR BETTER LIVES

The mission of the OECD is to promote policies that will improve the economic and social well-being of people around the world. This review has been developed through the OECD's Public Governance and Territorial Development Directorate (GOV), which works to help governments implement strategic, evidence-based and innovative policies to strengthen public governance and respond effectively to economic, social and environmental challenges.

WORLD GOVERNMENT SUMMIT القمة العالمية للحكومات

The MBRCGI sponsored this review in conjunction with the World Government Summit, which is dedicated to shaping the future of government worldwide. Each year, it sets the agenda for the next generation of governments with a focus on harnessing innovation and technology to solve universal challenges facing humanity. It serves as a platform for knowledge exchange, leadership, networking and analysis.

OPSI Observatory of Public Sector Innovation

As a part of GOV, the Observatory of Public Sector Innovation (OPSI) collects and analyses examples of government innovation to provide research and practical advice on how to make innovation work, and serves as a global forum for the exchange of innovative ideas. OPSI led the development of this review.

For more information about OPSI or this review, please visit http://oe.cd/opsi or contact opsi@oecd.org.

Country codes and acknowledgements

ISO codes of countries referred to in this report

Argentina ....ARG
Australia ....AUS
Austria ....AUT
Belgium ....BEL
Brazil ....BRA
Canada ....CAN
Chile ....CHL
Colombia ....COL
Costa Rica ....CRI
Czech Republic ....CZE
Denmark ....DNK
Dominican Republic ....DOM
El Salvador ....SLV
Estonia ....EST
Finland ....FIN
France ....FRA
Germany ....DEU
Greece ....GRC

Guatemala ....GTM
Honduras ....HND
Hungary ....HUN
Iceland ....ISL
Indonesia ....IDN
Ireland ....IRL
Israel ....ISR
Italy ....ITA
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Latvia ....LVA
Lithuania ....LTU
Luxembourg ....LUX
Mexico ....MEX
Morocco ....MAR
Netherlands ....NLD
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Norway ....NOR
Panama ....PAN
Paraguay ....PRY
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Slovak Republic ....SVK
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Spain ....ESP
Sweden ....SWE
Switzerland ....CHE
Tunisia ....TUN
Turkey ....TUR
United Kingdom ....GBR
United States ....USA
Uruguay ....URY

Acknowledgements

TAB 19

Distributed Ledger Technology: beyond block chain

A report by the UK Government Chief Scientific Adviser

Contents

A short video has been made to accompany this report which can be viewed at: https://youtu.be/4sm5LNqL5j0

Foreword

The progress of mankind is marked by the rise of new technologies and the human ingenuity they unlock.

In distributed ledger technology, we may be witnessing one of those potential explosions of creative potential that catalyse exceptional levels of innovation. The technology could prove to have the capacity to deliver a new kind of trust to a wide range of services. As we have seen open data revolutionise the citizen's relationship with the state, so may the visibility in these technologies reform our financial markets, supply chains, consumer and business-to-business services, and publicly-held registers.

We know there will be challenges as Distributed Ledgers mature and disrupt how we think about and store data. The UK is in a unique position to explore those challenges and help maximise the benefits to our public services and our economy. We already have world-class digital capability, innovative financial services, a strong research community and growing private sector expertise. It is vital that our key assets – including the Alan Turing Institute, Open Data Institute and the Digital Catapult – work together with the private sector and with international partners to unlock the full potential of this technology.

We are both, therefore, delighted to be jointly leading efforts in this area, and look forward to working with other departments on seizing the opportunity as well as understanding how its use can be implemented for the benefit of UK citizens and the economy.

THE RT HON MATTHEW HANCOCK MP
Minister for the Cabinet Office
and Paymaster General

THE RT HON ED VAIZEY MP
Minister of State for Culture
and The Digital Economy

Executive Summary and Recommendations

Introduction

Algorithms that enable the creation of distributed ledgers are powerful, disruptive innovations that could transform the delivery of public and private services and enhance productivity through a wide range of applications.

Ledgers have been at the heart of commerce since ancient times and are used to record many things, most commonly assets such as money and property. They have moved from being recorded on clay tablets to papyrus, vellum and paper. However, in all this time the only notable innovation has been computerisation, which initially was simply a transfer from paper to bytes. Now, for the first time algorithms enable the collaborative creation of digital distributed ledgers with properties and capabilities that go far beyond traditional paper-based ledgers.

A distributed ledger is essentially an asset database that can be shared across a network of multiple sites, geographies or institutions. All participants within a network can have their own identical copy of the ledger. Any changes to the ledger are reflected in all copies in minutes, or in some cases, seconds. The assets can be financial, legal, physical or electronic. The security and accuracy of the assets stored in the ledger are maintained cryptographically through the use of 'keys' and signatures to control who can do what within the shared ledger. Entries can also be updated by one, some or all of the participants, according to rules agreed by the network.

Underlying this technology is the 'block chain', which was invented to create the peer-to-peer digital cash Bitcoin in 2008. Block chain algorithms enable Bitcoin transactions to be aggregated in 'blocks' and these are added to a 'chain' of existing blocks using a cryptographic signature. The Bitcoin ledger is constructed in a distributed and 'permissionless' fashion, so that anyone can add a block of transactions if they can solve a new cryptographic puzzle to add each new block. The incentive for doing this is that there is currently a reward in the form of twenty five Bitcoins awarded to the solver of the puzzle for each 'block'. Anyone with access to the internet and the computing power to solve the cryptographic puzzles can add to the ledger and they are known as 'Bitcoin miners'. The mining analogy is apt because the process of mining Bitcoin is energy intensive as it requires very large computing power. It has been estimated that the energy requirements to run Bitcoin are in excess of 1GW and may be comparable to the electricity usage of Ireland.

Bitcoin is an online equivalent of cash. Cash is authenticated by its physical appearance and characteristics, and in the case of banknotes by serial numbers and other security devices. But in the case of cash there is no ledger that records transactions and there is a problem with forgeries of both coins and notes. In the case of Bitcoins, the ledger of transactions ensures their authenticity. Both coins and Bitcoins need to be stored securely in real or virtual wallets respectively — and if these are not looked after properly, both coins and Bitcoins can be stolen. A fundamental difference between conventional currency and Bitcoins is that the former are issued by central banks, and the latter are issued in agreed

amounts by the global 'collaborative' endeavour that is Bitcoin. Cash as a means of exchange and commerce dates back millennia and in that respect there is a lineage that links cowrie shells, hammered pennies and Bitcoin.

But this report is not about Bitcoin. It is about the algorithmic technologies that enable Bitcoin and their power to transform ledgers as tools to record, enable and secure an enormous range of transactions. So the basic block chain approach can be modified to incorporate rules, smart contracts, digital signatures and an array of other new tools.

Distributed ledger technologies have the potential to help governments to collect taxes, deliver benefits, issue passports, record land registries, assure the supply chain of goods and generally ensure the integrity of government records and services. In the NHS, the technology offers the potential to improve health care by improving and authenticating the delivery of services and by sharing records securely according to exact rules. For the consumer of all of these services, the technology offers the potential, according to the circumstances, for individual consumers to control access to personal records and to know who has accessed them.

Existing methods of data management, especially of personal data, typically involve large legacy IT systems located within a single institution. To these are added an array of networking and messaging systems to communicate with the outside world, which adds cost and complexity. Highly centralised systems present a high cost single point of failure. They may be vulnerable to cyber-attack and the data is often out of sync, out of date or simply inaccurate.

In contrast, distributed ledgers are inherently harder to attack because instead of a single database, there are multiple shared copies of the same database, so a cyber-attack would have to attack all the copies simultaneously to be successful. The technology is also resistant to unauthorised change or malicious tampering, in that the participants in the network will immediately spot a change to one part of the ledger. Added to this, the methods by which information is secured and updated mean that participants can share data and be confident that all copies of the ledger at any one time match each other.

But this is not to say that distributed ledgers are invulnerable to cyber-attack, because in principle anyone who can find a way to 'legitimately' modify one copy will modify all copies of the ledger. So ensuring the security of distributed ledgers is an important task and part of the general challenge of ensuring the security of the digital infrastructure on which modern societies now depend.

Governments are starting to apply distributed ledger technologies to conduct their business. The Estonian government has been experimenting with distributed ledger technology for a number of years using a form of distributed ledger technology known as Keyless Signature Infrastructure (KSI), developed by an Estonian company, Guardtime.

KSI allows citizens to verify the integrity of their records on government databases. It also appears to make it impossible for privileged insiders to perform illegal acts inside the government networks. This ability to assure citizens that their data are held securely and accurately has helped Estonia to launch digital services such as e-Business Register and e-Tax. These reduce the

administrative burden on the state and the citizen. Estonia is one of the 'Digital 5' or D5 group of nations, of which the other members are the UK, Israel, New Zealand and South Korea. There are opportunities for the UK to work with and learn from these and other like-minded governments in the implementation of block chain and related technologies.

The business community has been quick to appreciate the possibilities. Distributed ledgers can provide new ways of assuring ownership and provenance for goods and intellectual property. For example, Everledger provides a distributed ledger that assures the identity of diamonds, from being mined and cut to being sold and insured. In a market with a relatively high level of paper forgery, it makes attribution more efficient, and has the potential to reduce fraud and prevent 'blood diamonds' from entering the market.

An important challenge for this new set of technologies is communication of its significance to policymakers and to the public — this is one of the important purposes of this report.

The first difficulty in communication is the strong association of block chain technology with Bitcoin. Bitcoin is a type of cryptocurrency, so called because cryptography underpins the supply and tracking of the currency. Bitcoin creates suspicion amongst citizens and government policymakers because of its association with criminal transactions and 'dark web' trading sites, such as the now defunct Silk Road. But digital cryptocurrencies are of interest to central banks and government finance departments around the world which are studying them with great interest. This is because the electronic distribution of digital cash offers potential efficiencies and, unlike physical cash, it brings with it a ledger of transactions that is absent from physical cash.

The second difficulty in communication is the bewildering array of terminology. This terminology is clarified by Simon Taylor who has provided a set of definitions at the end of this summary. A particular term that can cause confusion is 'distributed', which can lead to the misconception that because something is distributed there is therefore no overall controlling authority or owner. This may or may not be the case — it depends on the design of the ledger. In practice, there is a broad spectrum of distributed ledger models, with different degrees of centralisation and different types of access control, to suit different business needs. These may be 'unpermissioned' ledgers that are open to everyone to contribute data to the ledger and cannot be owned; or 'permissioned' ledgers that may have one or many owners and only they can add records and verify the contents of the ledger.

The key message is that, by fully understanding the technology, government and the private sector can choose the design that best fits a particular purpose, balancing security and central control with the convenience and opportunity of sharing data between institutions and individuals.

As with most new technologies, the full extent of future uses and abuses is only visible dimly. And in the case of every new technology the question is not whether the technology is 'in and of itself' a good thing or a bad thing. The questions are: what application of the technology? for what purpose? and applied in what way and with what safeguards?

To help answer these questions, the Government Office of Science established a senior group of experts from business, government and academia to assess the opportunities for distributed ledgers to be used within government and the private sector, and to determine what actions government and others need to take to facilitate the beneficial use of distributed ledger technology and to avoid possible harms. The aim was to decrypt the terminology behind the technology for policy audiences and provide policymakers with the vision and evidence to help them to decide where action is necessary, and how best to deploy it.

In summary, distributed ledger technology provides the framework for government to reduce fraud, corruption, error and the cost of paper-intensive processes. It has the potential to redefine the relationship between government and the citizen in terms of data sharing, transparency and trust. It has similar possibilities for the private sector.

This executive summary now sets out the eight main recommendations from our work. These are presented in the context of a summary of the key points from the seven chapters of evidence which cover vision, technology, governance, privacy and security, disruptive potential, applications and global perspective. The chapters have been written by experts in distributed ledger technology in a style that should be accessible to non-experts. I am extremely grateful to these experts for their guidance and thoughtful contributions.

Mark Walport, Chief Scientific Adviser to HM Government, December 2015

Vision

Distributed ledgers offer a range of benefits to government and to other public and private sector organisations. As their name implies, they can be distributed extremely widely in a precisely controlled fashion. They are highly efficient because changes by any participant with the necessary permission to modify the ledger are immediately reflected in all copies of the ledger. They can be equally robust in rejecting unauthorised changes, so corrupting the ledger is extremely difficult. However, distributed ledgers should not be seen as an end in themselves. It is only when they have other applications — such as smart contracts — layered on top on them, that their full potential can be realised.

The first role for government in supporting the development of distributed ledgers is to develop a clear vision of how this technology can improve the way government does its business and is able to deliver services to citizens. This needs to be followed by government acting as an expert customer to implement the technology — procuring distributed ledger solutions where they are applicable. In doing so, government can support and influence the development of economic activity in this sector, including new and growing businesses as well as larger incumbent businesses.

The opportunity is for government to enable a future where the delivery of government services is more personal, immediate and efficient. Wherever appropriate, citizens should have the opportunity to signal their individual preferences and needs through participation in smart contracts. The implementation of distributed ledgers with embedded smart contracts should lead to substantial improvements in compliance, cost-efficiency and accountability.

The UK Government Digital Service is developing a digital platform for government to deliver its services and distributed ledgers could be at the heart of this.

Recommendation 1: *We recommend that government should:*

- *Provide ministerial leadership to ensure that government provides the vision, leadership and the platform for distributed ledger technology within government. Specifically, the Government Data Service should lead work in government as a user of distributed ledgers and the DCMS Digital Economy Unit should lead work on government as an enabler of distributed ledgers (working with the Department of Business, Innovation and Skills and with Innovate UK).*

- *The Government Digital Service and the DCMS Digital Economy Unit should develop a high-level capability road map and a supporting outline plan based on the work of this report and very early stage activity already underway in departments, and deliver this in a timely fashion; and continue to oversee the recommendations made in the rest of this report, to maintain momentum and rapid action. In undertaking this work, they should work closely with other government departments and with industry and academia and should consider setting up a time-limited expert advisory group in support.*

Technology

Distributed ledger technology is still at a very early stage of development. The development of block chain technology is but the first, though very important step towards a disruptive revolution in ledger technology that could transform the conduct of public and private sector organisations. The technology can be adopted so that 'legitimate' changes to ledgers can be made in principle by anyone (an 'unpermissioned' ledger), or by a limited number of individuals or even a single authorised person (in a 'permissioned' ledger). For government applications, 'permissioned' ledgers are likely to be more appealing than Bitcoin's unpermissioned model, because they allow the owner, or owners, of the data to enforce rules on who is and is not allowed to use the system. Distributed ledgers have the added advantage of moving a lot of the complexity of managing security into the background, making systems easier and cheaper to use.

There are many unsolved problems to tackle before the full potential of this and related technologies can be realised, including the resolution of issues of privacy, security, performance and scalability. There is also an extraordinary array of opportunities to develop algorithms that will add sophistication to ledgers by supporting 'smart' contracts, signatures and other applications. These will enhance and diversify the value and range of uses of ledgers. This field is developing rapidly and many of these problems are already being investigated and, in some cases, solved. If government waits for 'perfect' solutions, it will miss the opportunity to shape and procure implementations of the technology that will provide maximum benefit to the public sector, and the UK may lose opportunities for economic benefit as well.

As well as ensuring that the technology is robust and scalable, we need to understand the ethical and social implications of different potential uses and the financial costs and benefits of adoption. With respect to research and development, the UK is in a good position, though we cannot take this for granted as there is interest and competition in development of distributed ledger technology around the world.

The research councils are playing an important role, led by the EPSRC and ESRC, supporting research in universities and in the newly-created Alan Turing Institute. There is also an important role for business to invest in research and development, and key opportunities for joint public and private investment to tackle generic problems around security, privacy and the development of standards — all areas where industrial advantage will be gained by co-operation rather than competition.

Existing digital investments by the government and private sector include the Digital Catapult, Future Cities Catapult and Open Data Institute. Added to this are groupings such as the Whitechapel Think Tank which can provide a focal point for discussion and sharing ideas. This means that the UK is in a good position from which to build a solid distributed ledger research and testing capability. But there is a danger that we will not get the most from this potentially fragmented activity and there is a strong case that the research and development community in the public and private sectors should 'self-organise' in a way that encourages co-operation where appropriate and competition where it will stimulate the most creative research.

Our next two recommendations are aimed at encouraging further research and establishing UK capability to trial and experiment with different distributed ledger solutions:

Recommendation 2: *The UK research community should invest in the research required to ensure that distributed ledgers are scalable, secure and provide proof of correctness of their contents. They need to provide high-performance, low-latency operations, appropriate to the domain within which the technology is being deployed. They need to be energy efficient. The newly-created Alan Turing Institute, working with groupings such as the Whitechapel Think Tank, could play an important role in co-ordinating and 'self-organising' the public and private research and development sector interested in this and related technologies. The private sector should consider investing in the Alan Turing Institute to support the pre-competitive research that will ultimately facilitate new commercial applications that are robust and secure. This includes work on obvious areas such as cryptography and cybersecurity but also extends to the development of new types of algorithm.*

Recommendation 3: *Government could support the creation of distributed ledger demonstrators for local government that will bring together all the elements necessary to test the technology and its application. A demonstrator at a city level could provide important opportunities for trialling and implementing distributed ledger technologies. Innovate UK could use its work with cities in the development of 'city deals' to implement the development of a city demonstrator.*

Governance

Effective governance and regulation are key to the successful implementation of distributed ledgers. Governance comprises the rules set by the owners and participants of the ledger that safeguard their private interests. This needs to be supplemented by regulation and / or legislation, which comprises the framework of rules that are set by an outside authority to protect the broader interests of society. Government legislates and creates the framework for regulation, singly or in partnership with other governments, and usually creates or enlists a regulator accountable to government to undertake the work.

In the case of the digital world, there are two sets of rules or codes that control the operation of digital technologies. The first is the classical set of rules provided by the legislative framework, the code of law and regulation. The second is the set of rules that determine the operation of the algorithms encoded by the software. This is the technical code, and there needs to be at least as much focus on ensuring the rigour of the technical code as on legislative code.

Successful implementation of a distributed ledger will require a combination of governance to protect the participants and stakeholders and regulation to ensure the system is resilient to systemic risk or criminal activity. The challenge is to strike the balance between safeguarding the interests of participants in the system and the broader interests of society whilst avoiding the stifling of innovation by excessively rigid structures.

There are also opportunities to take advantage of the potential interactions between legal and technical code. For example, public regulatory influence could be exerted through a combination of legal and technical code, rather

than exclusively through legal code as at present. In essence technical code could be used to assure compliance with legal code, and, in doing so, reduce the costs of legal compliance. This could provide a 'use case' for the use of technology to enhance regulation, so-called RegTech, which formed one of the key recommendations of the FinTech report from the Government Office for Science[1].

Determining the optimum balance between governance and regulation, and between legal code and technical code, is going to require unusual mixes of skills, including the need for lawyers, mathematicians and computer experts to work together to resolve many of the key issues, which are outlined in Chapter 3.

Recommendation 4: *Government needs to consider how to put in place a regulatory framework for distributed ledger technology. Regulation will need to evolve in parallel with the development of new implementations and applications of the technology. As part of the consideration of regulation, government should also consider how regulatory goals could be achieved using technical code as well as legal code. The DCMS Digital Economy Unit could take ownership of this recommendation.*

Security and privacy

Criminals have moved away from cracking metal safes and bank vaults. The money is now in their digital equivalents and these are proving vulnerable to the hackers and crackers of the codes of the digital world. The cryptographic codes of the digital world are extremely hard to break, but however hard these may be, they can be vulnerable to being bypassed. Bypass mechanisms range from the human, who may give away the key accidentally or deliberately, to the presence of 'back doors' due to deficiencies in the software code. The hardware hosting distributed ledgers may provide additional vulnerabilities and equal attention should be paid to the resilience and security of hardware systems.

In the case of Bitcoin, the 'wallets' that hold the currency have proved vulnerable to theft — but the ledger itself has remained resilient, though in principle it would be vulnerable if over 50% of the computer processing power for the Bitcoin ledger fell into the hands of a single malevolent individual or organisation. Indeed, a great strength of distributed ledgers is that they should be highly resilient to attack.

However, it is not only the integrity of the ledger that matters. Privacy and confidentiality are also key issues. Depending on the nature of the ledger, it may hold personal confidential records that could range from financial to familial and health. The opportunity is for distributed ledger technologies to provide much greater security for these data than is available in current databases, but this is not a given. This is another area where much research and development is needed as part of the development of the technology.

Security and privacy are areas where Government has an important role to play, so our next recommendation is:

Recommendation 5: *Government needs to work with academia and industry to ensure that standards are set for the integrity, security and privacy of distributed ledgers and their contents. These standards need to be reflected in both regulatory and software code.*

For each particular use of the technology, government and private sector users, as appropriate, should conduct a bespoke risk assessment to identify the relevant threats. The Centre for the Protection of National Infrastructure (CPNI) and CESG should keep a watching brief on distributed ledger technology and play a central role inside and outside government in providing expert advice on ensuring the integrity, security and privacy of distributed ledgers. As suggested in recommendation 2, the newly created Alan Turing Institute, working with groupings such as the Whitechapel Think Tank and with CESG could play an important role in co-ordinating and 'self-organising' the public and private research and development sector.

It must not be overlooked that the software and hardware systems can become degraded over time, as better technology emerges and hostile agents learn 'new tricks'. So for systems intended to have a long lifetime, the initial design should make it straightforward to update hardware and software components during that lifetime. Additionally, as part of trialling new implementations of the technology, it is important to include penetration testing at both the system and user levels.

Trust and interoperability

As set out in Chapter 7 on global perspectives, trust is a risk judgement between two or more people, organisations or nations. In cyberspace, trust is based on two key requirements: prove to me that you are who you say you are (authentication); and prove to me that you have the permissions necessary to do what you ask (authorisation). In return, I will prove to you that I am trustworthy by delivering services or products to you in a secure, efficient and reliable fashion.

Authentication and identification are interlinked but they are not the same thing. Authentication does not require that I know your identity but it does require that you provide me a token that is inextricably linked to your identity, for example the pin number associated with a credit or debit card, or a fingerprint allied to a biometric passport or other document. Equally, when I provide my authentication token to you, I need assurance that I am providing it to the correct individual or organisation, ie that you are who you claim to be. So it is equally important that organisations can provide authentication to their users, be they individuals, other organisations or government.

The opportunity in the digital environment is to use and create much more powerful and robust identity management tools that provide authentication whilst protecting privacy. One such system is public key infrastructure (PKI) relying on a cryptographic standard called X.509. Organisations using PKI can federate in order to provide, share and potentially simplify the secure delivery of services or products. Another important international standard is being developed for organisational identification, known as the Register of Legal Organisations (ROLO), and this may help to underpin the authentication of organisations as opposed to individuals.

Another key enabler of secure authenticated interactions by individual users is the use of smartphones as the *de facto* trusted user device. The latest smart phones incorporate important security features such as a 'Trusted Platform Module', which secures digital certificates and cryptographic keys for authentication, encryption and signing, and a 'Trusted Execution Environment'

and a 'Trusted User Interface', each of which are resistant to interference by 'malware'.

This discussion of authentication shows that, in order to maximise the power of distributed ledgers, these may need to be interoperable with other ledgers. However, maximising the potential of interoperability goes far beyond interoperability of authentication — it requires agreements about data interoperability, policy interoperability and the effective implementation of international standards.

Recommendation 6: *This recommendation is linked to Recommendation 5. Government needs to work with academia and industry to ensure that the most effective and usable identification and authentication protocols are implemented for both individuals and organisations. This work needs to go hand in hand with the development and implementation of international standards.*

A disruptive future – some potential use cases for government

Distributed ledgers have the potential to be radically disruptive. Their processing capability is real time, near tamper-proof and increasingly low-cost. They can be applied to a wide range of industries and services, such as financial services, real estate, healthcare and identity management. They can underpin other software- and hardware-based innovations such as smart contracts and the Internet of Things. Furthermore, their underlying philosophy of distributed consensus, open source, transparency and community could be highly disruptive to many of these sectors.

Like any radical innovation, as well as providing opportunities distributed ledgers create threats to those who fail or are unable to respond. In particular, through their distributed consensual nature they may be perceived as threatening the role of trusted intermediaries in positions of control within traditionally hierarchical organisations such as banks and government departments.

With its wide range of stakeholders, services and roles, the government has a multitude of different operations. Some distribute value rather than create it, and others create and maintain effective regulatory regimes. Many of these activities will be enhanced by innovations afforded by distributed ledgers, and others will be challenged.

Ultimately, the best way to develop a technology is to use it in practice. The expert group that supported the development of this report has scoped some specific examples of potential uses by the UK government, and these are set out in five use case studies in Chapter 6

- protecting critical infrastructure against cyberattacks

- reducing operational costs and tracking eligibility for welfare support, while offering greater financial inclusion

- transparency and traceability of how aid money is spent

- creating opportunities for economic growth, bolstering SMEs and increasing employment

- reducing tax fraud

Each of these case studies provides an overview of the distributed ledger proposition, its potential benefits and an assessment of the maturity level of the technology to deliver the application.

Only a tiny fraction of the possible applications are identified in this report but we believe they provide a good starting point for government to start piloting the technology within departments. So our final set of recommendations are aimed at implementing trials of distributed ledger technology and developing government capability:

Recommendation 7: *Understanding the true potential of distributed ledgers requires not only research but also using the technology for real life applications. Government should establish trials of distributed ledgers in order to assess the technology's usability within the public sector.*

We suggest that the trials should be co-ordinated in a similar fashion to the way that clinical trials are implemented, reported and assessed, in order to ensure uniformity and maximize the rigour of the process. The outcome of these trials and the lessons learnt should feed into the road-map proposed in Recommendation 1.

Areas where we believe work could be taken forward include the protection of national infrastructure, reducing market friction for SMEs and the distribution of funds from DWP and other government departments. During the development of this report, we found a small number of officials who are already thinking deeply about potential uses for distributed ledger technology by government. We recommend that these individuals be strongly supported and encouraged to move ahead in partnerships between government departments and GDS.

Recommendation 8: *As well as top-down leadership and coordination, there is also a need to build capability and skills within government. We recommend the establishment of a cross-government community of interest, bringing together the analytical and policy communities, to generate and develop potential 'use cases' and create a body of knowledge and expertise within the civil service. GDS and the Data Science Partnership between GDS, Office for National Statistics, Cabinet Office and the Government Office for Science could act as the convenors of this community of interest. There are important opportunities for government to stimulate the business sector by acting as a smart customer in procuring distributed ledger applications.*

Conclusion – taking a global perspective

The UK is not alone in recognising the importance of distributed ledger technologies. Other countries, large and small, are already moving quickly to adopt distributed ledgers — and the case study of Estonia shows how quickly a small country with an effective digitally-aware leadership can progress. However, there is still time for the UK to position itself within this leading group — indeed, it is essential for it to do so, given the importance of the financial and services sector to the UK economy.

Patrick Curry, Christopher Sier and Mike Halsall have considered in Chapter 7 the features of advancing digital nations and argue that the hallmarks of these include:

- A digitally-informed leadership

- An empowered focused government department for all national digital transformation, which is internationally minded and collaborates closely with all industry sectors

- A living, collaborative national plan, which is industry-led with government investment

- Technologically aware, qualified and experienced senior political officials in every government organisation

- Engineers and digital business leaders as politicians

We are still at the early stages of an extraordinary post-industrial revolution driven by information technology. It is a revolution is bringing important new benefits and risks. It is already clear that, within this revolution, the advent of distributed ledger technologies is starting to disrupt many of the existing ways of doing business.

The earliest accounting records of humans date back to Babylon, Assyria and Sumer, over 5000 years ago. Many clay tablets have survived as a record of the early technological revolutions in the development of writing, counting and money. It is less clear whether digital records will have the same longevity as clay tablets. But, leaving that aside, it is clear that there is a huge opportunity for the UK to develop and use distributed ledger technology for the benefit of citizens and the economy. There are a series of 'grand challenges' to tackle to maximise the benefits and minimise the harms of the extraordinary developments in information technology. This report sets out some key recommendations for the government, based on expert evidence. The most important of these is the need for close partnership between the public and private sector, within the UK and between the UK and other nations.

Definitions

The terminology of this new field is still evolving, with many using the terms block chain (or blockchain), distributed ledger and shared ledger interchangeably. Formal definitions are unlikely to satisfy all parties — but for the purposes of this report, the key terms are as follows:

- A **block chain** is a type of database that takes a number of records and puts them in a block (rather like collating them on to a single sheet of paper). Each block is then 'chained' to the next block, using a cryptographic signature. This allows block chains to be used like a **ledger**, which can be shared and corroborated by anyone with the appropriate permissions.

  There are many ways to corroborate the accuracy of a ledger, but they are broadly known as **consensus** (the term 'mining' is used for a variant of this process in the cryptocurrency Bitcoin) — see below.

  If participants in that process are preselected, the ledger is **permissioned**. If the process is open to everyone, the ledger is **unpermissioned** — see below.

  The real novelty of block chain technology is that it is more than just a database — it can also set rules about a transaction (business logic) that are tied to the transaction itself. This contrasts with conventional databases, in which rules are often set at the entire database level, or in the application, but not in the transaction.

- **Unpermissioned ledgers** such as Bitcoin have no single owner — indeed, they cannot be owned. The purpose of an unpermissioned ledger is to allow anyone to contribute data to the ledger and for everyone in possession of the ledger to have identical copies. This creates censorship resistance, which means that no actor can prevent a transaction from being added to the ledger. Participants maintain the integrity of the ledger by reaching a consensus about its state.

  Unpermissioned ledgers can be used as a global record that cannot be edited: for declaring a last will and testament, for example, or assigning property ownership. But they also pose a challenge to institutional power structures and existing industries, and this may warrant a policy response.

- **Permissioned ledgers** may have one or many owners. When a new record is added, the ledger's integrity is checked by a limited consensus process. This is carried out by trusted actors — government departments or banks, for example — which makes maintaining a shared record much simpler that the consensus process used by unpermissioned ledgers. Permissioned block chains provide highly-verifiable data sets because the consensus process creates a digital signature, which can be seen by all parties. Requiring many government departments to validate a record could give a high degree of confidence in the record's security, for example, in contrast to the current situation where departments often have to share data using pieces of paper. A permissioned ledger is usually faster than an unpermissioned ledger.

- **Distributed ledgers** are a type of database that is spread across multiple sites, countries or institutions, and is typically public. Records are stored one after the other in a continuous ledger, rather than sorted into blocks, but they

can only be added when the participants reach a quorum.

A distributed ledger requires greater trust in the validators or operators of the ledger. For example, the global financial transactions system Ripple selects a list of validators (known as Unique Node Validators) from up to 200 known, unknown or partially known validators who are trusted not to collude in defrauding the actors in a transaction. This process provides a digital signature that is considered less censorship resistant than Bitcoin's, but is significantly faster.

- A **shared ledger** is a term coined by Richard Brown, formerly of IBM and now Chief Technology Officer of the Distributed Ledger Group, which typically refers to any database and application that is shared by an industry or private consortium, or that is open to the public. It is the most generic and catch-all term for this group of technologies.

  A shared ledger may use a distributed ledger or block chain as its underlying database, but will often layer on permissions for different types of users. As such, 'shared ledger' represents a spectrum of possible ledger or database designs that are permissioned at some level. An industry's shared ledger may have a limited number of fixed validators who are trusted to maintain the ledger, which can offer significant benefits.

- **Smart contracts** are contracts whose terms are recorded in a computer language instead of legal language. Smart contracts can be automatically executed by a computing system, such as a suitable distributed ledger system. The potential benefits of smart contracts include low contracting, enforcement, and compliance costs; consequently it becomes economically viable to form contracts over numerous low-value transactions. The potential risks include a reliance on the computing system that executes the contract. At this stage, the risks and benefits are largely theoretical because the technology of smart contracts is still in its infancy, and some time away from widespread deployment.

Distributed Ledger Taxonomy

How many copies of the ledger?	→ One →	**Traditional ledger eg a personal bank account**
↓ Many		
Who can use these copies?	→ Owner group →	**Permissioned, private shared ledger eg Bankchain, a clearing and settlement network**
↓ Anyone		
Who maintains integrity of the ledger?	→ Trusted ledger owners or actors, by validation →	**Permissioned, public shared ledger (ie a distributed ledger) eg Ripple, a global financial transactions system**
	→ Any user, by untrusted consensus →	**Unpermissioned, public shared ledger eg Bitcoin, a cryptocurrency**

Figure courtesy of Dave Birch (Consult Hyperion)

Vision

Digital currencies such as Bitcoin rely on an underlying technology called a block chain. This records every transaction made in identical copies of a digital ledger that is shared among users. This 'shared ledger' approach could streamline a plethora of different services, both in government and the wider economy.
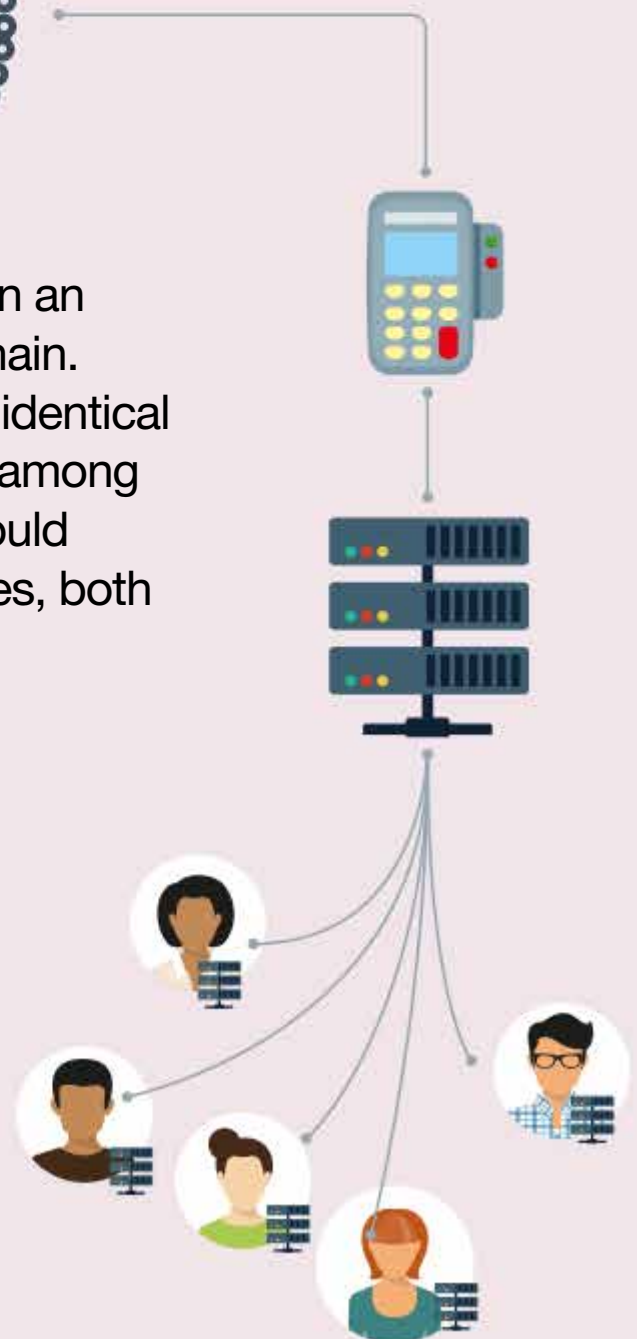
Author
Simon Taylor,
VP for Blockchain R+D, Barclays

Chapter 1: Vision

Introduction

Digital currencies such as Bitcoin have pioneered a new approach to tracking financial transactions. Their underlying technology — commonly called a block chain — records every transaction made in that currency in identical copies of a digital ledger that is shared among the currency's users.

Financial institutions, regulators, central banks and governments are now exploring the possibilities of using this 'shared ledger' approach to streamline a plethora of different services, both in government and the wider economy.

Many of these potential applications are medium-term prospects, but the long development cycles for government and the private sector, and the early promise that significant efficiencies could be gained, suggest that ministers and civil servants must now begin to consider how this technology could benefit them. This chapter outlines those opportunities.

What is a shared ledger?

A shared ledger is essentially a database that keeps track of who owns a financial, physical or electronic asset: a diamond, a unit of currency, or items inside a shipping container, for example. Crucially, every participant can keep a copy of the block chain, which is updated automatically every time a new transaction occurs. The security and accuracy of the information is maintained through mathematics — specifically by cryptography — to ensure that all copies of the ledger match each other. Almost anything that exists on paper today could exist on a shared ledger (see Chapter 2 for a more detailed discussion of shared ledger technology).

Since its launch in 2008, Bitcoin has relied on block chain technology. Many clichés and misconceptions have grown up around the digital currency and its underlying principles. Its associations with Silk Road, the digital black market, have left some people with the impression that Bitcoin is intrinsically linked to money laundering and terrorists. That misconception continues to affect how people think about block chain technology.

In fact, shared ledgers and databases may offer some major benefits to government and financial services, thanks to four important properties of block chain technologies.

1) **Reconciliation Through Cryptography**. Institutions such as businesses and governments currently send messages to each other to pass on details of transactions. Once the message is received, each institution then updates its own ledger. But today, there is no easy way to ensure that these copies match. Block chains can solve this in a number of ways: by simply sharing the same underlying data, for example, or by providing 'proof points' to verify the data. This approach could also be applicable to government data sets. The different actors (users) of the ledger come to a consensus about the state of the underlying data through a number of different consensus algorithms (eg Proof of Work, Proof of Stake, Practical Byzantine Fault Tolerance).

2) **Replicated to Many Institutions**. Many parties can have a copy of some

or all of the data, making it less likely that there is a single point of failure. Replication is a significant challenge for current database technologies, creating cost and complexity in industry and government IT projects. An additional benefit of this technology is that if one ledger is compromised, the remainder are not. Many parties can also confirm that those records have been added by performing the reconciliation calculations themselves.

3) **Granular Access Control**. Distributed ledgers use 'keys' and signatures to control who can do what inside the shared ledger. These keys can be assigned specific capabilities only under certain conditions. For example, a regulator may have a 'view key' that allows it to see all of an institution's transactions, but only when a key owned by a court gives it permission (control) to do so.

4) **Granular Transparency and Privacy**. Because many parties have a copy of the ledger (point 1), and many parties can verify every record (point 2), a shared ledger has a high degree of transparency. This allows a regulator or an independent body such as the judiciary to see with confidence that the contents of a database had not been edited or modified in any fraudulent way. Given the right conditions, it also allows them to unlock records that would otherwise be completely private and un-viewable. This could be useful for businesses (eg banks) in their regulatory reporting, fraud prevention, and could even empower citizens to hold the government to account (see Chapter 5 for a more extensive discussion). Records are added with a unique cryptographic signature that proves the right participant has added the right record according to the right rules.

When combined, these properties can solve challenges that were previously very expensive or challenging.

What is a smart contract?

If a block chain is the database, then the smart contract is the application layer that makes much of the promise of block chain technology a reality. Most conventional contracts have no direct relationship with the computer code that executes them (see Chapter 3). In many cases the paper contract is archived, and the software will execute an approximation of the contract's terms written in computer code (see Fig. 1).

Figure 1: Conventional contracts have no direct relationship with the computer code (app) that executes them.

User

App
(Controls who can do what)

User

Database
Managing permissions difficult
Sharing data very difficult
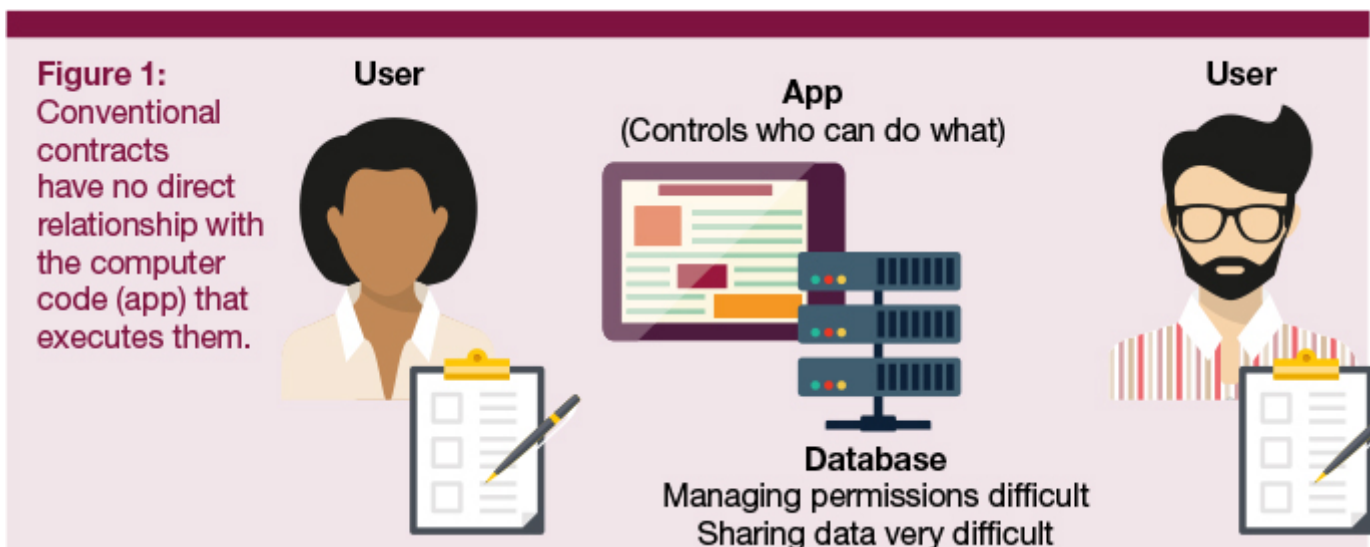
Figure 2: Smart contracts contain the computer code that executes the contract.

User view of shared ledger

Contract view of shared ledger

User view of shared ledger

This is quite effective when signing up to use a service (eg video on demand), but highly challenging when delivering multiple complex services to one user (eg updating an address in multiple government department databases). This has resulted in ever more complex data protection and data privacy legislation to manage the confidentiality and privacy of the individual in an assured way. In addition, activities like data sharing or agreeing contracts have remained in paper form, rather than being automated in the wider economy.

Combining the key attributes of a shared ledger (reconciliation through cryptography, replicated to many institutions, granular access control,

Figure 3: Smart contracts can control which institutions access private data.

Smart Contract (Controls who can share/view addresses)

User 1

User 2

OPT IN

OPT OUT

Institution
Can view User 1
New Address
Cannot view User 2
New Address
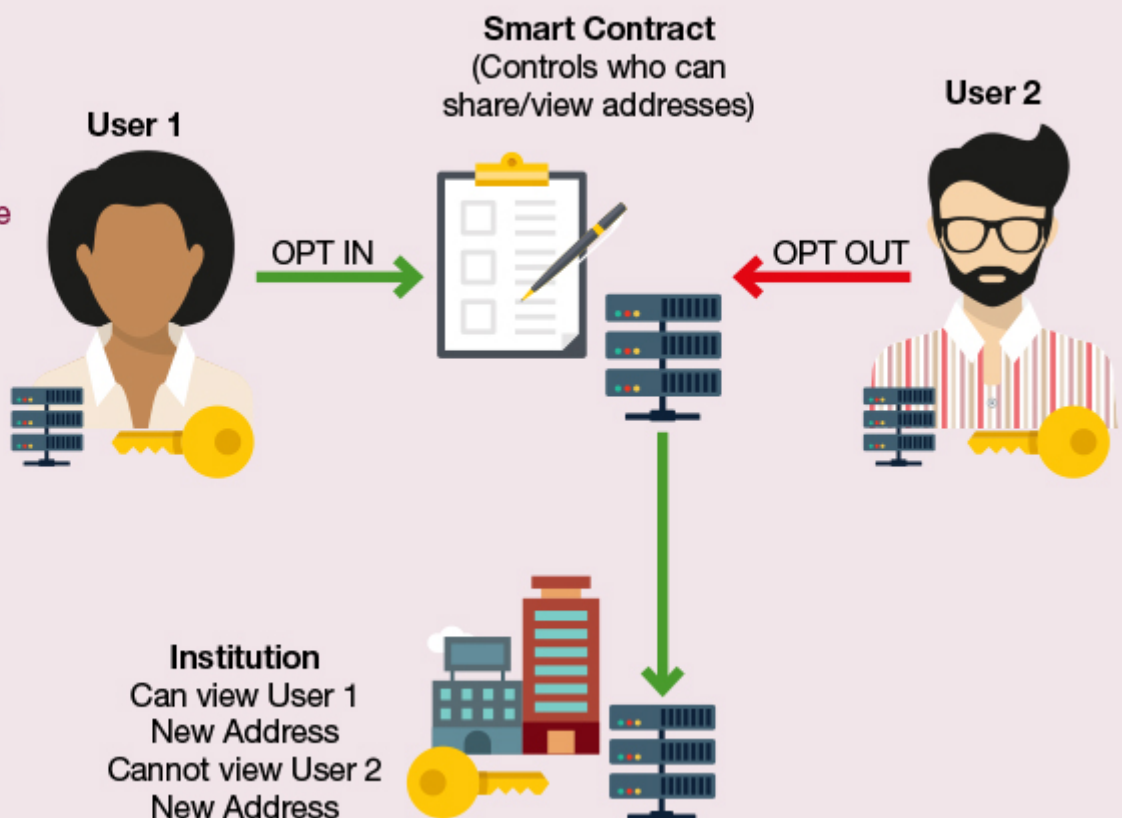
and granular transparency and privacy) with smart contracts may create opportunities to address some of these challenges, by allowing data to either be replicated or shared under specific conditions. If two users sign a smart contract, it will then contain logic that operates on the data in all parts of the shared ledger (see Fig. 2). This could facilitate the automation or removal of manual process in government and private sector institutions, which may drive efficiencies in productivity and growth. Note there are other challenges like management of legacy databases and processes, but the "permissioning" across multiple systems is where Smart Contracts come into their own.

In an alternative scenario (Fig. 3), User 1 opts in to a smart contract on a shared ledger to share their address with an institution that possesses a blue key (there may be many other institutions, with many different keys). But User 2 has opted out of sharing their address, so the institution only receives a copy of the latest address from User 1. This may be useful when an individual changes their address via their local council, because the change could be reflected on their passport, drivers licence and other key department databases. Services such as Onename.io use this concept today with social networks, and it could be extended to all institutions.

Smart contracts are being considered for a wide variety of uses, particularly for regulatory compliance, product traceability and service management, and also to defeat counterfeit products and fraud in the following sectors:

- Food
- Financial Services
- Energy
- Pharmaceuticals
- Health
- Aerospace
- Aviation
- Telecommunications
- IT and communications
- Transport
- Utilities
- Agriculture
- Oil and gas

Some of these are discussed later in this chapter, and in Chapters 6 and 7.

In summary, a smart contract is useful when machines, companies or people want to create a digital agreement, with cryptographic certainty that the agreement has been honoured in the ledgers, databases or accounts of all parties to the agreement.

A vision for the future

A key role of democratic government is the appropriate distribution of resource among its citizens, both individual and corporate. This goes beyond the distribution of monetary resource and includes social intangibles such as security, democracy, the conditions for the maintenance of the rule of law; and economic conditions such as the promotion of free markets, keeping inflation low and steady, protecting the rights of private property, and guaranteeing contracts. This distribution in turn is based on an agreement between the citizen and the government on how rules are set (through voting and manifestos).

As that democratic model has developed, the machinery of government (ie the mechanism by which this distribution takes place) has become larger, more centralised and, arguably, more remote from the individual citizen.

The collection of (monetary) resource through taxation of various kinds has become hugely complex and costly, as has its distribution through welfare support, grants and pensions. This complexity may in part derive from its centralised nature.

The private sector has started to recognise that this centralised model delivers poor customer service, is no longer economic and also fails to take into account the full benefits of e-commerce and digital capability. Governments are beginning to recognise that citizens' expectations should be met in similar ways, with real time, personal and digital services offered for all government services. Application of shared ledgers and smart contracts offers the opportunity to put government in the lead in this area, ensuring that the benefits of the technology are enjoyed by those who need it most, not just those who can best afford them.

This trend is also apparent in the growth of the less-formal 'sharing economy', and in popular, social-media led phenomena such as the Arab spring and the Occupy movement. These show a shift in how society communicates and organises itself. To date, however, there has been no successful way to embrace these in a secure way while continuing to promote free markets and guarantee contracts. It is often said that the reason we have never shifted democracy online is because there is no way to be sure who is voting for what without a highly costly and arguably non-libertarian centralised identity system. Assuming this is undesirable, the properties of block chain technology (reconciliation through cryptography, replicated to many institutions, granular access control, and granular transparency and privacy) could be turned to the benefit of citizens.

In addition, the early involvement of government in the development and deployment of block chain technology offers an opportunity for reducing the complexity and cost of government. That would lead to a more personal, immediate and potentially more democratic basis for governance, with consequent increases in compliance, cost-efficiency and accountability.

Steps towards embracing block chain technology

Shared ledger technology is being actively promoted and developed in key global economies such as the United States, China, Singapore and Latin America. The UK has an opportunity to compete in this race by understanding and supporting the growth of this nascent sector.

The government's potential involvement in distributed ledger technology can be seen through three lenses:

- Government: the civil service
- Government: the legislator
- Government: the steward of the economy

Government: the civil service

The civil service has a number of key duties that could be impacted by this technology, with strong use cases focusing on the nexus of privacy, data portability and the sensory capabilities of mobile technology (see Chapter 6 for more detailed case studies).

Government: the legislator

Distributed ledger technology is still young, and likely to see several more cycles of development. As such, the government's actions can target three separate 'horizons' in the technology development process.

Horizon 1: Supporting an Emerging Ecosystem
There are already a number of digital currency exchanges, 'wallet' providers and other service providers both in the Bitcoin ecosystem and in other shared ledger systems. Recognising that the technology and businesses will continue to mature, Horizon 1 activities may include:

- Requiring exchanges to verify the identities of their customers (known as KYC, or 'Know Your Customer' regulation).

- Issuing guidance for the banking sector to demonstrate the difference between the types of companies in this space: (i) those who transfer value via block chain systems; (ii) those who provide software to industries that use block chains; (iii) those who provide block chain-based software to solve conventional business problems.

- Establish security standards for wallet providers.

- Creating challenges for academia and the start-up ecosystem to look at specific gaps in the block chain ecosystem, such as: (i) establishing the appropriate technical architectures; (ii) establishing how the technology could enhance efforts to improve customer identity verification, tackle money laundering, and prevent crime; (iii) establishing how the use of multi-signature wallets can create new government–citizen user experiences and empower citizens to control and audit their own data held by the government.

- Leveraging partners to sustain a co-ordinated conversation between the government and industry.

Horizon 2: Early Trials and Pilots

Where the government has specific opportunities it may wish to begin performing local trials of use cases. Particular questions the government may want to consider are:

- What key utilities could benefit from shared ledger / database technology?

- Where might a trial support policy (eg pension reform, welfare reform)?

- Where can a trial offer the greatest learning opportunity?

Horizon 3: Position the UK as a Leader in the Global Race

Much of the venture capital investment in distributed ledger technology has to date focused on Bitcoin, and the west coast of the United States. But the emerging opportunities for this technology lie in other applications.

- The UK should recognise this nuance and create guidance to that effect through its regulatory bodies (see Chapter 3 for more on governance and regulation).

- The UK could create a centre of excellence for these technologies and add this to the global FinTech / UK Trade and Investment agenda.

Government: the steward of the economy

To understand how the government can best promote and realise the benefit of this technology, it will be helpful to look at use cases in two different areas: financial services; and insurance and other industries.

Financial Services

Examples of where the technology could be applied to the finance sector include:

- Increased efficiency in capital markets

- Reduced fraud and increased efficiency in trade finance

1. Increased efficiency in capital markets

Capital markets still rely on paper records to reconcile a trade between counterparties. While central utilities have been created in the past, the ability to reconcile ('clear') a transaction and be sure that the counterparty has agreed is significant because today it requires reliance. Many of the fines and much of the fixed cost base of banking is based on the concept of reliance. In essence, one bank must rely on the processes of another bank and has no way to verify the behaviour of that bank. A block chain technology can help by showing the chain of transactions (reconciliation through cryptography), and the actors involved, in a way that is transparent to a regulator. In addition, auditing this data is expensive and happens after the trade has taken place. The large banks are now finding appropriate vehicles to collaborate on this technology to unlock efficiencies.

2. Reduced fraud and increased efficiency in trade finance

Trade finance still operates in much the same way as it has for thousands of years. There are often at least 5 or 6 parties involved in the buying or selling of a particular item (eg the buyer, the buyer's bank, the shipping company,

the courier, the seller and the seller's bank). There have been attempts to both standardise and create central utilities in trade finance. Shared ledgers offer some unique advantages.

- A 'partially permissioned' system could enable the secure signing of a paper document (eg a bill of lading stating which products were in a container, how many, what colour etc). This could then be signed (provably and digitally) by each of the parties. (Key properties: **High Transparency; Reconciliation Through Cryptography**)

- Rather than simply storing the documents, as is done today, a shared ledger system would record proof of the state of those documents. If adopted more widely, the documents could be distributed via the shared ledger, rather than printed and signed. (Key properties: **Highly Scalable and Replicable**)

Industry and Institutions

1. Asset tracking and provenance assurance

Many items, such as fine art or consumer electronics, physically carry digital markers. There is, however, no global utility to track and trace these items that would offer control of the permissions that determine who can see which assets are being managed. Many organisations rely on paper documents to prove the origins of produce. But there is no way to verify these origins if the paper trail is forged. If parts of that supply chain used a shared ledger, and 'signed' the ledger digitally, it would be clear to all parties that the documents had not been amended or forged in any way.

For example, Provenance.org is a start-up using block chain technology to give retailers confidence in the provenance and sustainability of garments. Retailers currently rely on paper documents to confirm the provenance of garments, but there is no way to ensure that the right person completed those documents, at the right time. Using block chain technology, the appropriate person could digitally sign a contract with their private key, giving a far higher confidence that the right person signed the document at an exact date and time. The nature of block chain technology means that this would be visible to all retailers who had the appropriate privileges.

2. Confidential Use of Data with User Control

Data accuracy and confidential data sharing are key challenges for institutions. Insurance companies can create more accurate products, prices and premiums if they have additional data that is validated as accurate by one or more trusted sources (eg governments or banks). The difficulty has been to do this in a secure way while ensuring that the citizen remains in control of their data.

A block chain would provide proof of how every piece of data was accessed, perhaps using a solution such as Guardtime. Using trusted execution environments (TEEs) in mobile phones, such as ARM's TrustZone chip, any request to access data held in government would be recorded in a block chain. Unless the citizen had granted permission to the insurance company, this data would not move. If any attempt to change or access the data is made, the citizen or relevant authorities would be made aware immediately.

Shared ledger technology, when combined with simple mobile user interfaces, potentially moves a lot of the complexity of managing security into the background. The institutions that choose to adopt this way forward will need to win the confidence of the public, and early trials and implementations will be helpful in achieving this.

3. Industrial Equipment (a linked 'Internet of Things')

It can be difficult to gather accurate, real-time data about industrial equipment across many sectors, including transport, utilities and agriculture. With the advent of the Internet of Things (IoT), some of these difficulties are being addressed with low-cost commodity hardware, but this is potentially vulnerable to attack. According to a recent report[2] from the IBM Institute for Business Value:

> "The result: a proliferation of hundreds of billions of devices that will be no more expensive than their dumb counterparts, yet able to operate and act as part of complex, integrated systems."

> "In a network of the scale of the IoT, trust can be very hard to engineer and expensive, if not impossible, to guarantee. For widespread adoption of the ever-expanding IoT, however, privacy and anonymity must be integrated into its design by giving users control of their own privacy. Current security models based on closed source approaches (often described as "security through obscurity") are obsolete and must be replaced by a newer approach – security through transparency."

> "In our vision of a decentralized IoT, the blockchain is the framework facilitating transaction processing and coordination among interacting devices. Each manages its own roles and behavior, resulting in an "Internet of Decentralized, Autonomous Things" – and thus the democratization of the digital world"

If each device functions both as an autonomous agent, and a part of the whole, there is no central point of failure. In this use case, institutions would apply IoT devices and gain many of the benefits associated with real time data and connectivity outlined in the recent Government Office for Science report on the IoT[3]. Shared ledger and block chain technology provide new business and technology models for higher security implementation of IoT.

Example 1: A tractor that operates as an autonomous unit can authorise access to multiple farmers in an area, enabling a pay per use model. It has the ability to discover and pay for climate data, and communicate with its manufacturer for maintenance and repairs.

Example 2: Industrial equipment can be empowered to order new parts, as long as there is certainty that that device is genuine and has the authority to do so. This may also lead to new ways of financing such equipment, and new marketplaces based on the equipment's performance or efficiency.

Conclusion

It is possible to envision a future where this technology creates a form of 'glass government' that is more accountable to the citizen. There are a number of use cases, and as the technology progresses it is almost certain more will emerge. This may help to achieve policy objectives. The key points for ministers and the civil service are:

The technology is in its early stages but shows significant promise. To unlock the promise of block chain technology, it is essential to understand how the combination of:

- Reconciliation through cryptography

- Large scale, secure replication of data

- Provable Transparency

can be used over three horizons:

- Supporting the emerging ecosystem

- Early trials and pilots

- Positioning the UK as a global leader

Technology
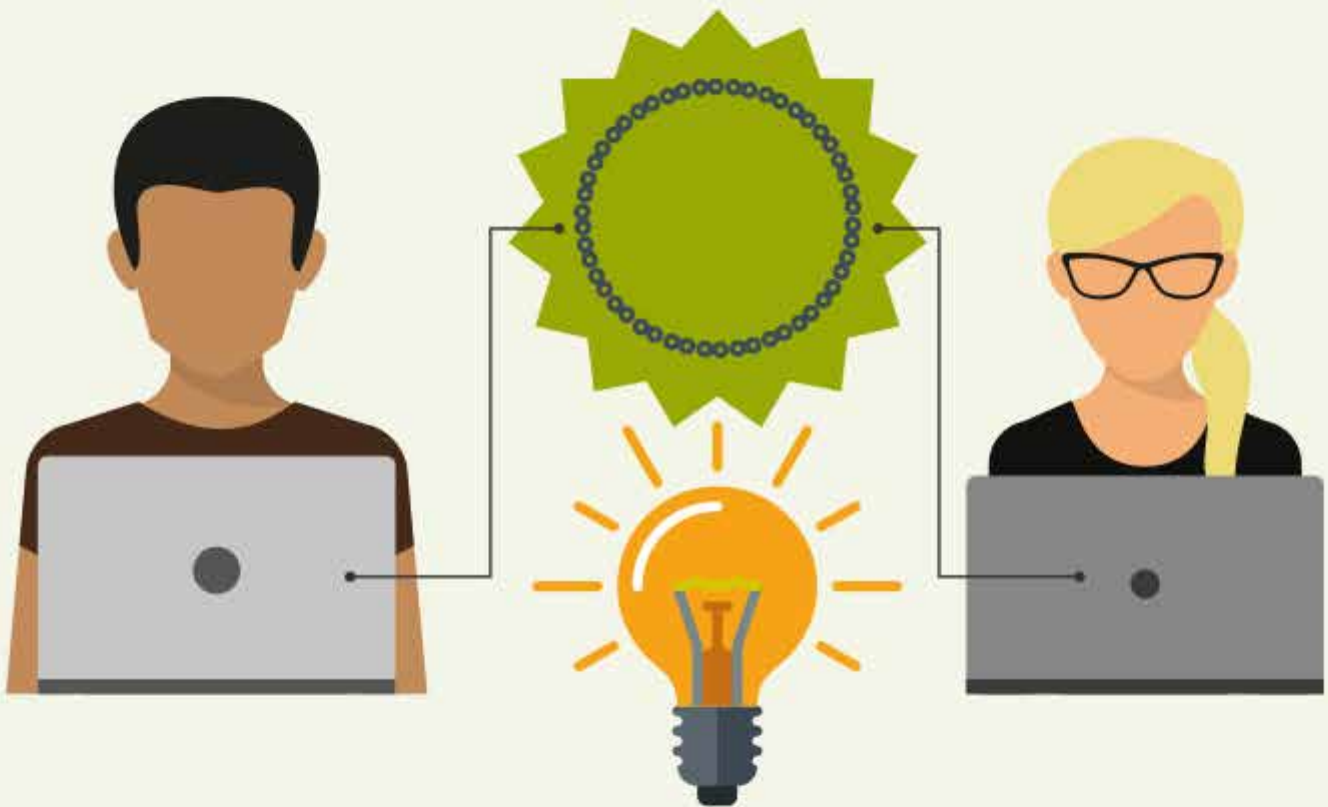
Physical cash is unlike any other form of money. It can be transferred between two people without the involvement or permission of any third parties such as banks or governments. Bitcoin and its block chain have shown us how to perform this trick electronically. But the implications and opportunities of this digital technology are much broader.

Author
Richard G Brown,
Chief Technology Officer, R3

Chapter 2: Technology

Introduction

Bitcoin is a new form of **digital cash**. Rather than being issued by a central bank, such as the Bank of England, its issuance is controlled by a **decentralised** network of computers. This network relies on cryptography and other techniques to regulate the supply of Bitcoins and keep track of who owns them. Bitcoin is consequently known as a **cryptocurrency**.

Banks keep track of customer balances on a **ledger**. Bitcoin also uses a ledger, but it is maintained collaboratively by the decentralised network of computers, and is known as a **distributed ledger**.

As new batches of entries are added to the distributed ledger, they include a reference back to the previous batch, so that all participants can verify for themselves the true provenance of everything on the ledger. These batches are called **blocks**, and the whole collection is a **block chain**.

This chapter will explain more about these concepts, why they are important, and how they might form the basis of a much broader suite of applications.

What is money?

A £20 note is an extraordinary thing. Simply handing the note to someone instantly transfers £20 of value to them, without requiring a third party to verify the transaction. If the two people were alone, nobody else in the entire world need know it had happened, and nobody could have stopped the transfer.

But this peer-to-peer transfer only works at close distance. To transfer £20 of value to somebody in a different town or country, we need to trust other people and cede some degree of control to them: the postal worker who handles an envelope containing the cash, or the bank that carries out an electronic funds transfer. Indeed, if the bank believes that the money is connected to illegal activities, it can block the electronic transaction or seize electronic funds.

The world's financial plumbing — payments systems, the working relationships between banks, electronic communication networks such as SWIFT (the Society for Worldwide Interbank Financial Telecommunication) — are a direct consequence of the fact that physical cash really is fundamentally different to every other form of money. Only physical cash is a bearer instrument. And only physical cash can be transferred without someone else's permission — it is 'censorship resistant'.

Or so we thought until late 2008, when Bitcoin was announced. Its creator claimed that it was a system of "purely peer-to-peer electronic cash", which could be controlled outright by the holder, and sent to anybody without needing a bank's permission or running the risk of confiscation.

Every full participant in the Bitcoin system has a copy of every transaction, arranged in 'blocks', going all the way back to the start of the system. Each block is cryptographically linked to the previous block, forming a block chain that maintains a full history of transactions, and therefore acts as a distributed ledger. Users can access the ledger with a variety of different applications (such

as Coinbase or Blockchain — not to be confused with the underlying technical concept), and every copy of the ledger is synchronised by algorithms set up to reach 'consensus' about the state of the ledger.

Bitcoin did not appear out of nowhere in 2008. Research into digital currency systems goes back decades, and each of the components of the system already existed. Bitcoin's breakthrough was to combine existing techniques in an innovative way, and to do so at a time when the idea of open source development on the internet was mature, and when people were receptive to the idea of alternative monetary systems.

The system is designed so that it becomes progressively harder — effectively impossible — for older blocks to be rewritten. Once a transaction is sufficiently confirmed, it can never be reversed, rendering it censorship resistant. In short, it truly is digital cash.

FAQ

What is 'the block chain'?

A block is simply a list of payments. A block chain is a list of blocks, each one referring back to the one that went before. However, when people talk about the block chain, they tend to mean the collection of technologies and techniques that underpin the Bitcoin system, which other projects have used as inspiration because they solve unrelated problems in finance and elsewhere.

Little wonder, then, that governments and regulators around the world have viewed this invention with such caution. A censorship resistant, digital bearer asset would seem to be an ideal currency for criminal networks, and Bitcoin became the primary monetary unit of Silk Road, the now-defunct digital black market.

Yet most regulators, including multiple agencies in the UK, have chosen not to ban Bitcoin, and many legitimate companies are investing heavily in this form of technology. Why?

Opportunity or threat?

Firstly, these systems are not as uncontrollable — or 'unpermissioned' — as one might expect. Contrary to public perception, the underlying architecture makes it relatively easy to track transactions and establish the identity of people who misuse the system. Regulators have also learned how to control the 'on-ramps' and 'off-ramps' where value flows in and out of the system.

Platforms like Bitcoin may sound alarming at first, but users are not guaranteed anonymity and if they want to convert their bitcoins into pounds, dollars or euros then the exchange systems are expected to enforce relevant regulations regarding identity, money laundering and terrorist financing. Furthermore, and as will be argued shortly, many of the most interesting applications of this technology enforce rules about who is and is not allowed to use the system.

The second emerging belief is that the technology underpinning Bitcoin could have valuable and benign uses, and could enable significant future innovation. Bitcoin's censorship resistance is problematic from a law-enforcement and regulation perspective, and it is therefore unlikely that major corporates or banks will engage closely with Bitcoin or related technologies in the short to medium term.

But the distributed ledger technology behind cryptocurrencies offers an

openness that could be immensely valuable. Open platforms, controlled by no one firm and with a thriving community of developers, have been shown time and again to be drivers of innovation. They can enable outsiders and new entrants to offer new products and services for previously marginalised users (see Chapter 5 for more on the technology's disruptive potential).

Although distributed ledger technology was invented to satisfy one goal (digital cash), firms and other institutions are now actively exploring how it can be applied to a variety of other pressing problems. For example, businesses often find 'permissioned' block chains far more appealing than Bitcoin's unpermissioned model, because specific parties are authorised to verify transactions. This allows the businesses to create secured, private networks involving mutually trusting firms and individuals (for a more extensive discussion of permissioned and unpermissioned systems, see Chapter 3).

FAQ

FAQ: What fundamentally differentiates Bitcoin from previous currencies?
Bitcoins can be owned by any individual, without permission from any bank or government. They can be sent to anybody else in the world who knows how to operate a 'Bitcoin wallet'. It is this principle of 'censorship resistance' that captures Bitcoin's essential breakthrough — and which explains early concerns by lawmakers and regulators.

Overall, it is clear that there could be a continuum of technologies in this space, which can be categorised by how 'decentralised' they are (ie to what extent are they truly permissionless) (see Fig. 1). But centralisation is just one dimension along which this domain can be analysed. Other categories under active exploration include the degree to which use of funds can be prescribed (eg funds that can only be spent by a child if a parent co-signs) and the possibility of representing assets other than money (eg securities or even title to property).

Figure 1: Different ledger technologies vary in their 'degrees of centralisation'

| Permissionless, Public, Shared Systems (eg Bitcoin) | Permissioned, Public, Shared Systems | Permissioned, Private, Shared Systems | Today's Typical Systems |

100% Decentralised ← Distributed Ledger Technology Covers a Broad Set of Usages → Centralised Ledgers 100% Centralised
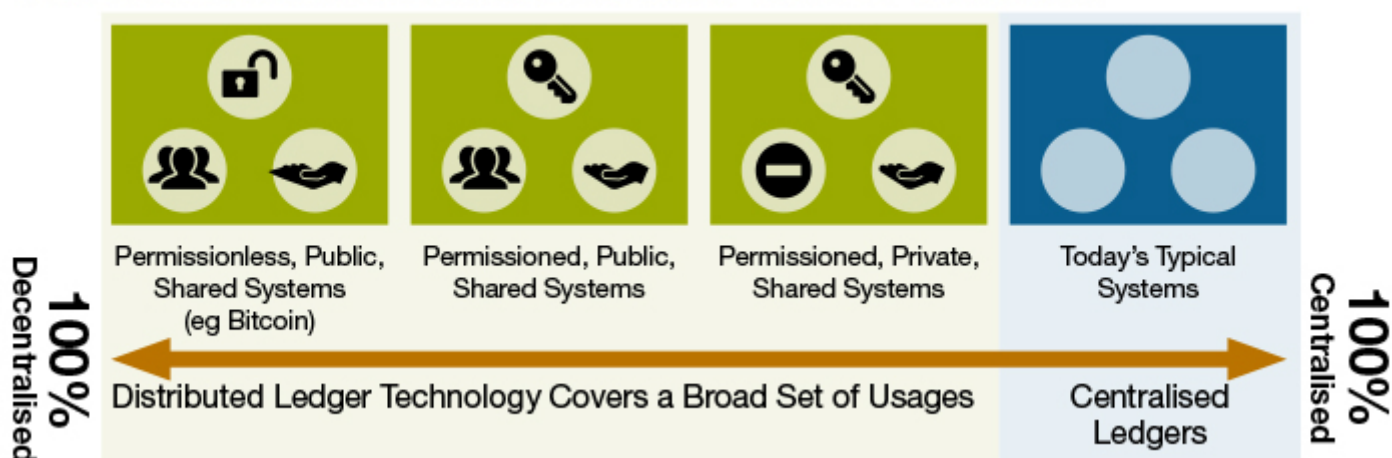
Potential applications

Distributed ledger technology could solve business problems that can be summed up as cost, duplication and reconciliation.

Take banking. Every bank has built or bought at least one (usually several) systems to track and manage the lifecycles of their financial transactions. Each of these systems cost money to build and even more to maintain. They must be connected to each other and synchronised, usually through a process known as reconciliation. This involves teams of people in each bank checking with their counterparts in other banks to make sure everything matches, and to deal with the problems when it does not.

A common solution involves setting up a single, centralised ledger shared by all participants. The UK has had a number of successes that rely on this approach, especially in the Faster Payments Service. But centralised utilities are typically expensive and, as their data and processing is centralised, they often must be integrated with each participant's own systems. Alternatively, many decentralised databases can sit around the edges of a network while messages move between them (see Fig. 2).

Figure 2: Distributed networks can avoid the time-consuming reconciliation processes used by centralised and decentralised databases

Tim Swinson

Centralised   Decentralised   Distributed
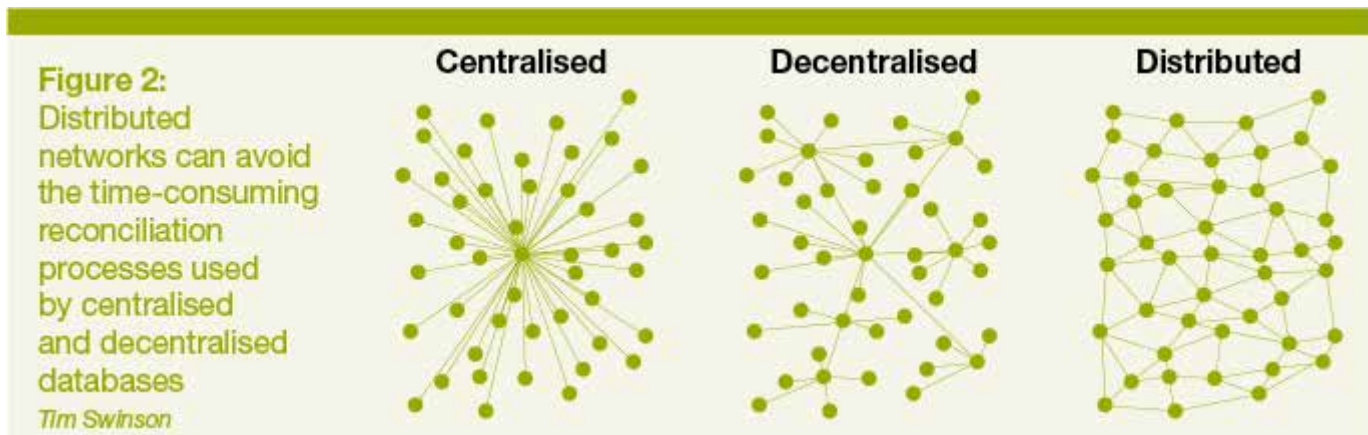
Bitcoin, in contrast, synchronises thousands of computers in a distributed network via the internet: if my computer thinks that I own a Bitcoin, then so does every other computer in the network. If a similar technique could be used in banking, all the banks' systems could stay in step with each other without requiring armies of people to reconcile and resolve the issues. Crucially, we do not need Bitcoin to achieve this — it is the underlying distributed ledger technology that offers a possible solution.

This could help to tackle one of the biggest problems with financial services: the costs of using paper. In recent years, there have been many different initiatives intended to remove paper documents from the economy. However, in many cases the new technology has simply recreated old processes in a new way, or continues to rely on paper in other stages of the process. For example, providing finance to exporters remains an extremely manual process: an importer's bank often issues a letter of credit, against which the exporter's bank will advance funds. Although this process is usually electronic, the subsequent verifications rely on bundles of paper documents that are manually processed around the world. A shared ledger technology could, in contrast, replace certain aspects of paper-based banking with processes that operate in a much speedier and paper-

Research and horizon scanning

John G Baird, Lead for the RCUK Digital Economy Theme, EPSRC

The Engineering and Physical Sciences Research Council (EPSRC) leads the Digital Economy (DE) Theme on behalf of Research Councils UK (RCUK). Since 2008, the DE Theme has invested over £170 million in applied multidisciplinary research, with a particular focus on societal challenges around the digitisation of the economy and its effects on social inclusion, rural economy, personal data, security, identity, trustworthiness and privacy. The DE Theme is leading on taking forward both the Digital Currencies and the Internet of Things activities announced in the March 2015 Budget. In the area of distributed ledger technologies, to date we have invested in the following activities:

1. Cryptocurrency Effects in Digital Transformations (CREDIT)[1], an 18-month £0.4 million research project that aims to investigate the phenomena of cryptocurrencies and their associated underlying technology, the block chain, grouped around 4 main themes: digital transformations, privacy, community and institutions. The main outcomes of the research will be:

- A step-by-step guide aimed at helping start-ups and incumbents understand the issues to consider for incorporating block chain technologies into their products and services

- A number of small pilot studies with companies examining the potential impacts of cryptocurrencies

- A community of academic researchers and professionals able to further develop this nascent research area

2. CREDIT builds on two previous scoping reviews that we supported: 'The disruptive role of crypto-currencies'[2] and 'ICT and the Future of Financial Services'[3]. These both reviewed the current understanding of cryptocurrencies and revealed gaps in the understanding of social, ethical, legal, regulatory impacts of crypto-currencies. As a result, we recently issued a £10 million call for research proposals on 'Trust, Identity, Privacy and Security in the Digital Economy'[4], which features "Broad applications of distributed ledger technologies" as one of its six focal areas. This focal area seeks to support research that blends and balances the technological advancement in distributed ledger systems with an understanding of the societal, ethical, legal and business frameworks needed to build confidence, trust and adoption of such systems by individuals, communities, organisations and states. Ultimately, we hope this research will pave the way towards a 'smart' economy that can support diverse scenarios of monetary and non-monetary value exchange between individuals and organisations and, in the future, 'smart' objects.

3. Finally, we have also funded a £260,000 research project, 3rd Party Dematerialisation and Rematerialisation of Capital (3DaRoC)[5], which explored how to design effective digital retail financial services based on case studies with two retail finance organisations: Zopa Limited, a peer-to-peer lender; and the Bristol Pound, a community currency. The project has produced an online toolkit to assist users and businesses interested in the key issues impacting the design and use of digital financial products[6].

less way. The Engineering and Physical Sciences Research Council (EPSRC) is already supporting exploratory research on such financial applications (see case study on research and horizon scanning, above).

But the opportunities are not limited to banking. Applications are being explored in healthcare (patient records), government (land registries and benefit disbursement— see Chapter 6), electronics (including the 'Internet of Things' —

see Chapter 1) and even the world of art and jewellery (tracking the provenance of diamonds — see Chapter 5).

It is important to stress that these technologies are very early in their development, and there are many unsolved problems to tackle before these applications can be realised, including issues of privacy, performance, and scalability. Does the technology actually work well enough for the banks to trust? Who will build these platforms if they can't easily charge a fee when they are shared and mutualised?

But the field is developing rapidly and many of the problems are already being resolved. It is now becoming possible to distinguish between those aspects of the technology that will change over time, and those that are innate and are unlikely to change. Already, we can see that distributed ledger technology could enable firms and governments to run more efficiently, without expensive reconciliation and duplication. And it could allow both incumbents and new entrants to compete on equal terms in offering new products and services to consumers based on open access to securely shared data.

That could usher in a world-changing revolution that goes far beyond censorship-resistant digital cash.

Governance and Regulation

Both the legal and the digital spheres are governed by rules, but the nature of these rules is different. In a digital environment, both laws (legal code) and software/hardware (technical code) regulate activity. The impact of both must be considered in setting out regulations that cover distributed ledger systems.

Author
Vili Lehdonvirta, Oxford Internet Institute, University of Oxford;
Robleh Ali, Manager – Digital Currencies, Bank of England

Chapter 3: Governance and Regulation

Introduction

This chapter deals with rules and rulemaking in distributed ledger systems. We will distinguish between **legal code** (rules consisting of legal obligations) and **technical code** (software and protocols). We will also distinguish between **governance** (rule-making by the owners or participants of a system with the purpose of safeguarding their private interests) and **regulation** (rule-making by an outside authority tasked with representing the interests of the public).

Legal code vs technical code: Two types of rules

The financial system is both a set of legal obligations between institutions and a set of digital records of these obligations. Both the legal and the digital spheres are governed by rules, but the nature of these rules is different. In a seminal text on the subject[1], Lawrence Lessig of Harvard University addressed how these legal and digital rules interact to govern activity. Lessig argued that in a digital environment both laws (legal code) and software/hardware (computer code) regulate activity, and that the impact of both needs to be considered when constructing a theory of regulation. In this chapter we refer to technical code rather than computer code. This definition covers both software and protocols, as distributed ledgers rely on both to function.

One fundamental difference between legal code and technical code is the mechanism by which each influences activity. Legal code is 'extrinsic': the rules can be broken, but consequences flow from that breach to ensure compliance. Technical code, in contrast, is 'intrinsic': if its rules are broken then an error is returned and no activity occurs, so compliance is ensured through the operation of the code itself. Another characteristic of software is that a machine will rigidly follow the rules even where that compliance produces unforeseen or undesirable outcomes. This leads to some striking differences in the operation of distributed ledger systems compared with the current financial system.

1. Current financial system: ruling via legal code

The modern financial system is already largely digital and heavily reliant on technical code. This technical code governs the creation and amendment of the digital records of the legal obligations between institutions. Financial regulation is aimed at the effects these legal obligations produce: for example, whether a bank has sufficient capital or liquidity. The financial system is already governed by this combination of technical code and legal code, but financial governance and regulation has traditionally focused on the latter.

Enforcement of the public element of the legal code falls to a specialised group of financial regulators charged with ensuring compliance by participants in the system. Participants must provide the information that their regulator needs to assess whether they are in compliance with the system's rules. If an institution is not in compliance then the regulator can take action to bring them back into line. This is not to say technical code has no influence on the existing regulatory process — all the information provided to the regulators is digital, and the product of technical code — but governance and regulatory aims are pursued by producing legal code rather than by changing the technical code.

2. Distributed ledger systems: ruling via technical code

Distributed ledger systems such as Bitcoin have shown that they can function without legal rules. Instead, the rules that each participant must follow are defined and enforced only by technical code. Each participant in the network runs the same or compatible software that defines what kinds of transactions are permissible. For example, the Bitcoin software allows participants to spend only balances that they can prove they own with cryptographic keys. The Bitcoin software also regulates how new currency is issued, and places an absolute cap on the size of the money pool. There are no bylaws or other legal documents stating these rules, and no humans to enforce them — distributed ledger systems are solely governed by their own technical code.

To prevent participants from modifying their copy of the code to issue transactions that are against the rules, each transaction needs to be verified before it enters the ledger. In an 'unpermissioned' distributed ledger system like Bitcoin, verifiers (known as miners) are chosen by lottery. The system seeks to assure their integrity through a system of economic incentives, in a process governed by the software. In a 'permissioned' distributed ledger system, verifiers are appointed by the system's proprietor, and their integrity is assured through conventional means, such as a legal contract.

In summary, distributed ledger systems differ from the conventional financial system in that they are ruled by technical code rather than legal code. One advantage of this is that compliance costs are low: participants need only use a compliant software package to issue transactions. It might seem that enforcement costs are lower, too, but this is not necessarily the case because the mining system that is used to verify transactions in all of the most popular distributed ledger systems consumes significant computational resources. That cost must eventually be borne by the system's users.

Governance vs regulation: Two types of rule-making

Because the current financial system and distributed ledgers are primarily governed by different types of rules, we must therefore ask the question: who makes the rules?

1. Current financial system: a mesh of private and public rule-making

There are many places where legal code is being produced in the current financial system, but these can be broadly divided into two categories: private rule-making (governance) and public rule-making (regulation). An example of private rule-making is the Visa Core Rules promulgated by the financial services company Visa Inc. to govern the actions of all the participants in the Visa system. Such private rule-making is done by proprietors of private financial networks like Visa, as well as by private associations of financial institutions wishing to coordinate their activities to one another's benefit. An example of public rule-making is the statutory oversight of Visa Europe's payment system by the Bank of England.

The design of the public legal code in the current financial system is the province of policymakers who have to consider the effect of regulations on the different institutions of the financial system (a 'microprudential' approach) as well as the impact on the system as a whole (a 'macroprudential' approach). As the financial system is global, international bodies such as the Basel Committee on Banking Supervision convene policymakers from around the world to reach voluntary

accords that can then be translated into legislation in a specific jurisdiction.

2. Distributed ledger systems: ad hoc private rule-making

Unpermissioned distributed ledger systems are sometimes thought to exist independently of human rule-making, and governed only by mathematical algorithms. This is a misconception. Just like legal code, technical code needs to be produced and maintained by humans who define the rules that the code embodies. Using Bitcoin as an example, the initial version of the software was published by Satoshi Nakamoto (a pseudonym). In 2010, Nakamoto handed control of the project to Gavin Andresen, an Australian-born programmer living in the United States. Like any software, Bitcoin needs to be regularly updated to address bugs, security issues, and changes in the operating environment. Such an update can in principle change any aspect of the software, including accounting and ownership rules. Who gets to write the software and how that process is governed is therefore critically important to all participants in a distributed ledger system.

In the case of Bitcoin, the software is governed by an ad hoc process involving a handful of informal institutions and power holders. Figure 1 shows who has written most of the current Bitcoin code. The software is open source and anyone can suggest changes to it, but technical authority to admit changes to the official version of the software is held by a team of five core developers appointed by Andresen. The core developers' power is constrained by an informal self-imposed charter, which states that significant changes to the rules require broad consensus from the community. Any update to the software must furthermore be installed by a majority of the miners (as measured by the computer processing power they contribute) for the changes to become effective. A handful of individuals who manage so-called mining pools are therefore very influential in determining whether or not miners ratify a software update in this way.

This governance process worked well when the changes to the code were uncontroversial bug fixes, but it has started to show signs of breaking down recently, because some decisions require choosing which stakeholders' interests to prioritise over others'. Andresen and others have stated that the process needs to become more formal. The community is debating what such a formal governance system should look like, but this is complicated by the fact that

Figure 1. Bitcoin Core active lines of code by developer, 14 May 2015 (source: author's analysis)
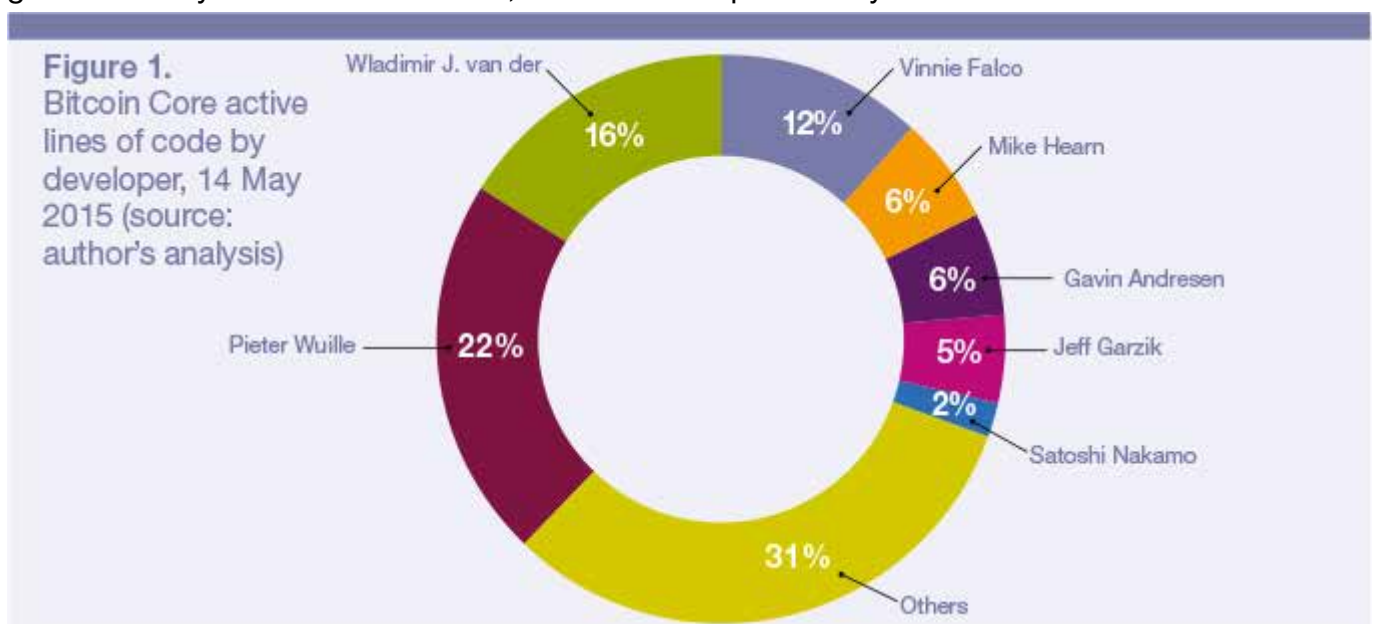
Bitcoin was founded on an ethos of anti-institutionalism. This is an interesting conundrum, as it demonstrates the worth of legal code and shows that technical code alone does not produce an optimal outcome.

In permissioned distributed ledger systems, governance of the software is made simpler by the fact that there is usually a proprietor with clear legal and technical authority over the code. It is up to the proprietor to determine how the code is modified, and up to the users (often customers of the service) to decide whether they are comfortable with having the proprietor exercise authority over the software. Service level contracts and other conventional means can be used to establish responsibilities and enforce them. Permissioned distributed ledger systems are in this respect not very different from conventional private financial networks like Visa or software-as-a-service (SaaS) systems.

How should we regulate distributed ledger systems?

Governance in a distributed ledger system as described above is concerned with the system's stakeholders' interests, but there may also be broader social interests involved in how a distributed ledger functions. For example, regulators may wish to collect taxes, prosecute crimes, and limit the use of a distributed ledger for criminal purposes. If a system is adopted to the extent that it starts to have potential knock-on effects elsewhere in society, regulators may also wish to ensure that the system is resilient against systemic risks and market failure. This regulation can be applied through legal code or technical code.

1. Regulating distributed ledgers via legal code

Regulating a permissioned distributed ledger system is simply a matter of imposing legal obligations on its proprietor. Regulating an unpermissioned system like Bitcoin via legal code is more complicated, as there is no single legal entity in control of the system. It would be difficult to regulate what software people are allowed to install on their computers. Attempts to regulate Bitcoin via legal code have instead focused on regulating the businesses that deal with Bitcoin, such as exchanges and wallet providers. These businesses can be regulated in their own right (eg to prevent a wallet provider from disappearing with customers' money) or as a means to indirectly regulate what the ledger is used for (eg ensuring compliance with anti-money laundering regulations).

A well-known example of regulating Bitcoin via legal code is the BitLicense, issued by the New York State Department of Financial Services to businesses offering digital currency services to New York residents[2]. The deadline for businesses to obtain the license was 8 August 2015, and unlicensed service providers can be penalised.

2. Regulating distributed ledgers via technical code

The technical code for distributed ledger systems like Bitcoin is currently produced by private actors in an ad hoc process. But technical code, comprising software and protocols, can also emerge from the public sector. For example, TCP/IP and some other core internet protocols were the result of government-funded research projects and are now maintained under the auspices of the Internet Society, an international non-profit organisation with an open membership structure based on geographic location and special interests. Other parts of internet infrastructure are maintained by international multi-stakeholder processes, and some parts remain under the oversight of US public regulators.

While this patchwork is far from a perfect solution, it points to the possibility of public involvement and democratic representation in the production of technical code — public regulation via technical code as opposed to legal code.

Table 1 Examples of privately and publicly produced legal code and computer code		Legal code	Protocol
	Privately produced	Visa Core Rules Faster Payment Service Rules	Financial Information eXchange (FIX) protocol Bitcoin
	Publicly produced	European Market Infrastructure Regulation BitLicense	Internet (TCP/IP) World Wide Web (HTTP)

Applied to distributed ledger systems, this could mean anything from instituting formal multi-stakeholder processes for maintaining the technical code, to developing public standards for the code. If this allowed governments or the public directly to attain legitimate regulatory goals by influencing the rules built into the computer code, it could lessen the need for a body of new legal code to regulate these systems.

Alternatively, the public sector could develop a permissioned system that allows public regulatory influence to be exerted through a combination of legal and technical code, rather than exclusively through legal code as at present. Some of the core internet technologies have shown that it is possible for governments to successfully catalyse the creation of technical code that has become foundational to private sector activity.

Conclusions

In contrast to conventional private financial networks like Visa, unpermissioned distributed ledger systems like Bitcoin lack a central legal entity with formal responsibility over the system. Instead, they are governed by ad hoc processes, usually centring on a handful of software developers who produce the system's software code. If these systems are to grow in value and influence, they will most likely need to develop more robust internal governance processes. The lack of a central legal entity also makes it more challenging for public regulators to regulate distributed ledger systems via legal code. Governments should therefore also consider ways of regulating distributed ledger systems by influencing the technical code that defines their rules. In finding the right blend, the government should consider the strengths and weaknesses of both technical code and legal code, recognising that the two interact and should be designed accordingly.

The emergence of Bitcoin and distributed ledger systems has brought the issue of technical code to the fore in the context of the current financial system as well. Distributed ledgers show that financial systems can be governed and regulated with technical code as well as legal code. Policymakers should recognise the influence of technical code on the financial system and consider how such influence could be made part of the regulatory system, with potential benefits such as lower compliance costs.

Security and Privacy

There are many different types of distributed ledger systems, each offering various opportunities and threats regarding security and privacy. It is important to analyse the business and security requirements of any proposed implementation before deciding which type of ledger to use.

Author

M. Angela Sasse, University College London, with contributions from: George Danezis and Sarah Meiklejohn, UCL; Daniel Shiu, Government Communications Headquarters; Phil Godsiff, University of Surrey

Chapter 4: Security and Privacy

Introduction

Security can be simply defined as: "Things that should happen, do; and things that shouldn't happen, don't." For any particular implementation of distributed ledger and block chain technology, the risks of desired and undesired outcomes depend on how the technology is designed, implemented and governed. Different stakeholders will face different risks.

Threats to the systems include not only attacks by external entities, but also actions by internal stakeholders and failure of components (such as software). Prior to any implementation, detailed threat models need to be developed, and specific security requirements identified, to deliver the outcomes.

Effective security provides a necessary but not sufficient foundation to deliver privacy for individual and organisational stakeholders. We must also consider how the information disclosed in a particular implementation might be combined with other available information to identify individuals or groups, or detect their activities.

Innovation advantages

One of the main security features of Bitcoin and other cryptocurrencies is the decentralised control over the network. The system is governed by a global set of peers who operate based on consensus (see Definitions, p17), so there is no central point of trust or failure. This means that any malicious actor must put in considerable effort to attack the system. For individual users, the system can also achieve a high degree of security — in order to move the bitcoins held in a wallet, an attacker must know the private key associated with a given public key (which is where the bitcoins are held). Thus, the attacker must be able to subvert the security of an established cryptographic standard (the Elliptic Curve Digital Signature Algorithm, ECDSA) in order to steal someone's bitcoins.

Bitcoin and associated 'altcoins' apply a much broader computer security infrastructure — namely distributed ledgers — that provides high-integrity and view consistency. Such ledgers use cryptographic techniques to ensure that anyone can check if a particular record is within the ledger, as long as they possess a small amount of crucial information. At the same time, complex consensus protocols are employed to ensure that everyone in the system gets a consistent view of the ledger. This is key to Bitcoin's ability to prevent double spending, but it could be equally important when using distributed ledgers for other applications, such as recording contracts or deeds. Distributed ledgers naturally lend themselves to implementing high-level services that involve notaries, time-stamping, and high-integrity archiving, and promise to lower the costs of these activities by increasing automation, enabling easy switching of service providers, and peer transactions.

One of the main problems for secure on-line communications lies in establishing that a public key belongs to a service that a user wishes to access. The prevalent mechanism used since the 1990s is known as a Public Key Infrastructure (PKI) — essentially a set of trusted third parties that provide certificates attesting the link between keys and services. But these certificate authorities have been to shown

to be fallible; when compromised, they may issue invalid certificates unnoticed.

The Certificate Transparency[1] (CT) system (recently initiated by Google, and now overseen by a working group) uses distributed ledger technology to mitigate this problem. All certificates are appended to a distributed ledger, and any user or services can check that the certificate they are about to use is the one in the ledger. Consequently, rogue certificates can be detected quickly — a significant disincentive to attackers seeking to compromise and abuse the PKI system.

The problem of establishing authoritative bindings between keys and entities also exists when users want to protect personal communications. But current solutions (such as the PGP Web of Trust, or centralised solutions) are either unusable or have brittle security properties. One promising alternative is CONIKS[2], which relies on a specially crafted distributed ledger to store and retrieve user public keys that can be used to encrypt or sign emails. Unlike CT — which relies on a network of third parties to maintain and audit the distributed ledger — CONIKS uses communication providers and their existing databases of users to build a high-integrity ledger.

Security challenges

The security advantages of the decentralised systems identified above — specifically, resilience and robustness — only apply completely to unpermissioned ledgers that subscribe to a global trust theory. For permissioned ledgers, or examples with other centralised functions, there will be less resilience and robustness, but a better ability to assure central trust and/or functions.

In fact, there is a broad spectrum of options (see Chapter 2) between totally decentralised systems (as in Bitcoin) and totally permissioned system (a private, dedicated network). An example of a middle-ground solution that uses the strength of both is the proposal from George Danezis and Sarah Meiklejohn of University College London for centrally-banked cryptocurrencies[3] — relying on a centrally-controlled server to establish the block chain while using a distributed network of 'mintettes' to absorb transactions.

Given this spectrum of solutions, it is important to analyse the business and security requirements of any proposed implementation before deciding which type of ledger to use.

For example, the key priorities of a system to manage welfare support payments for the Department for Work and Pensions would include ensuring both the availability of the service and its resilience against network disruption (see Chapter 6). The greatest threats would probably come from opportunistic cyber-criminals targeting individual users for monetary gain. Therefore:

- The system should be designed to require minimum knowledge and effort from individual users ie there should only be a small number of choices and configurations, with clear feedback of consequences

- If commodity devices such as smartphones are used, ensure that credentials and keys are securely accessed and not visible to other applications

- The ledger itself should be maintained across a wide network of servers to allow for resilience against network outages

- For wider deployments, the payment authorisation service should be centralised on dedicated hardware and hardened against attack

Alternatively, a system that might be used for distributing foreign aid would need to ensure the integrity of transactions (to avoid funds being syphoned off for other purposes); and maintain the availability of the system during disaster relief situations, for example. Threats may come from nation states that could gain geopolitical advantage from disrupting transactions, or from dishonest agents within the states receiving aid. Therefore:

- The system should run on a small, hardened and dedicated network of servers that establish government copies of the ledger with offline back-ups

- Clients should be encouraged to set up their own networks of ledgers, with advice on secure design that allows regular updates or corrections from the government servers

- Allow the system to be taken offline if a serious network attack is suspected

Arguably, though, the most serious threat to any government-backed system is obsolescence. If it is too difficult to use, or does not offer the functionality required, it will not be adopted.

Another threat that has recently emerged is that of a system being hijacked because a different software implementation creates a 'split' within an existing system. Cryptanalysis researcher Nicolas Courtois at UCL, who has followed Bitcoin closely, reported in August 2015 that:

"There will be a possibility to mine blocks with a new version number and new rules. This is meant to make bitcoin more democratic: larger blocks, more transactions per second, lower fees, wider adoption. Current bitcoin has reached its capacity limits (not much more than 3 transactions per second) in the recent months and bitcoin developer community has FAILED to solve this problem."

This shows that the governance of any government-backed implementation will require serious forethought of possible technical developments, and how to protect it from takeover by other entities — hostile or not.

Security recommendations

For each particular use of the technology, the government should carefully identify the relevant threats. Although no nation state actor is interested in disrupting Bitcoin, they might be interested in attacking a UK national digital currency — and if there is any financial gain to be made from fraudulent ledger entries, it is likely that organised crime will target users with low security awareness.

Given the threats identified, the government should decide on an appropriate level of security for the threat actor, and the lifetime of the proposed usage. If cyberattacks are anticipated then systems should be designed with secure usability in mind from the outset. For example, unpermissioned networks of ledgers allow actors to threaten network integrity either by adding their own servers or operating a denial-of-service attack on legitimate servers; to counter this, a long-term ledger of interest to nation states might need quantum resistant signature schemes.

It is easier to build a new secure infrastructure than to adapt existing infrastructure to a new secure application. As such, a dedicated new set of permissioned servers would be easier to configure and accredit than reusing existing internet servers. Advice on building secure systems should be sought either from the UK Government Communications Headquarters (GCHQ) or reputable industry providers.

For systems intended to have a long lifetime, the initial design should make it straightforward to update components during that lifetime (eg the ability to switch out nodes of the network with more modern hardware; the ability to upgrade cryptographic algorithms that can no longer be used securely).

In any trial of the technology, it is also important to fund penetration testing of the experiment at both the system and user levels. Real-world attackers would not be interested in a small scale proof-of-concept, but could become a threat when an application is deployed at scale.

Privacy challenges

The Bitcoin cryptocurrency was designed from the outset to provide a form of pseudonymity[5] (its designer Satoshi Nakamoto referred to this property as "anonymity", but this is a misnomer).

Users can create a number of wallets to hold bitcoins, and there is no restriction on the number of wallets they can own, nor any 'Know Your Customer' requirements to open a wallet. Coins are transferred from one wallet to another, and the obscured relationship between wallets and real-world persons provides a degree of privacy.

The decision to allow pseudonymous identities, and to not link wallets to any real-world identifiers, is a pragmatic one for Bitcoin that has contributed to its wide adoption. Most jurisdictions do not have any strong way of linking real-world identities to online transactions, and thus a reliance on the existence of such mechanism would have prevented the deployment of Bitcoin at the time, and even today. Furthermore, given the international nature of the Bitcoin network, it is unclear which jurisdiction would have been entrusted with certifying identity information, and how one could establish whether a legal jurisdiction is entitled to identify a certain user.

Finally, requiring identification as part of opening wallets potentially has an impact on the fungibility of bitcoin as a currency: if an identity provider has to be involved to authorise transactions then they may be able to block them, selectively denying the value stored in some user's bitcoins. Other parties could not be sure that value stored in bitcoins would be unconditionally available in the future. Thus Bitcoin pseudonymity allowed both rapid adoption (by avoiding dependencies on non-existent or fragmented identity infrastructures), and also preserves important aspects of Bitcoin as a currency (ie its status as an unconditional store of value).

This pseudonymous relation between users and wallets is, however, not full or perfect anonymity. Chains of transactions in and out of wallets, and from wallet to wallet, are visible to all, and can be traced and tracked in public. UCL's Sarah Meiklejohn and colleagues have shown that chains of transactions may be traced throughout the Bitcoin block chain to link, for examples, instances of

bitcoin theft with specific attempts to withdraw bitcoins through exchanges[6]. This approach could be used to enforce some Know Your Customer rules, because once a particular wallet address is identified and linked with a physical person, it is possible to uncover all of their transactions.

This weak form of pseudonymity, combined with the transparency of transactions on the bitcoin block chain, actually represents a privacy challenge. Unlike traditional online payments, which are only visible to transacting parties and financial institutions, Bitcoin payments — including the wallets involved, the approximate time of the transaction, and the transaction values — are recorded in a publicly visible block chain. Anyone can process the block chain and draw inferences about, for example, the turnover of an on-line merchant, the buying profile of a particular user, or even the many transfers between private individuals — a capability that was restricted in the past to financial institutions and law enforcement.

Privacy recommendations

A number of techniques, and alternative cryptocurrencies, have been proposed to alleviate the privacy problems of a fully transparent block chain.

The first set of techniques involves 'mixing' systems. These take coins from a number of users, and output coins to different addresses that are not linked to the original users. By breaking the link between payer wallets and payee wallets, they provide some measure of anonymity. There are, however, two key challenges with engineering such systems. Firstly, the anonymity they provide is not perfect: although a coin may be traced to one of a number of addresses, is not perfectly hidden amongst all possible wallets in Bitcoin. This partial leakage of information allows the application of statistical attacks to de-anonymise repeated transaction through so-called Statistical Disclosure Attacks[7]. The extent to which these attacks are effective is an open question. Secondly, dishonest mixes have the potential to accept coins but never pay out, effectively stealing them. A number of bitcoin mix designs (such as Mixcoin[8]) attempt to alleviate this problem through making part of the mix operation transparent enough to ensure the integrity of its operation, without compromising its privacy.

A second family of systems radically alters the way bitcoin payments are made, and what is recorded in the block chain, to provide stronger privacy. For example, Zerocoin[9], Zerocash[10], Pinocchio Coin[11], or certain Sigma protocols[12] adapt group signature algorithms to the setting of cryptocurrency transactions. A payer provides a zero-knowledge proof that they own some coins from a list, without revealing which, while also leaking enough information to prevent double spending. This allows them to pay a coin without being fully linked to previous transactions. As with mixing systems, these techniques may only hide payees within a limited list of potential users, not all, which opens the way to de-anonymising multiple transactions. They are, however, robust in terms of integrity, and do away with mixing as a third party operation that could pose a performance or trust bottleneck.

Disruptive Potential

Distributed ledger technologies (DLTs) represent a significant challenge to existing business and governance models. Technical innovations such as DLTs can enable revolutionary changes in those business structures, ultimately causing major changes in the way in which the economy and society itself is organised and governed. Such changes are more far reaching than normal innovations in products, services and operating systems.

Author
Phil Godsiff, Senior Research Fellow, Surrey Centre for the Digital Economy, Surrey Business School, University of Surrey

Chapter 5: Disruptive Potential

Introduction

Technological innovations can have a huge impact on how businesses operate. New technology can enable businesses to offer new products and services, capture new revenue streams, introduce lower-cost operations, and streamline their organisational structures. If existing businesses are slow to adapt, or try to create barriers to entry, new entrants can take advantage of innovations to replace these incumbents.

Sufficiently radical technical innovations can lead to revolutionary changes, not only in business models or industries, but eventually in the way in which society is organised and governed. For example, the steam engine led to the development of railways and enabled the movement of the population to urban centres.

Distributed ledger technologies (DLTs) have disruptive potential beyond innovation in products, services, revenue streams and operating systems within existing industry frameworks. They have the potential to disrupt the whole economy, and society. Understanding this can help to frame the opportunities and threats afforded by distributed ledger technologies — and how they can inform changes in the role of the government, and the services it delivers.

The role of innovation

Organisations constantly innovate to improve their competitive advantage. We tend to think of innovation in terms of new products and processes: the manufacturing industry focuses on product innovation, while the service industry develops through process innovation. Even small changes can affect the structure of an industry: many manufacturers of computer disk drives failed to adapt to the introduction of lighter and smaller drives, for example[1]. Innovation can also occur within business models, and often legitimise new relationships within an industry to create 'cooptetion', where firms both co-operate and compete[2].

The digital revolution has led to an increasing awareness that innovation can also occur at the level of the business model[3], and even at the level of whole industries — just think of how the Uber app, which enables customers to hire drivers in their vicinity, has disrupted the taxi industry. Changing an organisation's viewpoint from short-term profit to long-term wealth creation can lead to radically altered activities and views of the future, for example by using open source software to create a platform that others can modify and exploit[4].

Technology innovations, such as apps, now allow customers to act as resource

FAQ

What is the disruptive potential of DLTs?

DLTs have the potential to be radically disruptive. This is partly because of the developments they have already helped to bring about (eg in cryptography and software engineering); the industries and services they could innovate (eg financial services, real estate, healthcare, identity management); and their processing capability (eg low cost, real time, immutability). But their disruptive potential also lies in their underlying philosophy of distributed consensus, open source, transparency and community.

integrators, 'pulling' solutions rather than having them pushed by suppliers. This can challenge existing assumptions on value creation through, for instance, 'prosumption' (a model where the same actors are involved in both production and consumption, used by ridesharing service BlaBlaCar and the accommodation rental service Airbnb), peer-to-peer lending and crowd sourcing. This form of innovation impacts industry structure and has the potential to create new industries; it changes "who does what", and "who gets what"[4].

Developments in mobile payment systems introduced by new entrants are opening up new customer bases (eg by allowing small merchants to turn their phone into a bank card reader); previously unused data are being delivered to new stakeholders to create new revenue streams to capture value; and there is growing use of digital wallets and value transfer through different operating systems such as mobile phone providers (eg M-Pesa) rather than banks. But in many of these cases, the underlying transactions are still processed through established players using legacy systems (eg clearing banks and competing card schemes such as Visa and Mastercard). M-Pesa challenged the notion that value transfer for exchange transactions had to be done through banks, and leapfrogged several developmental stages. But these innovations still rely on an existing hierarchical structure, using proprietary technology and trusted intermediaries. Though the change improves customer convenience, and significantly reduces costs to users and customers, this is evolution rather than revolution.

Technological revolutions

Innovation generally proceeds incrementally, but is punctuated by radical episodes, described by economist Joseph Schumpeter as "creative destruction", and by Carlota Perez as "technological revolutions"[5]. These innovations exist in a complex dynamic between technology, the economy and society, and sometimes an innovation can fundamentally alter the way in which a particular society or economy is organised.

The past few centuries have seen a handful of these technological revolutions: the original Industrial Revolution, the Railway Revolution, and the Oil Revolution, for example. Each one changed industrial structure, brought new forms of energy, and impacted the way society could organise (see Table 1). Now we are in the Information and Telecommunications Revolution, typified by information intensity, connectivity, specialisation, and globalisation.

There are typically three pillars to these revolutions: significantly lower costs, new communication methods, and changed infrastructure and logistics. Lowering the costs of pervasive inputs generates market tensions — and, often, financial bubbles and crashes — that ultimately lead to demands for an overhaul of existing institutions. According to Perez, the revolutionary innovations are characterised by a "set of inter-related radical breakthroughs, forming a constellation of interdependent technologies" and the "strong interconnectedness of the participating systems in their technologies and markets, and their capacity to profoundly transform the rest of the economy (and eventually society)"[5].

	Description	Year (approx)	New Technologies and Industries	New Infrastructure	'Common Sense Principles'
1st	Industrial Revolution	**1770**	Mechanised industry	Canals and water power	**Factory production, productivity, local networks**
2nd	Steam and Railways	**1830**	Steam engines, iron machinery	Railways, telegraph, ports	**Economies of agglomeration, standardised parts, urbanisation**
3rd	Steel, Electricity, Heavy Engineering	**1875**	Cheap steel, heavy chemistry	Electrical networks, global shipping	**Economies of scale and vertical integration, science as productive force, efficiency**
4th	Oil, Automobile, Mass production	**1910**	Cars, cheap oil, petrochemicals, home appliances	Road networks, universal electricity	**Mass production, horizontal integration standardised products, energy intensity, suburbanisation**
5th	Information and Telecommunications	**1970**	Cheap microelectronics, computers, mobile telephony	Worldwide digital communications	**Information intensity, decentralised networks, knowledge as capital, economies of specialisation, globalisation**

Table 1: the five technological revolutions (adapted from Perez[5])

Each technological revolution brings a different set of 'common sense principles' that change how businesses and society operate. These moved from mechanisation in factories; through economies of scale and vertical integration, mass production and standardisation; to functional specialisation, hierarchical pyramids and bureaucracy; and on to today's information intensity and decentralised networks, marked by "heterogeneity, diversity, adaptability and co-operation"[5]. These revolutions ultimately lead to a new techno-economic paradigm, with different cost structures, different opportunities for innovation, and organisations built on markedly different principles. In each paradigm, organisations develop along an 'S' curve, from disruptive innovation, through use and exploitation (and resistance), to maturity and eventual replacement[5]. Changing these existing mind sets and replacing them with a new one requires a transformational shift that requires new skills, abilities and knowledge, which fundamentally change the way business operates.

Previous technological revolutions had little or no impact on pyramidal, hierarchical systems of organisation and governance. But some suggest that our new technological era enables a potentially emergent 'Collaborative Commons', in which society is motivated by collaborative interests rather than individual gain[6]. This could imply distributed, consensual community structures that do not depend on intermediaries organised in hierarchies (such as banks and governments). DLTs represent a challenge in precisely this way.

Distributed ledger technology

DLTs are involved in potentially revolutionary innovations in a number of related areas: virtual currencies, distributed open and transparent record keeping, non-hierarchical networked systems, cryptography, and software engineering. DLTs represent an innovation towards the radical end of the change spectrum because of their potential to impact a broad extent of areas in the business model: from new products and services, through operating systems and organisational structures, to the sheer number of potential industries that could be affected. As such they form part of the interconnected and inter-related breakthroughs that form a technological revolution.

DLTs offer significant benefits to operational costs. Not only are they intrinsically low-cost, they can also avoid duplication and inefficiencies in control and co-ordination by enabling a common, open ledger that could operate at an industry

CASE STUDY 1

Diamonds

Leanne Kemp, Founder and CEO, Everledger

The diamond industry is highly susceptible to criminal activity. Gems are small and easy to transport in a covert manner, transactions tend to be confidential, and diamonds retain their value for many years. As such, diamonds are involved in money laundering and terrorist financing on a global scale.

Efforts to stem this illicit activity have included tracking diamonds with paper documents to certify their provenance. But document tampering is widespread — indeed, documents are sometimes created to cover up illegal transactions — and several countries with a major diamond trade still have insufficient legislation to guard against these crimes.

To combat this, the diamond industry is beginning to implement a system called Everledger, based on block chain technology, which establishes a digital 'passport' for each diamond. This records its provenance, travel, and transactions with a unique cryptographic 'fingerprint'.

This system has three stages:

- Establish an e-ID (electronic identity) for each diamond, by digitising its attributes and a laser-inscribed serial number onto an authoritative block chain ledger

- Assign a digital passport to the diamond to record its travel, transaction history and provenance

- Detect and guard against illegal activities or fraudulent behaviour

By using an immutable block chain to hold this data, the ledger could provide transparency around all diamonds, revealing their origin, trail of ownership, and the processes they might have undergone. This ledger can act as a single version of verifiable truth about diamonds for the industry, governments, consumer markets, border control and law enforcement agencies.

The system also enables the use of smart contracts — terms and conditions relating to the sale and transport of the diamonds that can be carried out automatically. By using a block chain to create a distributed ledger, smart contracts can be tracked and used to verify business relationships and agreements. The block chain's transparency offers a way to enforce the contract, whether it is related to changes in ownership of the diamond, financing of the diamond, its insurance policy, registered rights title and so on. Authenticating the transaction, along with documentary proof of authenticity, provides a vital evidentiary trail for government and law enforcement.

level, thus reducing the systemic costs involved in processes such as cross checking between individually held ledgers and databases. The ability to digitise and securely store information on practically any asset, from diamonds to bags of rice, allows organisations to identify and track their ownership and location (see case study on diamond authentication, p56). New methods of recording obligations and transfer of value using programmable contracts are being developed using DLT: Ethereum, for example, is a decentralised platform for 'smart contracts' (see Chapter 1). Their potential for disruption may even extend to a new landscape in which trusted or necessary intermediaries operating in a hierarchical monopoly — a 'hub and spoke' model — are joined or replaced by a more open, flatter community-based consensual structure (see case study on corporate actions, p58).

The development of DLTs and associated technologies also offers the possibility of real time recording of transactions and access, making transactions quicker and cheaper (see SETL case study, p60). For example, motor insurance could be based on the state of both the car and its driver, with insurance provision changing between suppliers depending on behaviour, price and appetite for risk. This could lead to a 'programmable economy' involving smart contracts, relying on decentralised networks and agents that require less human involvement, and operating as distributed autonomous organisations that deliver a wide variety of products and services.

The best example of an operating DLT is the cryptocurrency Bitcoin, and the most obvious place for a new currency to innovate is in financial services. DLTs offer a lower cost of operation within existing structures and governance, but they also provide the chance to reduce system-wide costs and complexity. They could do this by removing the duplication and cost of many separate, proprietary systems, and by challenging those systems' centralised architectures. Money creation no longer becomes the sole responsibility or prerogative of national governments, for example. Instead, new forms of currency could emerge where identity, and connections between people, becomes the means of endorsing and underwriting transactions within a community[7].

A further development enabled by the technological advances is the possibility of adding specific attribute information (eg physical assets or contracts) to the basic bitcoin to produce 'coloured coins'. This opens up the possibility of money with more than just value: it could carry attributes such as necessary purpose, expiry date, or location of allowed use. For example, money may have restrictions on the kind of goods and service it can be used to purchase (see Chapter 6); or someone renting a flat through Airbnb may have their electronic access key revoked if they fail to pay on time, or if their contract has expired.

FAQ

What are the threats arising from DLT?

Like any radical innovation, DLTs provide opportunities to incumbents, and also threats to those who are unable or fail to respond. Through their distributed consensual nature they also threaten the role of trusted intermediaries in positions of control within a hierarchy. Block chains that explicitly create a new currency, such as Bitcoin, challenge the current supremacy of governments in managing the national and international economic and monetary system.

Considerations for government

With its wide range of stakeholders, services and roles, the government obviously has a multitude of different operations. Some distribute value rather than create it, and others create and maintain effective regulatory regimes. Many of these activities will be enhanced by the innovations afforded by DLT, and others will be challenged. Change is possible at the product and service level, and at the operational and organisational level.

CASE STUDY 2

Corporate actions

Dominic Hobson, Founder, COOConnect

Listed companies must provide their annual accounts in a structured format, but any company announcements that may require action by investors or their representatives — known as corporate actions — are typically published as unstructured text, or in PDF format. Those relying on the information have to read and interpret the data manually before taking action.

Over 90 per cent of corporate actions are distributed by data vendors, and then processed on behalf of investors by an agent such as a custodian or fund manager. Information is manually extracted from the original, interpreted and re-keyed by vendors. Levels of automation are low, errors frequent, and the process highly inefficient. One estimate puts the global cost of corporate actions processing at up to $10 billion per year1. Custodians frequently reimburse clients for missed or incorrect execution of instructions.

Block chain technology could make this process more efficient. Corporate actions represent contractual information and value, which can in principle be transferred directly between payers and payees without the need for intermediaries, provided the parties can trust the source data and have the necessary experience to act upon the information they receive.

If a block chain was coupled to an application that captures and stores corporate action announcements in a structured format, it could be used to ensure that the data is from a verified source, and prove the time-stamped date that it was issued. This could be done in reverse

for the execution of instructions. A distributed ledger based on such a block chain would reassure parties at every point in the process that their information is accurate, up-to-date, and unchanged since it was published by the issuer. In theory, it could eliminate all intermediaries between the issuer and the fund manager, guaranteeing the accuracy and timeliness of the information.

The important question is whether this can be organised in a fully-decentralised manner. Corporate action information differs from simpler contractual information (such as money changing hands) because investors and shareholders often need to use intermediaries with specialist knowledge to act on their behalf.

These intermediaries may need to be able to modify or augment the data before passing it on, and the original corporate action itself may change, through follow-up announcements that supersede earlier ones. This modified data could quickly lose its provenance as data vendors share it with clients or package it with other data, making the process difficult to automate.

On its own, block chain technology is currently too slow to cope with these constantly shifting packages of data. Bitcoin's block chain can handle about 20,000 transactions per hour, with up to an hour's latency before a transaction can be trusted. That would be very inconvenient in a corporate action process, which is subject to a final deadline that fund managers prefer to keep open as long as possible.

For instance, the process of ensuring that financial transfers such as welfare payments go to the right person at the right time could be improved in a number of ways (see Chapter 6). A single ledger carrying the identity and entitlements of potential claimants, updated in real time, could be a radical innovation that is much more efficient, reducing both operating and development costs. Adding attributes to a particular payment could mean that as well as the amount, the purpose and timeline of expenditure could be both specified and tracked. This would, of course, involve extensive negotiations with stakeholders, and may require some management of this form of currency to ensure any desired parity with sterling.

There are innovative possibilities in replacing hierarchical organisations with more distributed systems. The government and its agencies tend to have tiers of authority, both internally and within their respective systems: for instance, citizens are represented by elected officials in local, national and supranational institutions; financial matters involve clearing banks, clearing houses, central banks and governments. Rather than relying on periodic ballots based largely on paper records, democracy could be achieved through a voting block chain, with electors given a digital wallet and a 'vote-coin'. This has the potential to reduce fraud (because each voter can check that their vote was counted), but also to introduce a real-time democracy with a vote on any issue. This raises significant questions of social responsibility and willingness to partake, but could create more distributed forms of democracy.

The Monmouth-based company Codel, which handles corporate actions data, has overcome these limitations by combining a block chain system with its digital notary software. This system creates an immutable audit trail that parties along the chain can refer to in order to establish authenticity, offering valuable reassurance about the provenance of data.

These run alongside Instant Actions, a new searchable central registry of corporate action information that is a collaborative venture between industry participants and Codel. The registry's data is stored in the ISO 15022 and ISO 20022 formats, which provide guidance for the distillation of financial information into machine-readable formats. This means the registry can be updated as corporate action information is modified or superseded. This guarantees the integrity and accuracy of the information, which can then be made available to all parties in the corporate actions chain via the SWIFT secure network. This overcomes the verification delays of using a block chain alone, and the information — effectively shared as a distributed ledger — can be updated, distributed and modified in real-time, guaranteeing that it is accurate and up to date.

The government could help such systems to flourish by altering regulations to require companies to issue corporate actions information using a distributed ledger approach.

Threats

The innovations enabled by DLTs may be attractive, but they are not without significant threats, including those involving the nature of money and the role of hierarchies and trust.

SETLing transactions

Dominic Hobson, Founder, COOConnect

Clearing, settlement, custody and registration services all add a significant cost burden to issuing, trading and holding securities. There are a plethora of specialist agents and counterparties involved in moving securities and cash between investors. Not only are there specific charges for these services, there are also ancillary costs related to dealing with the myriad of different systems that need to be interfaced and integrated with business processes. In total, the global finance industry pays around $65 billion to $80 billion per year in post-trade costs.

Block chain technology offers a means of significantly reducing the complexity and cost of these post-trade services, enabling participants to operate a shared ledger that is stored on a large number of servers acting as nodes. The authority to execute transactions is conferred by public-private key cryptography.

Transactions are added to the database in blocks, and each block is reviewed by the nodes. The block is only added to the database if the node reaches a consensus that the block only contains valid transactions. Apart from setting up and maintaining the nodes, this block chain network should be completely autonomous, and does not require a controlling or regulating entity.

The SETL solution

A privately funded venture called SETL intends to develop and deploy a specialist block chain that will allow financial market participants to settle securities transactions on a peer-to-peer basis, and to maintain a distributed 'golden' ledger of securities and cash balances. In particular, SETL aims to have central bank money available on the block chain. Its block chain will run on an autonomous basis, and will integrate with the current financial markets, payments and

exchange infrastructure.

SETL will be able to handle both the security and cash side of each transaction and will also allow for one-sided transfers of securities and cash, either as simple payments or to settle bespoke contracts, corporate actions, dividends and coupons.

SETL will be designed to collapse the costly and risky clearing and settlement process into a real-time settlement process between counterparties. In addition, by establishing a golden ledger of ownership, SETL will substantially reduce the overhead of securities registration and custody.

The SETL block chain will have the following characteristics:

- Public keys used in the SETL block chain will need to be signed by a certifying authority, making it apparent to users of the block chain who has certified each key. Certifying authorities will maintain details of the real-world identities of public key users, and complete anti-money laundering and Know Your Customer checks. SETL anticipates that the certifying authority will disclose that information when legally required to do so.

- It will have sufficient capacity to process thousands of transactions per second, commensurate with normal volumes in the financial markets.

- It will be able to handle multiple asset classes, including cash and securities of all types.

- It will allow multi-signature transactions, enabling authorization by a designated subset of users.

- It will allow 'atomic transactions' (ie either all transactions occur, or none do), so that

DLTs could disrupt conventional financial services, whose core business is money and value transfer. But money itself is already being disrupted in all its forms and uses through cryptocurrencies such as Bitcoin, an invented money with no government backing; and 'colored coins', which allow units of currency to carry different types of value. The management of money, and through that the economy, is seen by many to be a key role of government, so alternative currency systems may pose a threat to that role.

transactions will only be processed if all stages have been submitted and properly authorized.

- It will contain specific functionality designed to facilitate the management of liquidity by the participants.

- It will maintain a complete record of transactions and balances historically for the purpose of simplifying regulatory record keeping, transaction reporting and audit.

Wider benefits

Balances of cash and other assets currently tend to be maintained on specific systems and can only be deployed for particular purposes: in other words, they are 'system specific.' Cash and assets held on a block chain are, in contrast, available to be deployed for any purpose. This will both reduce the amount that banks have to deploy in liquidity reserves, and will simplify their management of liquidity.

SETL expects to be able to provide a solution that will run alongside the existing Bank of England Real Time Gross Settlement (RTGS) system, providing a safe and viable alternative should RTGS be unavailable at any time. SETL will be available at all times, reducing the inter-bank risk that currently accumulates when RTGS is not running eg overnight and at weekends.

The SETL payment and settlement system will be simple, unified and immediate. If the UK is the first to deploy such a system, it will promote London and sterling as the location and currency of choice for financial services. It is likely that once established in London, the system would be adopted more widely, further consolidating London's position as the global leader in international finance.

DLTs pose a threat to any hierarchical structure through an ability to connect and operate in a distributed network, without trusted or necessary intermediaries, by replacing top-down control with consensus. Hierarchies can have serious disadvantages: duplication, added cost, potential abuse of power, and opportunities for financial mismanagement. But hierarchies do offer advantages whenever a neutral broker is needed; and, for example, in representative democracy.

Representative democracy provides stability and an ongoing process of civil government that could be threatened by wider use of DLTs. Nation states are already facing threats caused by globalisation and increasingly fluid borders, yet some of the original developers and adherents of Bitcoin espouse extreme anti-government views. The challenge will be to ensure that DLT and its associated innovations are directed towards a connected, productive society, within a supportive infrastructure.

Conclusions

The convergence of creativity and technology can lead to radical changes in existing business models and the organisational structures they sit within. DLT is presently as much a series of challenges and questions to existing structures, as opposed to a set of answers and practical possibilities. But it appears to have at least some qualities, and to be in the appropriate context, to produce change at the more revolutionary end of the spectrum.

DLTs offer significant challenges to established orthodoxy and assumptions of best practice, far beyond the recording of transactions and ledgers. These potentially revolutionary organisational structures and practices should be experimentally trialled — perhaps in the form of technical and non-technical demonstrator projects — so that practical, legal and policy implications can be explored.

Radical innovation in business models, particularly in structures and operating systems, can occur through experimentation within a relaxed but effective regulatory environment. The government should consider how regulatory regimes can best encourage and exploit an environment in which these low-cost operating models and organisational structures could be explored, with new entrants able to participate freely.

More research is needed, at a system-wide level, on the financial costs and benefits of adopting distributed ledger technology. This would enable the government to identify what existing frictional costs could be avoided, and where remaining cost savings and opportunities could be found.

Applications in Government

Distributed ledger technology is already having a profound impact on how private companies manage data and interact with customers and suppliers. If applied within government it could reduce costs, increase transparency, improve citizens' financial inclusion and promote innovation and economic growth. This chapter considers five case studies that illustrate those benefits.

Author
Catherine Mulligan, Research Fellow, Imperial College London and Head of Digital Strategy and Economics, Future Cities Catapult. Additional contributions from Simon Taylor, VP for Blockchain R+D, Barclays; and Mike Halsall, Global Grand Challenges, Singularity University, NASA Research Park, California

Chapter 6: Applications in Government

Introduction

Distributed ledger technologies (DLTs) can do far more than simply manage digital currencies such as Bitcoin. The concepts and structures developed for distributed ledgers and the block chains they use are extremely portable and extensible to other areas of economic and social activity. As such, they have a profound potential for application within government operations — indeed, the eventual impact of DLTs on British society may be as significant as foundational events such as the creation of Magna Carta[1].

If applied properly — and issues of privacy, security, identity and trust are addressed thoroughly (see Chapter 4) — distributed ledgers create genuine opportunities for the government and other local and regional authorities in the following ways:

- Reduced cost of operations, including reducing fraud and error in payments

- Greater transparency of transactions between government agencies and citizens

- Greater financial inclusion of people currently on the fringes of the financial system

- Reduced costs of protecting citizens' data while creating the possibility to share data between different entities, allowing for the creation of information marketplaces

- Protection of critical infrastructure such as bridges, tunnels etc

- Reduced market friction, making it easier for small and medium-sized enterprises (SMEs) to interact with local and national authorities

- Promotion of innovation and economic growth possibilities for SMEs

This very broad range of possible benefits are delivered through the application of DLTs in three different ways:

- Within currency applications

- To manage contracts and create new forms of contracts

- To prompt new applications by third parties, and provide more efficient ways of structuring and carrying out activities

Within this chapter, we illustrate each of these opportunities and its application to the different technical implementations through five separate case studies:

- Protecting critical infrastructure against cyberattacks

- Reducing operational costs and tracking eligibility for welfare support, while offering greater financial inclusion

- Transparency and traceability of how aid money is spent

- Creating opportunities for economic growth, bolstering SMEs and increasing employment

- Reducing tax fraud

Case 1: Protecting Critical Infrastructure

Overview
DLTs can enable the UK and its government to better protect critical civil infrastructure against cyberattacks.

Background
Digital technologies are increasingly embedded in countries' critical infrastructures, and many of these systems are also connected via the internet. This exposes them to the possibility of attacks from hackers or other nations that are able to go undetected by existing cybersecurity defences. It is, for example, possible to seize control of critical routers, allowing them to be monitored and manipulated. This would allow the data from all the companies and government organisations behind the routers to be captured. Moreover, as various other embedded technologies are adopted in civil infrastructure — including bridges, railways, tunnels, flood barriers and energy installations — the chance that such attacks could cause damage to property and human life increases.

DLT proposition
DLT may be applied to ensure that the operating system and firmware used in a piece of critical infrastructure has not been tampered with. A distributed ledger could monitor the state and integrity of the software for illicit changes, and assure that data transmitted from systems that apply Internet of Things (IoT) technologies has not been tampered with.

Outcomes
- Efficiency and effectiveness improvements to large-scale infrastructure, ensuring better protection to human life

- Data integrity can be assured for transmissions to and from critical infrastructure

Maturity level
Ready

Case 2: Department for Work and Pensions

Overview
Novel payment models will enable HM Treasury (HMT) and the Department for Work and Pensions (DWP) to distribute welfare support more efficiently and improve policy delivery. By applying DLTs in the registration and payment processes for government grants and benefits, DWP will be better equipped to:

- Prevent financial losses through fraud and error

- Support the most vulnerable citizens by offering them the benefits of full financial inclusion

- Support the achievement of the government's wider policy objectives, especially getting people out of poverty in a sustainable way

- Offer good value for money and place public expenditure on a sustainable footing

Background

The DWP pays out roughly £166 billion of taxpayer's money in welfare support per year. Some £3.5 billion of that sum is overpaid through fraud (£1.2 billion), claimant error (£1.5 billion) and official error (£0.7 billion)[2] of which £930 million is recovered. Adding in the fraud and error that exists in the current tax credit system, which will be moving to DWP over the next few years as an element of the new Universal Credit regime, there is a total baseline of over £5 billion per year in gross overpayments.

Apart from the direct financial cost of overpaying money to those not entitled to it, the taxpayer also bears the cost of post-payment intervention (debt collection, investigation and prosecution, claimant queries and dispute resolution).

A further, as yet unquantified, proportion of welfare support spending will fail to meet policy objectives in less identifiable ways. For example, it may effectively fund expenditure by claimants that arises from the way that welfare support is distributed, ultimately servicing non-bank debt and paying the 'poverty premium'[3].

DLT proposition

A large number of welfare claimants are un- or under-banked[4] and face barriers to greater financial inclusion such as credit checks, access to traditional financial products, and the costs of unauthorised transactions. DLTs offer a cheap and supportive means of getting these claimants into the benefits system.

Digital identities could be confirmed through distributed ledgers running on securely-encoded devices — or even through software on a mobile device — which would allow end-users to receive benefits directly, at reduced transaction costs to banks or local authorities. This may allow them to become more fully included in the financial system through a secure distribution point that is more reliable than a bank account. Such a solution could also be linked with other systems to reduce the level of fraud and official error in the delivery of benefits, as identities would be more difficult to forge.

Such activities may help to achieve one of the DWP's principal policy objectives: to lift people sustainably out of the cycle of poverty and state dependence. Through the innovative application of such technologies, it would be possible — with agreement from the benefit claimant in question — to set rules at both the recipient and merchant ends of welfare transactions. This may present the opportunity for ministers to consider options for achieving better policy outcomes from the distribution of welfare support by agreeing or setting rules around the use of benefits.

Outcomes
- Reduction of losses due to fraud and official error

- Enable ministers to assure taxpayers that public funds are being used more effectively for the purposes of meeting genuine need

Maturity level
- Requires a lot of education for the recipients

- Requires some integration of sterling onto a distributed ledger for benefits

- May create a subset of the economy with a stigma attached to 'benefit coins'

Case 3: Stregthening International Aid Systems

Overview

DLT could enable the government to better control the distribution of foreign aid, and to ensure that the funds reach the intended recipients. This will also help ministers help improve transparency and encourage effective financial management. The use of DLT could therefore help in honouring the UK's international commitments to achieve the Global Goals.

Background

In order to meet global obligations, countries must support Global Goal action plans that incorporate transparency, accountability and integrity measures[5]. International aid donors place significant emphasis on helping to develop more transparent and robust aid systems. Activities preventing fraud, theft and mis-appropriation of funds can be expensive. Technological advancements that could help strengthen prevention efforts would be beneficial for the wider aid system

Fraud and corruption reduces opportunities for poverty alleviation, reduces inward investment, and is strongly linked to lower educational achievement. There is, therefore, a great opportunity to apply DLT in international aid in order to provide transparency and traceability of funds. Proving that money is being well spent could encourage nations to give more, and also all funders to target key outcomes more effectively.

DLT proposition

The key aspect of this proposition would be to use three main aspects of DLT. Firstly, it would allow international donors to issue coins that have a sterling value, without encountering many of the bureaucratic hurdles of traditional banking. Distributed ledgers achieve this through their lack of geographic boundaries — they operate in the same way in any jurisdiction in the world. There is an opportunity, therefore, to reduce the foreign exchange fees for international aid significantly below standard transaction costs. Moreover, it is possible to create smart contracts that can be used "to create self-enforcing contracts between strangers, offering citizens a framework for transactions independent of the domestic judicial and executive branch"[6].

Secondly, international donors could take advantage of DLT's ability to reduce the fungibility of cash, offering the possibility of reliable and irreversible transfers of digital goods — in this case aid funding. In addition, digital ledgers solve the double-spending problem: where digital currencies may allow end-users to spend the same unit of currency twice, digital ledgers prevent this because each 'coin' is unique. This makes payment without intermediation possible[6]. In cases where aid is meant to directly support end-users, it is possible to bypass the limitations and restrictions placed on currencies and banking services in some countries through peer-to-peer transfer of funds.

Thirdly, the use of unique sterling-linked coins could prevent them from being spent on items not deemed appropriate within the international aid context. For example, money sent to build infrastructure intended to reduce poverty could not be appropriated for other purposes. This stems from DLT's ability to trace exactly where the currency has been spent and by whom.

Outcomes
- Increased transparency of international aid spending targeted specifically at the Global Goals to reduce corruption to better achieve desired development objectives.

Maturity level
- Unpredictability of donor demands may create bigger problems than fraud and corruption, and would therefore need to be carefully aligned to project outcomes to ensure effectiveness.

- In every case of international aid, international donors needs to maintain a relationship with the host government. Where issues of corruption are linked to individuals within specific ministries or embedded within the systems of host governments, it is crucial to get buy-in from the recipient nations for this type of system.

- Converting distributed ledgers into usable services of this nature requires the creation of a whole range of complementary capabilities

Case 4: Reducing Market Friction and Enabling Innovation

Overview

One of the greatest potential benefits of DLT is its ability to remove barriers and friction in the market and enable the creation of new forms of information marketplaces[7]. As discussed in Chapter 1, the sharing of information between economic entities through distributed ledgers would enable new forms of innovation to emerge. This would allow ministers to achieve policy outcomes centred on assisting SMEs achieve economic growth through effective use of technological innovation.

Background

Reducing transaction costs for SMEs when dealing with local and national government would enable these businesses to move more freely within the market and face lower overall operating costs. At the same time, enabling these companies to register their intellectual property (IP) within a distributed ledger, rather than through traditional patent applications, may reduce the overall number of contract disputes. Contract disputes make up 57% of all litigation in the UK, more than any other category of legal action.

DLT proposition

DLTs could be applied in a broad variety of areas, particularly in smart contracts and asset registration. By registering assets on a distributed ledger, all property could effectively become 'smart assets', providing a robust and trustworthy proof of record for a broad variety of services that currently cost SMEs time and money. Examples include registering IP and patents, wills, notary services, NHS health data and SIPPs/Pensions. Distributed ledgers offer a new way to co-ordinate these types of services, in a truly digitally-enabled manner, with scale and efficiency.

Distributed ledgers have the ability to handle micropayments, decentralised exchange, token earning and spending, and transfers in a way that the web currently does not[8]. As a result, DLT has the potential to re-invent the operating costs of local jurisdictions and businesses through[9]:

- Business licencing

- Registration

- Insurance

- Taxation management at many municipal and regulatory levels

- Pension data

It is possible that DLTs could help to completely remove some functions, as companies are able to register identities not just for their businesses, but also for their assets. More importantly, citizens can also have more control over their data assets (such as health data), which are traditionally held by government. This would enable citizens to check whether their data has been accessed and used in the correct manner for the correct reasons.

In addition, the use of distributed ledgers allows for sharing of data across new forms of information marketplaces — or possibly even data utilities — allowing for the sharing of pension data.

Outcomes
- Reduced transaction costs for SMEs and streamlined cost of operations for local and national government. Additionally, having a trustworthy proof of ownership for digital assets such as IP will reduce the options for litigation, providing an overall social benefit for UK society.

Maturity level
- Requires local and national authorities to adopt DLTs

Case 5: European VAT

Overview
The economy can be categorised in many ways, including (i) the tax-compliant economy, (ii) the tax quasi-compliant economy and (iii) the tax non-compliant (or 'black market') economy. VAT shortfalls occur in all three for a variety of reasons that may include business insolvency; creative use of international laws to structure companies in such a way as to circumvent tax liability; or the more straightforward 'no paperwork, cash only' scenarios. The annual shortfall in the EU's value added tax (VAT) revenue is estimated to be between €151 billion and €193 billion[10].

DLT has both the exponential growth characteristics and the potential to make transactions significantly more transparent. The UK could play a pivotal role in supporting the development of technology, process protocol and implementation solutions for DLT in order to reduce the EU's VAT shortfall.

Background
Moore's Law correctly forecasted the exponential growth in digital computational processing density several decades ago. In fact, information technology has been growing exponentially since the late 1800s, with current predictions indicating this should continue throughout the 21st century.

Information technologies are self-generating because they help to navigate the unknowns of nature through scientific discovery. This in turn enables us to develop faster and more cost effective technologies, thus uncovering more

of nature's secrets, which ultimately leads to a compounding of technological capacity.

There are numerous information technologies available to help significantly reduce VAT shortfalls, including machine learning, super digital computers, quantum analogue computing, and distributed ledger technology. The key challenge is for governments to implement and leverage these technologies faster than organised crime groups can deploy them.

DLT proposition

The development of an EU-wide series of VAT standards and protocols would enable DLT to be deployed across Europe, with unilateral alignment of all VAT accounting transactions, from invoices to bank receipts. The system could include smart contracts designed to outsmart the tax quasi-compliant economy, which would also help to address the various threshold differences in VAT applicability across EU member states.

With machine-learning devices reading the EU's VAT transactions in real time, erroneous transactions (including so-called carousel fraud) are far more likely to be spotted than by the current methods of auditing. Increasing traceability and transparency — including payment providers, banks and other financial institutions — would make the black-market economy more difficult to conceal.

Outcomes
- Reduce the administrative burden imposed on companies and other organisations to collect and pay VAT

- Increase transparency of real-time transactions throughout the economy

- Create opportunities to assess credit risk more accurately, reducing losses caused by insolvency

- Provide data to lenders that offer finance to SMEs, including credit factoring

- Enable smart contracts between treasuries and commerce

Maturity level
- Technologically ready

- Important to bring payment organisations into the conversation early on, as their data inputs are also required to ensure visibility over payment settlements

- Government agencies need to be able to handle DLT for tax

- End-users and small business owners need to understand how to use DLT for effective tax management

Conclusion

Distributed ledgers undoubtedly hold value for government, offering new ways of operating that reduce fraud, error and the costs of delivering services to underserved users. At the same time, these technologies offer new forms of innovation and the ability to reduce transaction costs for SMEs in the UK. This chapter has highlighted only some of the possible use cases. As distributed ledgers are adopted more widely, it is likely that a new form of operating government services will emerge.

Global Perspectives

Organisations that do digital business in cyberspace must be able to trust — and be trusted by — their partners. They also need to be interoperable with large and growing communities of other organisations around the world. Block chains have the potential to contribute to both.

Author

Patrick Curry, Director of the British Business Federation Authority; Christopher Sier, Director, FiNexus; and Mike Halsall, Global Grand Challenges, Singularity University, NASA Research Park, California

Chapter 7: Global Perspectives

Introduction

The rate of global change — both good and bad — is accelerating, driven by internet-enabled globalisation, societal expectations, and increasing competition for resources. Unlike the developing world, developed nations and their citizens have a consumerist ethos and privacy expectations that can conflict with traditional, resilient community values and personal norms of behaviour. This has left the state, rather than the community, responsible for helping those in distress and hard times. Governments struggle to satisfy these growing demands of consumer expectation and seemingly bottomless social assistance. US President John F. Kennedy's call — "ask not what your country can do for you, ask what you can do for your country" — has increasing relevance today: most citizens want to help their country but they lack the means to engage in the digital age. They want to be part of the herd, not a vulnerable outlier.

One consequence of this lack of community behaviour is a polarisation in attitudes, an emergence of differing perceptions and an increasing tendency to oversimplify complex changes into a series of binary disconnected issues. The global reality is a complex mesh of physical, virtual, legal, historical, geographical, societal, behavioural, economic, informational and technological factors. The rate of change and the speed of introduction of new, disruptive technologies add to this complexity. Scale, speed and complexity have to be considered together. This makes it increasingly difficult for industry leaders and national governments to understand this mesh, and to plan, implement and realise benefits using their traditional non-collaborative organisational structures. The initiative lies with those who are more agile, such as the financial markets and organised crime. Increasingly, developing nations such as Kenya and Rwanda are leaping to new technologies, unencumbered by this legacy. In the developed world, some smaller and more homogeneous nations are making significant advances that are transcending borders to provide international benefits, particularly in Europe (see case studies on European energy markets, p76, and on Estonia, p80).

The hallmarks of advancing digital nations include:

- A digitally-informed leadership

- An empowered, focused government department for all national digital transformation, which is internationally minded and collaborates closely with all industry sectors

- A living, collaborative national plan, which is industry-led with government investment

- Technologically aware, qualified and experienced senior political officials in every government organisation

- Engineers and digital business leaders as elected politicians.

The UK has much to do in each of these areas if it is to become one of the leading digital nations. Yet the world increasingly relies on digital economies. This requires us to do more than apply computer technology to existing economic

models; instead, we must reassess our understanding of what a digital economy is becoming, as well as its constituent actors and activities. This is similar to the transition from cash-based to asset-based accounting, which requires every organisation to have a much wider understanding of the complexity of supply chains, services and markets, and demands a different approach to collaborative risk management, decision making, gainsharing and shared liability. To do digital business in cyberspace, an organisation has to be able to trust, and be trustworthy. It also has to be interoperable with large and increasing communities of other organisations. Trust and interoperability are foundational in cyberspace, much more so than in the physical world. Block chains have the potential to contribute to both, but the magic is not in the technology — it is in how we use it nationally.

Trust and interoperability

Trust is a risk judgement between two or more people, organisations or nations. In cyberspace, trust is based on two key requirements:

- Prove to me that you are who you say you are (**authentication**)

- Prove to me that you have the permissions necessary to do what you ask (**authorisation**)

If I am not satisfied with the response, I can still choose to allow you to proceed, but I am incurring risk. However, there is no viable relationship unless others trust me too. In this sense, being trustworthy is analogous to being creditworthy.

Interoperability involves several factors:

- Data interoperability. We need to understand each other in order to work together, so our data has to have the same syntactic and semantic foundations

- Policy interoperability. Our policies need to be aligned or based on agreed common policy, so that I can be confident that you will treat my information in the way that I expect (and vice versa)

- The effective, collaborative implementation and use of international standards

Information protection is about access control, which requires authentication, authorisation and more. Authentication requires identity management of all entities involved (usually people, organisations, devices and software), to a given, internationally-defined level of assurance (LoA). Authentication across communities of multiple authorities or organisations requires federated identity management (FIM).

At an international scale, such FIM currently exists only at 'low assurance', designated LoA 1 in international standards[1]. It is primarily applied in social networking where multi-jurisdictionality is not a significant issue. Google, GakuNin (the Japanese universities network), Microsoft, Ping Identity, The Nikkei newspaper, Tokyu Corporation, mixi, Yahoo! Japan and SoftBank have also deployed FIM systems; and there are more mature deployments underway by other organisations, such as Deutsche Telecom, AOL, and Salesforce.com.

Medium assurance (LoA 2) requires evidence of identity during enrolment to meet Know Your Customer (KYC) requirements, which financial institutions

require of consumers and businesses in financial transactions. There is some federation at LoA 2, mostly in banking systems.

Several industries use security systems based on Public Key Infrastructure (PKI) federations that rely on a cryptographic standard called X.509. These offer high and very high assurance levels (LoA 3 and 4) for employee authentication, notably in aviation, the pharmaceutical industry, defence, banking and, increasingly, e-health. The US and China have the largest deployments of international-standard PKI federations, closely followed by South Korea (where it is mandated for all companies by regulation), Estonia, Netherlands and many others. At LoA 3+, it is possible to link a user's identity to other trust functions, such as legally-robust digital signatures, identity-linked encryption and physical access control in buildings. PKI federation isn't the only option for high assurance supply chain collaboration and sharing sensitive information at scale, but it is the de facto norm today. Block chains offer a potential alternative, but a combination of PKI federation and block chain federation offers even more attractive opportunities for greater digital accountability, assurance and trust in business processes, coupled with exploiting new technologies.

In the UK, only the police service operates a large-scale PKI federation in accordance with international standards, albeit in a basic form. With best-practice collaborative governance, this could be expanded to support many UK government services, including the emergency services; and international collaborations in areas as broad as trade, border controls or migrants and refugees, with other allies who have similar PKI federations today. The strategy for the government's Public Services Network to use PKI federation for employee authentication has yet to be implemented, however, so there is no high assurance identity management of employees or collaborative trust across government organisations, based on international standards, that could federate with industry partners and international allies eg US, France and the Netherlands. In combination with block chains, PKI federation could provide enhanced services extending to the privacy-friendly handling of identity data and greater traceability of payments.

The NHS has a very large PKI, but it does not comply with international standards and cannot (yet) federate. The MOD has international obligations to establish PKIs with the US-centric defence supply chains, and similar obligations under the NATO Cyber Defence Action Plan, but has no published implementation plans. Industry is considering other potential areas for PKI federation eg for countering food fraud, described in the 2014 Elliott Review into the integrity and assurance of food supply networks. It is also developing a memorandum of understanding with a South Korean government agency that would enable British companies to have PKI credentials that could be used in the supply chains of Korean businesses eg Samsung, Kia, Hyundai and Daewoo (which is currently the manufacturer of the largest container ships in the world). The UN's International Maritime Organisation is developing international guidelines for maritime cybersecurity, and has the potential to leverage the UK-Korea PKI federation initiative. There are more examples in other areas, and all would benefit from a forum where these discussions can come together in a collaborative manner.

The EU Parliament approved the Electronic Identification, Authentication and Trust Services Regulation (eIDAS) in September 2014, giving nations three years

to comply. Under eIDAS, if any nation 'notifies' an e-ID scheme for its citizens, the e-IDs are legally required to be accepted by every other member state for electronic public purposes. Much work has yet to be done, but eIDAS is forcing governments and industry to consider their overall plans to exploit FIM for societal and commercial benefit. In the UK, the government has introduced a federated, standards-based approach to identity assurance: GOV.UK Verify. GOV.UK Verify has been built to respond to the latest developments in the market by having competing providers of identity services and allowing users to choose which one to use. Enhancing and linking Verify to block chains and PKI federations could add value to Verify itself. Block chain and high assurance PKI federation solutions could benefit from Verify's privacy-friendly inputs. Together, in their different ways, they would contribute significantly to the UK's digital economy, border control and its efforts to combat cybercrime.

CASE STUDY 1

European energy retail market

Igor Nai Fovino and Jean-Pierre Nordvik, Joint Research Centre, European Commission

The European Commission Energy Union Framework Strategy[1] sets out the vision of an 'Energy Union' "with citizens at its core, where citizens take ownership of the energy transition, benefit from new technologies to reduce their bills, participate actively in the market, and where vulnerable consumers are protected". However, while the development of energy smart-grids is progressing steadily, the retail energy market is still waiting for modernisation. The Commission's policy initiative 'New Energy Market Design' will have to face several crucial points:

- how to deliver appropriate information on costs and consumption to consumers so that they can identify new opportunities in a fully-integrated continental energy market

- how to reward for active participation, facilitate switching of contracts and manage demand-response to dynamic prices

- how to ensure interoperability in the market for residential energy services, expanding consumers' choices, and enable a real gain from self-generation and self-consumption, and local micro-generation.

In this context, distributed ledgers can act as a new driver to enhance the level of integration and development of the energy retail market. The Joint Research Centre[2] of the European Commission is currently investigating their practical applications, such as the following cases.

1. Micro-Generation energy market. Micro-generation is the capacity for consumers to produce energy in-house or in a local community. The concept of 'market' indicates the possibility of trading energy that has been micro-generated among consumers and 'prosumers'. Traditionally, however, this market has been served by pre-defined bilateral agreements between prosumers and retail energy suppliers. Until now, electricity-generating prosumers have not had real access to the energy market, which remains a privileged playing field for the institutionalised energy suppliers. This has greatly limited the economic advantages of micro-generation for end-users. Distributed ledgers, in combination with smart-metering systems and next-generation batteries (to accumulate energy locally), have the potential to open the energy-market to prosumer production. Smart meters could be used to account and register the micro-generated energy on a distributed ledger (becoming the equivalent of an 'energy-coin' system).

Self-generated electricity could normally be either consumed within the house, or accumulated in next-generation batteries for later use, or simply given back to the grid. Alternatively, thanks to the distributed and pervasive nature of the ledger,

In cyberspace, every entity and transaction binds or links to an organisation. Establishing the validity of an organisation to the desired LoA, and information about it in real or near-real time, is a fundamental digital requirement. Increasing use of block chains will considerably increase this requirement to avoid any records in the chain becoming tainted. A new international standard is being developed for digital organisational identification, known as the Register of Legal Organisations (ROLO). Several nations, including the US, are already considering adapting the ROLO specification to meet their needs. Today, globalisation and the lack of digitally-suitable business registers is resulting in a situation, particularly in the EU, where the majority of financially active organisations in a country are not registered in that country or at all, but it is not possible to tell the difference. UK industry and government organisations, including law enforcement and cybersecurity organisations, urgently need ROLO UK as a digital trust anchor. Industry is starting to develop ROLO UK, which would benefit from greater participation by government user organisations.

Digital Economies

Digital economies seek to harness speed, reach and efficiency. Federated trust enables confidence and risk reduction. Interoperability enables efficiency and re-use of capabilities. In a mature supply chain, each time a company competes in a new programme or sector, re-use gives it agility and a competitive advantage: a view held by aerospace and defence companies and voiced publicly by Airbus, Boeing, BAE Systems, Lockheed Martin, Northrop Grumman, Raytheon[2] and others.

In February 2014, Neelie Kroes, then a vice-president of the European Commission and its digital agenda commissioner, stated that "democracy must talk to technology[3]". She argued that we are making a transition to a

the produced energy could also be redeemed elsewhere, for example when charging an electric vehicle abroad; or sold through the ledger to the best buyer, according a mechanism similar to that of a stock-exchange market.

2. Energy Contracts Ledger. A consumer who intends to change energy supplier currently needs to close their contract with their current supplier, then open a new contract with a new supplier, and revisit the contractual conditions of all complementary energy services provided by third parties. Managing the administrative complexity of these operations is a real barrier to developing a competitive energy retail market, and is a source of cost for energy suppliers and distributors. Using distributed ledgers to record energy contracts online would greatly simplify these operations. It would allow consumers to finalise the transition from one supplier to another with just a few clicks on a computer or mobile device. Likewise, energy suppliers and energy service-providers would save resources otherwise devoted to these administrative operations.

There are still questions about the scalability, security and stability of such applications. However, the benefits are so promising that they certainly merit further investigation.

data-driven world in which trust is key, and that "without security there is no privacy". She pointed out that strong cybersecurity is important to Europe's Single Digital Market, and that the EU Cyber Security Strategy is providing the right building blocks. Without such initiatives, she concluded, democracy would "fail to manage technology".

The dialogues on these topics involving the EU, US and the Association of Southeast Asian Nations (ASEAN) are gradually converging in banking, electronics, pharmaceuticals, food, maritime, aerospace, cyberspace and law enforcement. Through the UN and organisations like the Council of Europe, there is a growing push for developed nations to help developing nations as they become part of the global digital economy. But a lack of digital governance hampers developing nations, creating major opportunities for cybercrime and terrorism that ultimately target developed nations. The Commonwealth could play a significant role in tackling this situation. Collaboration is key.

The potential of decentralised ledgers and block chains

Economies rely on collaborative governance to provide trust in the financial markets, ensuring that all play by agreed rules. Digital economies are the same. The primary reason that block chains are associated with cybercrime is an absence of strategic governance to establish agreed rules and ensure compliance. Once such governance (with policies, procedures and mechanisms) and enforcement exist, the true societal benefits of block chains can be realised. Governmental concerns about the instabilities and vulnerabilities associated with cryptocurrencies and their trading exchanges have made governments cautious regarding the use of block chains, and, generally, they would prefer industry to lead in the development of a better situation.

The main areas for development today are:

- Ungoverned block chains are used for unregulated and criminal activities, particularly where parties seek to be anonymous and unaccountable

- Startup companies are working with leading banks to develop trusted cryptocurrencies and block chains eg a 'trusted Bitcoin'. This could offer significant benefit to major online consumer companies

- Private block chains are being used in closed commercial communities to support digital trust mechanisms, under their own rules. These are non-interoperable and cannot scale to support supply chains

Only recently have governments started to work with industry to explore the strategic potential of block chains. But implementation will accelerate, driven by four major enablers:

- To provide a basis for cryptographic trust in a similar way to PKI. This means that block chains could federate with each other and also with existing PKI federations. Block chains could leverage PKI's deployed scale and governance, while PKIs could leverage block chain's payment and ledger functions. These synergies would open up new opportunities that smart, collaborative governance could accelerate.

- Permissioned ledgers contain a data field of unlimited size. Information about a transaction, including the contract, licence or copyright, could be included,

providing a strong additional factor for trust. This enables 'smart contracts' (ie the binding of the contract to the transaction — see Chapter 1 for more), offering efficiency and non-repudiation.

- Leveraging new protocols, such as the new Uniform Economic Transfer Protocol (UETP) that links the producer to the carrier, the customer, the product, the payment and the banks, and also to the smart contract. The Netherlands is leading on this, with UK industry and possible police participation. US involvement is beginning and will accelerate due to their emerging regulations for cyberassurance across all supply chains. Other nations, such as South Korea and Japan, are expected to be involved soon.

- Smartphones are becoming the de facto trusted user device. The latest smart phones include important new security features, including: Trusted Platform Module, which secures digital certificates and cryptographic keys for authentication, encryption and signing; Trusted Execution Environment, where secure processing occurs without the operating system that could be vulnerable to malware; and Trusted User Interface, which prevents a malware attack between the user and the device. Using near-field communication, the smart phone could interact securely with some national e-ID cards and electronic passports, so that a user could interact securely online with an authority eg at a border or with the police. Consumers and employees now have a secure, trusted device for the first time ever, with which they can sign transactions (eg using a block chain) and payments (eg using a 'trusted Bitcoin'). Samsung, HTC, and LG have been selling tens of millions of such advanced security-enabled smartphones, ready for the software to be deployed in early-mid 2016. Apple and others are expected to follow suit.

Strong collaborative and pervasive governance is required to ensure that these capabilities are not abused or misused. These four enablers are encouraging greater use of block chains and distributed ledgers for financial purposes, and for a growing range of other digital, data-centric purposes across supply chains and with governments. As such systems mature, and their capabilities expand, these four enablers could help to solve a number of difficult social and global challenges. Examples include:

- **Transparent and honest government**. Trust among citizens in developing countries is lower than in countries where stable and accountable legal and regulatory structures engender better community and societal behaviours. It takes a long time for people living in regions devastated by wars and autocratic regimes to trust their governments and to be relatively free of corruption. Accountability and assurance mechanisms (using block chains, FIM and related capabilities), embedded in business processes, are vital to ensure effective implementation and enforcement of laws, policies and organisational structures.

- **Tax evasion and money laundering**. When the distribution curve of a country's wealth steepens excessively, money and asset ownership seeks off-shore domiciles to conceal wealth, reducing financial liquidity in home markets and thereby diminishing economic opportunity for those further down the wealth distribution curve. Eventually, capital starvation can start to unseat economies, followed by wide-scale youth unemployment that can scar lost

generations with a long-standing distrust in their leadership. This undermines democracy, creating conditions for societal fracture, failed states, terrorism and human misery. Again, accountability and assurance are required to tackle these problems.

- **Illegal trade and environmental vandalism**. About 50% of marine species have become extinct in the past 30 years, and the situation is similar on land. Despite international efforts under the *Convention on International Trade in Endangered Species* of Wild Fauna and Flora (CITES), the evidence suggests we are heading towards the Earth's sixth mass extinction. If we are to have any hope of rescuing the global situation, we have to implement much stronger detection and asset tracking mechanisms, with the same accountability and assurance.

- **Food fraud and supply chain disruption**. The UK is more dependent on food imports than ever before, and more vulnerable to national food denial than in 1917 or 1942. The food supply chain can be difficult to track — witness the meat adulteration saga of 2013 (widely known as the 'horsemeat scandal'),

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CASE STUDY 2

Estonian block chains transform paying, trading and signing

Alastair Brockbank, British Embassy Tallinn

Experimenting with block chain technology was a logical step for Estonia. By providing a distributed and unalterable ledger of information, it has ideal qualities for the storage and management of public keys. These are a form of encryption key, provided by a designated authority, which can be combined with a private key to effectively encrypt messages and authenticate digital signatures. Estonia now has the most regularly used national Public Key Infrastructure (PKI) in the world.

Moreover, as a decentralised solution, a block chain is inherently more portable and scalable. It is capable of computing vast amounts of data every second and seamlessly working across borders. For companies in a country of just 1.3 million people, block chains thus offer a way for national solutions to more easily become global solutions. Their computational power also makes them faster, and in certain cases the technology has the disruptive power to make existing intermediaries redundant.

The three case studies below — profiling a bank, a start-up and a cybersecurity provider — show the transformative power of block chains for a wide range of transactions. All three examples underline that block chains must be made user-friendly. The customer need not know that they are trading in coloured coins, nor that their ID card login uses hash-function cryptography. In this sense, a block chain acts as a silent, more efficient workhorse behind a solution that looks familiar: a mobile payments app, an online crowdfunding and trading platform, or a login portal.

As in the UK, the need for and extent of regulation is a key issue for the Estonian authorities. They understand that hesitation and indecision can be as damaging to innovation as strictness. The risks of innovators moving to new and less tightly regulated jurisdictions — specifically, the loss of revenue from failing to capitalise on commercial opportunities, and the potential for criminal activity — are patently clear.

for example — and there are many opportunities for fraud. The international and UK food supply chains have no choice but to follow best-in-class supply-chain assurance from other sectors, in order to implement accountability and granular traceability.

- **Supply chain threats**. As cybercrime and international intellectual property theft increase (involving sums of more than $7 trillion globally), supply chains are coming under increasing regulatory, market and societal pressures for stronger assurance based on collaborative risk management, including accountability and federated identity management.

Along with other advanced nations and international experts, the UK could influence the Council of Europe, the World Bank, G20 and the UN to implement block chains with strong authentication, to provide and enforce accountability and assurance. The UK government cannot do this alone. Industry wants the government to be part of an energetic national approach to achieve national capability and first-mover advantage, collaborating with industry to ensure UK is amongst global leaders.

A pioneering bank issues cryptocurrency securities

Earlier this year, LHV Pank — the largest independent Estonian bank — became the first bank in the world to experiment with programmable money when it issued €100,000 worth of cryptographically-protected certificates of deposits. The experiment followed the establishment of a new LHV subsidiary, Cuber Technology, focused exclusively on Bitcoin-based digital securities. Cuber's work comprises two strands: CUBER securities and the Cuber Wallet.

CUBER (Cryptographic Universal Blockchain Entered Receivable) securities are simply bank certificates of deposits recorded in the Bitcoin block chain. They are denominated in euros, may pay interest and are suitable for various purposes — as a store of value, medium of exchange, trust and escrow services, and even for machine-to-machine transactions, opening potential applicability in the Internet of Things (IoT). LHV views CUBER securities as the Lego building block for their future financial innovation.

The Cuber Wallet is the first demonstration of CUBER usability. It is a piece of software for mobile phones, enabling instant and free peer-to-peer euro transactions, and low cost instant payments for merchants and consumers, using underlying CUBER securities.

Users store their private keys on their smartphone to enhance security and mobility. To protect against server compromises, Cuber Wallet decentralises trust from the server and makes the users themselves the Bitcoin clients. The app uses SPV (Simplified Payment Verification) — a type of 'thin client' security — which means the user never has a complete copy of every block in the chain. Instead they download a smaller amount of data, the 'blockheaders', which link transactions to a place in the chain. This allows them to see that a network node has accepted the transaction, while blocks added after it further confirm that the network has accepted it.

The wallet uses bitcoins as a data carrier, which they 'paint' by adding unique markers to them. This then represents a claim in fiat currency against LHV Bank, as the entry into a database represents a claim against the traditional bank system. By using fiat currency, the wallet can be used not just for personal transfers, but also for retail payments — the merchant has to approve this payment method just as they have to approve credit cards. LHV is currently testing it in a few physical locations, but anticipate wider utility in online business, particularly for smaller payments.

The use of fiat currency undoubtedly makes the app more user friendly. LHV asserts that the underlying technology is the bank's concern: the user and merchant do not and should not need to

see, nor know, that Cuber uses Bitcoin.

Cuber's open source code and application program interface are available to third parties online, inviting other cryptocurrency exchanges and developers to tap into the technology. Both LHV and its development partner, ChromaWay, prefer to drive usable innovation with smaller software developers and start-ups, rather than large banks.

When pressed on their challenges, LHV is clear: regulatory uncertainty risks killing Cuber's transformative power by severely limiting its reach. The bank urges regulators to embrace block chain technology and adapt, rather than run scared from it.

On the face of it, being backed by a bank affords Cuber huge advantages, because transferring money from a conventional bank account to a digital wallet (and back again) is simplified. CUBER is technically still a security — the foundation of bank trading — albeit with decentralised record keeping. But in reality, being a bank remains a regulatory obstacle, because they are typically subject to more legal arbitrage than new innovators. Similarly, EU Know Your Customer (KYC) rules that require a face-to-face meeting to create a bank account disadvantage Cuber when other online payment services such as TransferWise and Holvi only need a quick online sign-up. If banks are to compete effectively in this market, regulation will need to impose no additional barriers to banks, nor reduce their mobility to reach and recruit new users.

Admittedly, LHV is in an unusual position: an 'innovation-friendly' bank doing it themselves, but whose forward progress is currently restricted by regulatory uncertainty. With no positive movement, Cuber will either have to be distanced from LHV's license and the advantages that being tied to a bank bring, or look at moving outside Europe to another jurisdiction.

Developing a simple, secure and legally compliant bridge between crypto and traditional banking continues to prove exceptionally challenging for all players. But none are closer than LHV.

A liquid aftermarket for start-up investments

The illiquidity of start-up investment is a common complaint from angel investors and founders alike. Backers typically need to part with at least €10,000, and must often wait 5 or more years to exit.

Funderbeam — a reputed business intelligence platform for investors — may well have found a solution to this problem: a block chain-based investment marketplace, to buy and sell coloured coin stakes in start-up syndicates.

Investors will soon be able to use Funderbeam's online platform to create an investment syndicate for one or several start-ups. Investment can be in any configuration, and there is no limit to the size of a syndicate. A £100,000 stake could comprise one lead investor and 99 backers investing £1,000; a lead investor on £75,000 and five backers on £5,000; or any other combination. Similar to crowdfunding, this diminishes the threshold to invest in start-ups.

What differentiates Funderbeam from the crowdfunding alternatives is the issuance of 'coloured coins' representing syndicate members' stakes, which can be instantly bought, sold, or traded with other investors. This enables more fluid management of investment portfolios, and expedites financing for start-ups. The Bitcoin block chain underpins the aftermarket, allowing for fast, effective and transparent asset ownership tracking.

Every syndicate is paired with a microfund. Once a syndicate is complete, and the start-up is funded, Funderbeam's aftermarket uses coloured coins to give all members of a syndicate a digital representation of their share in that microfund, which is immediately tradable. Backers can thus sell their whole share, or a proportion of it, once they have made a decent return or want to cut their losses.

Flexibility for investors is not the only benefit the block chain solution affords. Kaidi Ruusalepp, CEO of Funderbeam, also points to the efficiencies that a distributed ledger offers

through bypassing bureaucracy. "We don't need a business registry, central depository, or another formal authority to confirm the integrity of a transaction," he says. "With the block chain, every investment, every ownership change has a secure, distributed audit trail."

Jaan Tallinn, co-founder of Skype and an investor in Funderbeam, lauds the additional layer of security and verification it offers for online transactions. By being decentralised and unalterable, block chains can create more transparency in the equity market, without compromising anyone's privacy.

Funderbeam's offering — providing flexibility, speed, security and transparency — shows how distributed ledgers can provide an alternative but wholly viable basis for small and medium-sized enterprise (SME) financing to expand in the 21st century.

The next generation of public-key infrastructure

Since 2013, Estonian government registers — including those hosting all citizen and business-related information — have used Guardtime to authenticate the data in its databases. Their Keyless Signature Infrastructure (KSI) pairs cryptographic 'hash functions' (see below) with a distributed ledger, allowing the Estonian government to guarantee a record of the state of any component within the network and data stores.

This is no small undertaking. Estonia has the most regularly used national PKI in the world. Using their ID card, citizens order prescriptions, vote, bank online, review their children's school records, apply for state benefits, file their tax return, submit planning applications, upload their will, apply to serve in the armed forces, and fulfil around 3000 other functions. Entrepreneurs use the ID card to file their annual reports, issue shareholder documents, apply for licenses, and so on. Government officials use the ID card to encrypt documents for secure communication, review and approve permits, contracts and applications, and submit information requests to law enforcement

agencies. Ministers even use their ID cards to prepare for and conduct cabinet meetings, allowing them to review agendas, submit positions and objections, and review minutes.

Digital authentication is thus critical to government, business and public services alike, from drafting policy and legislation, to declaring finances and registering property and inheritance rights. Over 200 million digital signatures have been made using the ID card: some 39 per capita per year and rising. It is thus imperative for the government to know its records are the right records, and that they have not been altered from the inside, or by a cyber attack.

So how does a block chain help? It helps because every alteration of a piece of data is recorded. By providing proof of time, identity and authenticity, KSI signatures offer data integrity, backdating protection and verifiable guarantees that data has not been tampered with. It is transparent and works to the user's benefit too: citizens can see who reviewed their data, why, and when; and any alterations to their personal data must be authorised. Moreover, through using hash functions, as opposed to asymmetric cryptography used in most PKI, KSI cannot be broken by quantum algorithms. It is also so scalable that it can sign an exabyte of data per second using negligible computational and network overhead. It removes the need for a trusted authority, its signed data can be verified across geographies, and it never compromises privacy because it does not ingest customer data. It is clear that the system marks a major advancement in PKI.

Ultimately, the KSI block chain means that while the Estonian ID Card may never be immune to a breach (although there have been none so far), the government is assured that rogue alterations to public data will be 100% detectable.

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TAB 20

OPINION

Social networks are creating a global crisis of democracy

Silicon Valley once promised its digital revolution would topple dictators – but now it's disrupting the free world instead. **Niall Ferguson** asks: What have we done?

In 2016, Facebook's Mark Zuckerberg and other Silicon Valley titans saw their creations help Donald Trump win the White House. Now those companies are frantically hitting the escape key – and the world's democracies are waking up to the threats of social networks, Niall Ferguson argues.

PHOTO ILLUSTRATION/THE GLOBE AND MAIL

NIALL FERGUSON
CONTRIBUTED TO THE GLOBE AND MAIL
PUBLISHED JANUARY 19, 2018
UPDATED JANUARY 20, 2018

Niall Ferguson's new book, The Square and the Tower: Networks and Power from the Freemasons to Facebook, *is published this month by Penguin Press.*

"Esc!" It's the key on the top left of the keyboard that you hit frantically when your laptop crashes. Confronted by the ghastly reality that some of their proudest creations – Google, Facebook and Twitter – helped propel Donald Trump into the White House, the tech titans of Silicon Valley are hitting esc like panic-stricken sophomores whose term papers have frozen before they clicked on the "save" icon.

DJMJELLY

THE GLOBE AND MAIL

It wasn't supposed to be this way. For a time, it seemed as if the internet was on democracy's side, helping the crowds in Cairo's Tahrir Square or Kiev's Maidan topple terrible tyrants.

"Current network technology … truly favours the citizens," wrote Google's Jared Cohen and Eric Schmidt in their 2013 book *The New Digital Age*. "Never before have so many people been connected through an instantly responsive network," with truly "game-changing" implications for politics everywhere.

Mr. Cohen and Mr. Schmidt's 2010 article "The Digital Disruption" presciently argued that authoritarian governments would "be caught off-guard when large numbers of their citizens, armed with virtually nothing but cellphones, take part in mini-rebellions that challenge their authority."

The "real action" in what they called "the interconnected estate" could be found in "cramped offices in Cairo" as well as "on the streets of Tehran. From these locations and others, activists and technology geeks are rallying political 'flash mobs' that shake repressive governments, building new tools to skirt firewalls and censors, reporting and tweeting the new online journalism, and writing a bill of human rights for the internet age."

Even more euphoric was Mark Zuckerberg, the co-founder and chief executive of Facebook. In 2015, he called the internet "a force for peace in the world." Connecting people on Facebook was building a "common global community" with a "shared understanding" of the problems confronting humanity.

Oh, happy days. Oh, glad, confident morning. Sadly, over the past two years, it has gradually become apparent that internet may pose a bigger threat to democracies than to dictators.

DJMJELLY

A Facebook logo looms behind Mark Zuckerberg at the company's headquarters in Menlo Park, Calif.

MARCIO JOSE SANCHEZ/ASSOCIATED PRESS

For one thing, the growth of network platforms with unprecedented data-gathering capabilities has created new opportunities for authoritarian regimes, not least in China and Russia, to control their own populations more effectively.

For another, the networks themselves offer ways in which bad actors – and not only the Russian government – can undermine democracy by disseminating fake news and extreme views. "These social platforms are all invented by very liberal people on the west and east coasts," said Brad Parscale, Mr. Trump's digital-media director, in an interview last year. "And we figure out how to use it to push conservative values. I don't think they thought that would ever happen." Too right.

STORY CONTINUES BELOW ADVERTISEMENT

DJMJELLY

Having initially dismissed as "a pretty crazy idea" the notion that fake news on Facebook had helped Mr. Trump to victory, Mr. Zuckerberg last year came clean: Russians using false identities had paid for 3,000 Facebook advertisements that sent implicitly pro-Trump messages to Americans before and after the election. By some estimates, between 146 and 150 million users – more people than voted – had seen posts from accounts linked to the Internet Research Agency, a pro-Kremlin organization, including around 16 million users of Instagram, which Facebook owns.

One analysis of six Russia-linked Facebook pages found their posts had been shared 340 million times. And those were just six of 470 pages that Facebook had identified as Russian. Trolls with false identities had also used Facebook Events (the company's event-management tool) to promote political protests in the United States, including an Aug. 27, 2016, anti-immigrant, anti-Muslim rally in a rural Idaho town known to welcome refugees.

In May, 2016, two Russian-linked Facebook groups had organized simultaneous opposing protests in front of the Islamic Da'wah Center of Houston. "Heart of Texas," a bogus group claiming to favour Texas secession, had announced a noon rally on May 21 to "Stop Islamification of Texas." Meanwhile, a separate Russian-sponsored group, "United Muslims of America," had advertised a "Save Islamic Knowledge" rally for exactly the same place and time. This wasn't the kind of global community Mr. Zuckerberg had envisaged.

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THE GLOBE AND MAIL

United Muslims of America shared their event.
Sponsored · 🌐

The time has come to understand one simple thing: we the American muslims are as American

Support Hillary.
Save American Muslims.

JUL
9

Support Hillary. Save American Muslims!
Sat 1 PM EDT · The Obama White House · Wash...
150 people interested · 47 people going

⭐ **Interested**

174 Reactions 36 Comments

👍 Like   💬 Comment

After the 2016 election, Facebook unearthed examples of a Russian misinformation campaign whose posts were shared millions of times on the social network. Here are two examples presented as evidence to Congress last year.

U.S. HOUSE OF REPRESENTATIVES PERMANENT SELECT COMMITTEE ON INTELLIGENCE

This is not just an American story. To an extent that is not well enough appreciated, it is a global crisis of democracy. Similar efforts were made, albeit on a smaller scale, to influence the outcome of the British referendum on European Union membership – mainly via fake Twitter accounts – as well as last year's elections in the Netherlands, France and Germany. And the fact that the Russian meddling in the 2016 U.S. election has since become the focal point of multiple inquiries in Washington – which may even pose a threat to the legitimacy and longevity of Mr. Trump's presidency – does not mean that similar things are not going on in other countries even as you read this article. Canadians have good reason to _____ how social media could impact the 2019 federal election. When Facebook and Twitter told MPs last year that they could

Yet the most alarming revelation of the past year is not the importance of Russian fake news, but its unimportance. Former president Barack Obama implicitly acknowledged that in his recent Netflix interview with David Letterman. Having swept into the White House in 2008 as the first candidate of the social media age, Obama acknowledged that he had "missed … the degree to which people who are in power, special interests, foreign governments, et cetera, can in fact manipulate [social media] and propagandize."

However, the former law professor made no attempt to lay all the blame on outside forces. "What the Russians exploited," he said, "was already here … [The fact that] we are operating in completely different information universes. If you watch Fox News, you are living on a different planet than you are if you listen to NPR. That's what's happening with these Facebook pages, where more and more people are getting their news from. At a certain point, you just live in a bubble. And that's part of why our politics is so polarized right now."

What happened in 2016 was much more than just a Kremlin "black op" that exceeded expectations. It was a direct result of the profound change in the public sphere brought about by the advent and spectacular growth of the online network platforms. In many ways, the obsessive focus of the American political class on the Russian sub-plot is a distraction from the alarming reality that – as the European competition commissioner Margrethe Vestager argued earlier this month – the big tech companies, and the way their services are used by ordinary people, pose a much bigger threat to democracy. It is the threat from within we really need to worry about – not the threat from Putin.

Top apps by share of all smartphone touches
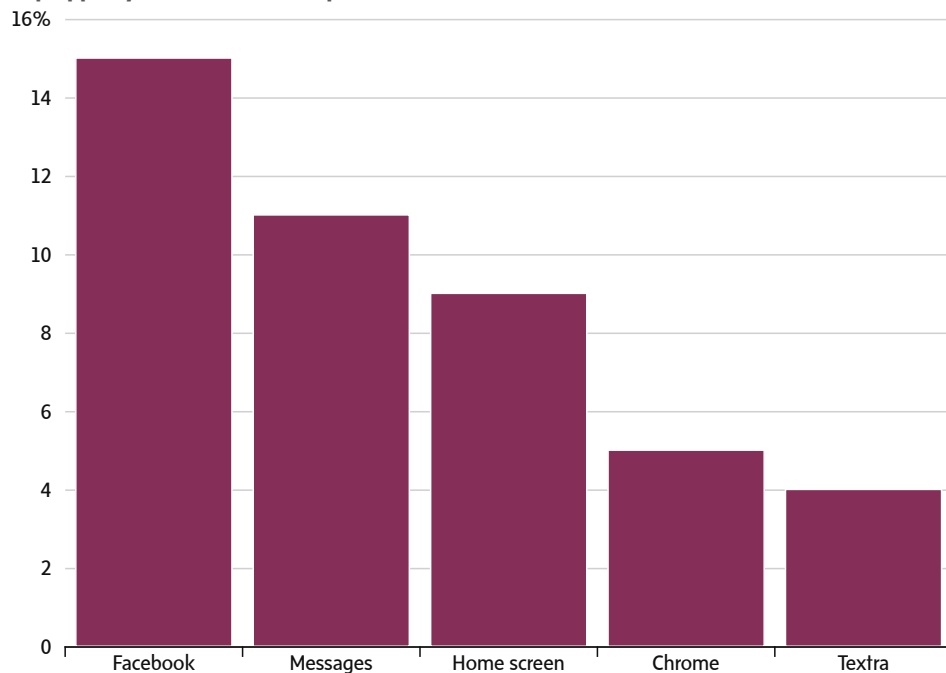
THE GLOBE AND MAIL, SOURCE: DSCOUT

DATA   SHARE

A POLARIZATION PROBLEM

DJMJELLY

and swipes that insidious little device an amazing 2,617 times a day.

And we don't just passively read. We engage. We like. We retweet. We reply. We comment. Now, it must be admitted that most of what we write is inane. In Canada, the five most-commonly used words in Facebook status updates are: "day," "hangover," "loud," "ticket" and "word." ("Hangover" is ranked 7th in Britain and 8th in the United States – make of that what you will.)

But a fair amount of what we engage with online is news. Two-thirds of U.S. adults are on Facebook. Nearly half – 45 per cent – get news from Mr. Zuckerberg's platform. More than one in 10 Americans get news from YouTube, while roughly the same proportion (11 per cent) get news from Twitter. In Canada, 51 per cent of people get their news from digital sources first.

Use and news consumption among U.S. adults, by source

Use site   Get news on site

Source	Use site	Get news on site
Facebook	66%	45
YouTube	58	18
Instagram	26	7
Twitter	15	11
LinkedIn	21	5
Snapchat	18	5
WhatApp	11	2
Reddit	6	4
Tumblr	4	1
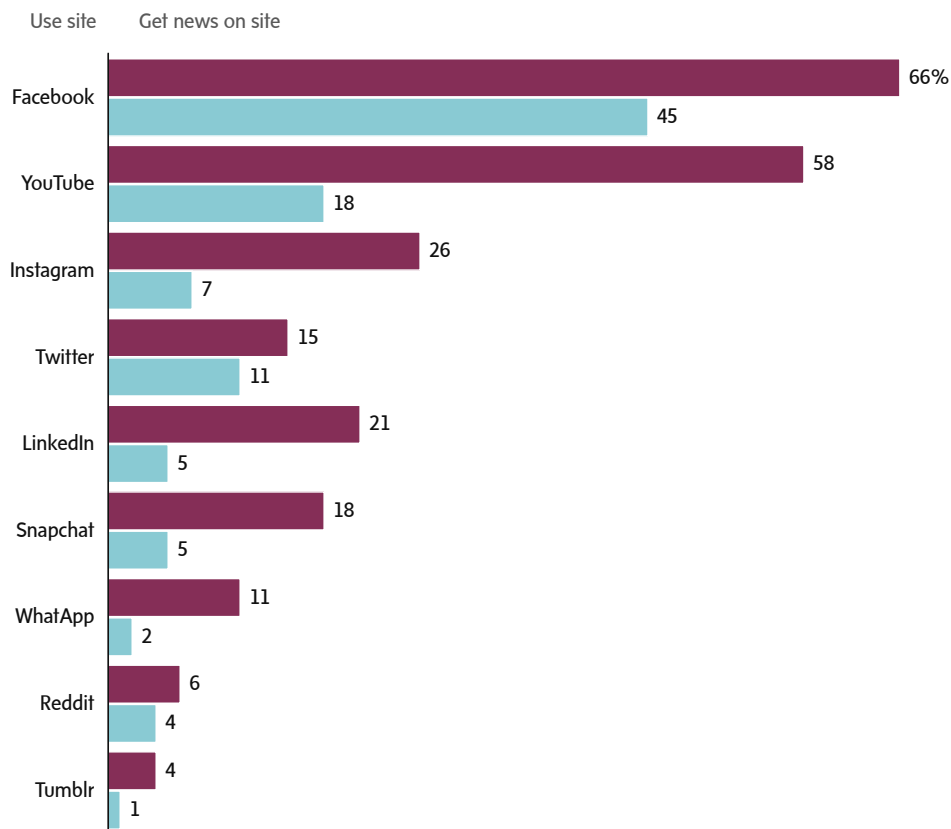
THE GLOBE AND MAIL, SOURCE:PEW RESEARCH CENTER STUDY, 2017

DATA   SHARE

As a recent Harvard paper co-authored by Gary King demonstrates, the network platforms essentially amplify news from established news outlets. As they do so, however, a strange thing happens. Whether one looks at blogs or at Twitter, social media tend to promote polarization. Liberal bloggers link to liberal bloggers, rarely to conservative ones. Liberal Twitter users re-tweet one another, seldom their conservative counterparts. And tweets on political topics – gun control, same-sex marriage, climate change – are 20 per cent more likely to be retweeted for every moral or emotional word they employ.

Note also that political Twitter is not for everyone. As Daniel Hopkins, Ye Liu, Daniel Preotiuc-Pietro and Lyle Ungar have shown, by analyzing nearly five million tweets generated by four thousand Twitter accounts in August, 2016, it is "very conservative" and "very liberal" users who are most likely to tweet political words.

Word use on Twitter by political figures and users by political type

% of total words used

Political words   Political names   Media/pundit names

DJMJELLY

rvative users	1.03
Conservatives	0.72
Mod. conservatives	0.51
Moderates	0.45
Mod. liberals	0.58
Liberals	0.66
Very liberal	0.98
Liberal political figures	3.92
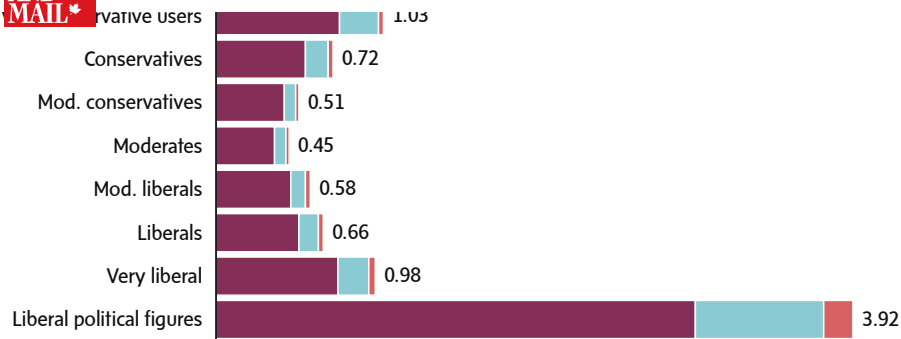
THE GLOBE AND MAIL, SOURCE:BEYOND BINARY LABELS: POLITICAL IDEOLOGY PREDICTION OF TWITTER USERS

DATA   SHARE

We see a similar phenomenon when we analyze the Facebook followers of U.S. legislators. In both the House of Representatives and the Senate, the pattern is clear: The more ideologically out there you are – whether to the left or the right – the more followers you are likely to have.

In this context, it becomes apparent that Russian fake news represented a drop in an ocean of inflammatory political commentary that was overwhelmingly indigenous. Between March, 2015, and November, 2016, 128 million Americans created nearly 10 billion Facebook posts, shares, likes and comments about the election. Remember how many Russian ads there were? That's right: a paltry 3,000.

According to new research by Brendan Nyhan of Dartmouth College, Andrew Guess of Princeton University and Jason Reifler of the University of Exeter, roughly one in four Americans saw at least one false story in the run-up to the presidential election. But fake stories were just 1 per cent of the news Hillary Clinton supporters read, and 6 per cent of the news Trump supporters read.

Remember, too, that not all the Russian-sourced news was fake. The tens of thousands of e-mails hacked from the accounts of John Podesta and other Democrats were as real as they were confidential. But it wasn't the Russians who were driving the traffic on the Breitbart website to record highs. It wasn't the Russians who explained to the Trump campaign how they could use targeted Facebook advertising to compensate – with precision – for what they lacked in dollars. It was Silicon Valley: its big data, its algorithms, its employees.

DJMJELLY

PHOTO ILLUSTRATION/THE GLOBE AND MAIL

A MATTER OF PRIORITIES

D on't take it from me. Take it from former Facebook staff who have spoken out in the past year. Antonio Garcia Martinez, the former Facebook engineer and author of the book *Chaos Monkeys*, put it starkly: "I think there's a real question if democracy can survive Facebook and all the other Facebook-like platforms," he said in an interview. "Before platforms like Facebook, the argument used to be that you had a right to your own opinion. Now, it's more like the right to your own reality."

Facebook's propaganda was all about building a global community. But in practice, the company was laser-focused on the bottom line – and highly resistant to outside criticism. Sandy Parakilas, who worked as an operations manager to fix privacy problems on Facebook's developer platform in advance of its 2012 initial public offering, has said that the company "prioritized data collection from its users over protecting them from abuse."

"When I was at Facebook," he said last year, "the typical reaction I recall looked like this: Try to put any negative press coverage to bed as quickly as possible, with no sincere efforts to put safeguards in place or to identify and stop abusive developers." The policy was to "react only when the press or regulators make something an issue, and avoid any changes that would hurt the business of collecting and selling data."

Perhaps the most scathing assessment came from former vice-president for user growth, Chamath Palihapitiya. "I think," he told an audience of students at Stanford's Graduate School of Business in December, "we have created tools that are ripping apart the social fabric of how society works. … The short-term, dopamine-driven feedback loops that we have created are destroying how society works. No civil discourse, no co-operation: misinformation, mistrust. And it's not an American problem – this is not about Russians ads. This is a global problem."

DJMJELLY

Chamath Palihapitiya speaks out about social media's harmful effects on society
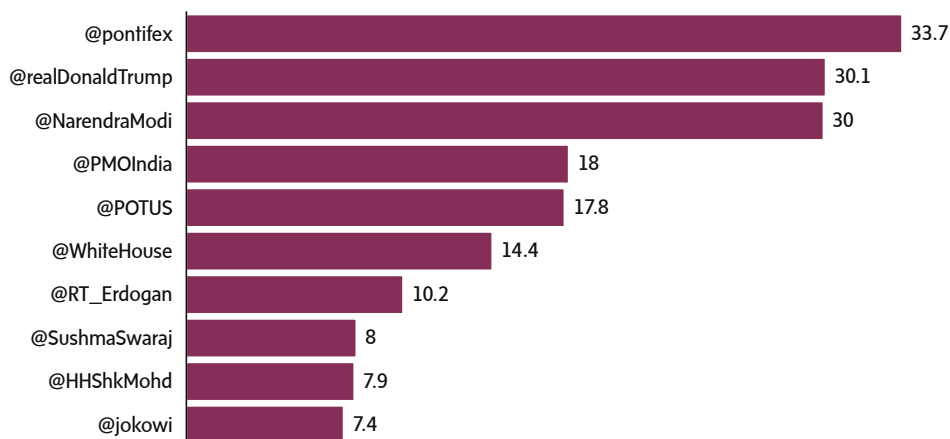
5:20

Mr. Palihapitiya said he felt "tremendous guilt" about his own part in this because he believed he and his former colleagues "kind of knew something bad would happen." He is not alone in feeling guilty. Facebook's first president, Sean Parker, has talked in similar terms. Another early employee told Vanity Fair, "Most of the early employees I know are totally overwhelmed by what this thing has become. They look at the role Facebook now plays in society … and they have this sort of 'Oh my God, what have I done' moment."

True, in recent months Facebook has scrambled to respond to all this recrimination. On Sept. 21, for example, Mr. Zuckerberg pledged to work "pro-actively to strengthen the democratic process." Facebook would require that all political ads disclose which page paid for them and ensure that each ad is accessible to everyone. Later last year, he announced plans to clamp down on "bad content and bad actors" by doubling the number of employees and contractors who handle safety and security issues to 20,000 by the end of 2018. And just last week, he announced an overhaul of the News Feed to prioritize "meaningful interaction" between users over the kind of media-generated content that advertisers like.

But if you think this kind of self-regulation is going to fix democracy's social-media problem, then I have a bridge to sell you. For one thing, it would take at least an order of magnitude more people to achieve meaningful monitoring of the vast amount of content that Facebook's two billion-plus users produce and share every day. For another, none of this alters the company's fundamental business model, which is to sell advertisers the precision targeting that Facebook's user data allows. Political advertising may henceforth be identified as such, in the way that it is on television. But just how much less effective will that make it?

Google says it will curate its "News" search results more carefully, to rank established newspaper sites above bulletin boards such as 4chan or Reddit, which are favourite channels for alt-right content. Anyone who thinks that will stop people reading fake news hasn't found the "scroll down" button on their keyboard.

The most followed world leaders on Twitter, 2017

Leader	Millions
@pontifex	33.7
@realDonaldTrump	30.1
@NarendraModi	30
@PMOIndia	18
@POTUS	17.8
@WhiteHouse	14.4
@RT_Erdogan	10.2
@SushmaSwaraj	8
@HHShkMohd	7.9
@jokowi	7.4

THE GLOBE AND MAIL, SOURCE: TWIPLOMACY 2017

DATA   SHARE

A NEW KIND OF POLITICS

The reality is, no matter how Facebook, Google and Twitter tweak their algorithms, a new kind of politics ̣   ̣ ̣   DJMJELLY ̣or̠ It can no more be unborn than the new kind of politics born when television revealed how much better-looking John F.
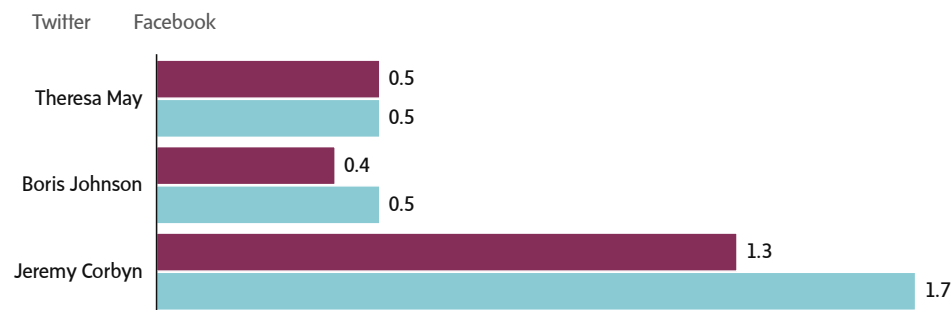
THE GLOBE AND MAIL

There are now two kinds of politicians in this world: the kind that know how to use social media as a campaign tool and the ones who lose elections. All over the world, the distinction is clear. The populists of the right and of the left understand the power of social media. The moderates who occupy the centre ground, with few exceptions – Justin "Selfie" Trudeau is one of them – are still playing by 1990s rules.

Among the few indicators that Mr. Trump had a good chance of beating Ms. Clinton were his enormous leads on Facebook and Twitter throughout the 2016 campaign. Applying similar metrics around the world yields startling results. Take Britain, for example. The Leave campaign's victory in the 2016 referendum on Britain's membership in the European Union owed a great deal to its pioneering use of Facebook advertising. Yet the principal political beneficiary of Brexit – the woman who became prime minister shortly after the referendum, Theresa May – is a social-media loser, with little more than half a million Facebook followers and even less on Twitter. By comparison, the Labour Leader Jeremy Corbyn – a grizzled populist of the left in the style of Bernie Sanders – has 1.3 million followers on Facebook followers and 1.7 million on Twitter (numbers as of Jan. 18). No other British politician comes close. Boris Johnson is often mentioned in the same breath as Mr. Trump, but all the two men really have in common is big hair. Mr. Corbyn has four times more Twitter followers than "BoJo."

Follower counts of Britain's political figures

In millions

Twitter　　Facebook

Theresa May	Twitter 0.5 / Facebook 0.5
Boris Johnson	Twitter 0.4 / Facebook 0.5
Jeremy Corbyn	Twitter 1.3 / Facebook 1.7

THE GLOBE AND MAIL, SOURCE: FACEBOOK, SOCIALBLADE (AS OF JAN. 18, 2018)

DATA　SHARE

Britain has no election scheduled for 2018 – although it is possible Ms. May's woefully weak government could fall as the economic costs of Brexit make themselves felt and the harsh realities of the EU's divorce terms become apparent. Elsewhere, however, electorates are preparing to vote in general elections, notably in Brazil, Colombia, Italy and Mexico. These contests will give us a chance to see how far the new politics has spread.

Start with Brazil, a country whose political elite has been battered by corruption scandals that led to the impeachment of the Workers' Party President Dilma Rouseff and probably disqualify her predecessor, Luiz Lula da Silva, from running this year. But who cares? Lula has three million Facebook followers and just 189,000 Twitter followers. Far ahead of him on social media is Luciano Huck, the entrepreneur and television star, host of the hugely popular Saturday night TV show *Caldeirao do Huck*. With 17 million Facebook followers and nearly 13 million on Twitter, Mr. Huck is in a league of his own in Brazilian politics.

A Huck candidacy would be the Brazilian equivalent of Oprah Winfrey (FB 11.6m, TW 41.4m) running for president in 2020. He is not a populist; he's just popular. In second place, however, comes Jair Bolsonaro (FB 5m, TW 0.8m), the former army parachutist whose political positions make Mr. Trump seem like a lily-livered liberal. Mr. Bolsonaro is an unabashed defender of the military dictatorship that ruled Brazil between 1964 and 1985. Name any politically incorrect position; Mr. Bolsonaro has taken it. "I would never rape you," he once told a female politician, "because you do not deserve it."

Follower counts of Brazil political figures

In millions

DJMJELLY

THE GLOBE AND MAIL

Luiz Lula da Silva
0.2
3

Dilma Rousseff
6
3

Luciano Huck
41.4
11.6

Jair Bolsonaro
0.8
5
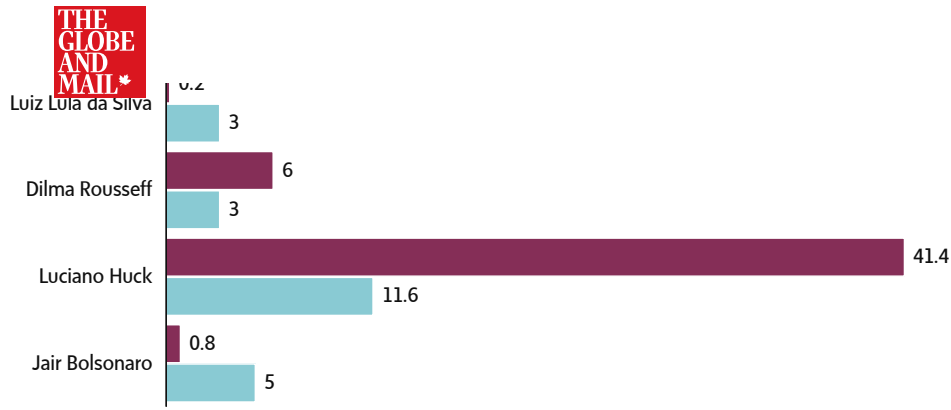
THE GLOBE AND MAIL, SOURCE:FACEBOOK, SOCIALBLADE (AS OF JAN. 18, 2018)

DATA   SHARE

Italian politics was in many ways the experimental laboratory for the kind of candidate who combines wealth and celebrity with political incorrectness. Silvio Berlusconi has claimed, not without justification, to have been the prototype Trump. Despite a criminal conviction, Mr. Berlusconi is still a political player, though more of a kingmaker than a candidate these days. Yet he is behind the times (FB 1m, TW 19,300). The King of Twitter in Italy is former prime minister Matteo Renzi (FB 1.1m, TW 3.34m), although on Facebook he trails the populists: the two Five Star Movement leaders, Beppe Grillo (FB 1.9m, TW 2.5m) and Luigi di Maio (FB 1.1m, TW 0.3m), as well as the Northern League leader Matteo Salvini (FB 1.9m, TW 0.6m).

Follower counts of Italy's political figures
In millions
Twitter   Facebook

Silvio Berlusconi
0.02
1

Matteo Renzi
3.3
1.1

Beppe Grillo
2.5
1.9

Luigi di Maio
0.3
1.1

Matteo Salvini
0.6
1.9
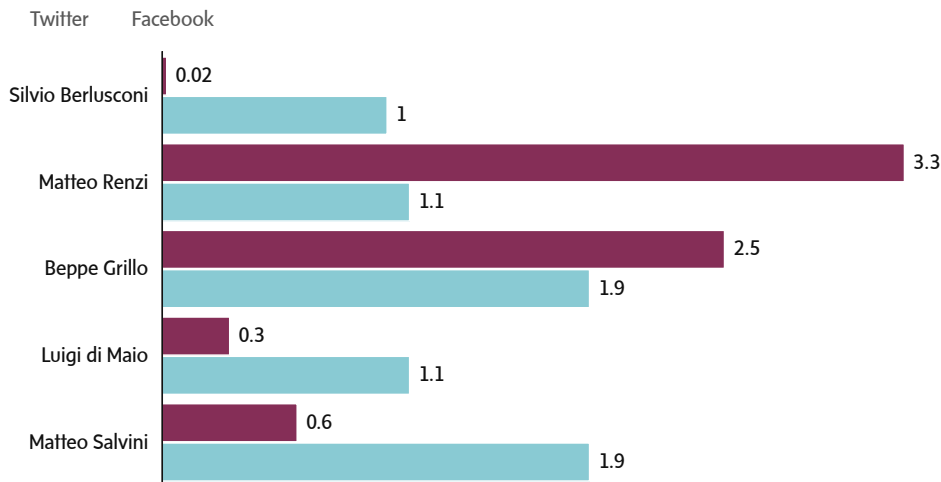
THE GLOBE AND MAIL, SOURCE:FACEBOOK, SOCIALBLADE (AS OF JAN. 18, 2018)

DATA   SHARE

In Mexico, the best-known populist – Andrés Manuel López Obrador, universally known by his initials as "AMLO" – is a man of the left. On social media (FB 2.3m, TW 3.5m), AMLO is far ahead of the likely PRI nominee José Antonio Meade (FB 0.3m, TW 1m) and his PAN (National Action Party) counterpart Ricardo Anaya Cortes (FB 0.9m, TW 0.4m). True, AMLO is not the most followed Mexican politician: Rafael Moreno Valle, the former governor of Puebla, is now neck-and-neck with him on Facebook. Only just behind AMLO on Twitter is the mayor of Mexico City, Miguel Angel Mancera. But neither Moreno Valle nor Mancera is going to be a presidential candidate.

Follower counts of Mexico's political figures
Millions
Twitter   Facebook

DJMJELLY

José Antonio Meade — 1 — 0.3

Ricardo Anaya Cortes — 0.4 — 0.9
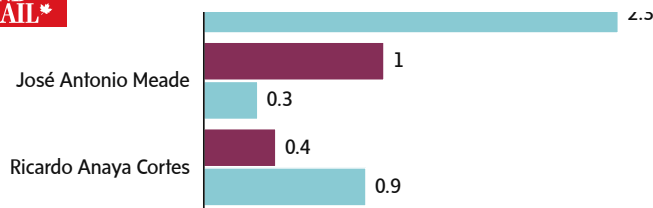
THE GLOBE AND MAIL, SOURCE:FACEBOOK, SOCIALBLADE (AS OF JAN. 18, 2018)

DATA   SHARE

Politics on Colombian social media also leans left. There, the leading figure is Gustavo Petro (FB 0.9m, TW 2.8m), the former mayor of Bogotá, who as a young man belonged to the guerrilla group the 19th of April Movement and who made his political reputation as an opponent of the conservative presidency of Álvaro Uribe.

THE INESCAPABLE THREAT

It used to be that all politics was local. Today, perhaps, all politics is becoming social, in that social media have emerged as the crucial battleground of modern elections. Just a few years ago, that would have seemed like a good idea. What could be more democratic, after all, than enabling politicians to communicate their messages directly to individual voters, and to hear back from them in real time? The only thing to worry about was whether or not online speech was truly free – the core preoccupation of Freedom House's annual "Freedom on the Net" survey.

But what if the biggest threat to democracy is not online censorship or surveillance, but the near-total absence of regulation of politics on social media? The public is beginning to sense this. A new Gallup-Knight survey, published last week, revealed that 57 per cent of Americans think that the way sites choose which stories to show to users presents "a major problem" for democracy. Just less than half of those interviewed favoured regulation of how the network platforms provide news.

The difficulty is knowing what form regulation should take. As Sam Lessin – another former Facebooker – has argued, the real transformation of the public sphere is that a candidate "can for the first time effectively talk to each individual voter privately in their own home and tell them exactly what they want to hear … in a way that can't be tracked or audited."

Forget fake news, Mr. Lessin argues. Forget the "feed bubbles" and "echo chambers" that have dominated the discussion in the United States. The real challenge is not that the public sphere has grown polarized. The challenge is that it has been so fragmented by misnamed social media that it is no longer a single public sphere.

"It has been a foregone conclusion for a long time," Mr. Lessin concludes, doubtless remembering the inspirational Zuckerberg speeches of the pre-2016 era, "that the internet has been a vehicle for moving us toward speaking one common language and being able to work together to solve the great problems of our era. … The sad reality is that the most exciting attempt to bring our world together is putting us at risk of not being able to trust what we see or hear" – but (and this is the point he missed) voting for the most engaging candidate anyway.

Hit "esc" all you like. This is the real – and inescapable – threat facing every democracy today.

DJMJELLY

TAB 21

SÉNAT SENATE

CANADA

DÉFI EN VUE

Intégrer les technologies de la robotique, de l'intelligence artificielle et de l'impression en 3D dans les systèmes canadiens de soins de santé

Comité sénatorial permanent des affaires sociales, des sciences et de la technologie

L'honorable Kelvin Kenneth Ogilvie, *président*

L'honorable Art Eggleton, C.P., *vice-président*

Octobre 2017

Pour plus d'information, prière de communiquer avec nous :

par courriel :   SOCI@sen.parl.gc.ca
sans frais :   1-800-267-7362
par la poste :   Comité sénatorial permanent des
                 affaires sociales, des sciences et de la technologie
                 Sénat, Ottawa (Ontario), Canada K1A 0A4

Le rapport peut être téléchargé à l'adresse suivante :
www.senate-senat.ca/social.asp

This report is also available in English

Sénat | Senate
CANADA

TABLE DES MATIÈRES

ORDRE DE RENVOI

Extrait des *Journaux du Sénat* du mardi 25 octobre 2016 :

L'honorable sénateur Ogilvie propose, appuyé par l'honorable sénateur Eggleton, C.P. :

Que le Comité sénatorial permanent des affaires sociales, des sciences et de la technologie soit autorisé à étudier, en vue d'en faire rapport, le rôle de l'automatisation dans le système des soins de santé, plus particulièrement la robotique, l'intelligence artificielle et l'impression en 3D, dans les secteurs :

- des soins directs aux patients;
- des soins indirects aux patients;
- des soins à domicile.

Que le comité dépose son rapport final au plus tard le 31 décembre 2017 et qu'il conserve tous les pouvoirs nécessaires pour diffuser ses conclusions dans les 180 jours suivant le dépôt du rapport final.

Après débat,

La motion, mise aux voix, est adoptée.

Le greffier du Sénat,
Charles Robert

MEMBRES

Les honorables sénateurs ayant participé à cette étude :

Kelvin Kenneth Ogilvie, *président*
Art Eggleton, C.P., *vice-président*
René Cormier
Tony Dean
Linda Frum
Nancy J. Hartling
Marie-Françoise Mégie
Richard Neufeld
Ratna Omidvar
Chantal Petitclerc
Nancy Greene Raine
Judith Seidman
Carolyn Stewart Olsen

Membres d'office du comité :
Les honorables sénateurs :

Peter Harder, C.P. (ou Diane Bellemare)
Larry W. Smith (ou Yonah Martin)

Autres sénateurs ayant participé, de temps à autre, à cette étude :

Les honorables sénateurs Beyak, Dagenais, Galvez, Gold, Griffin, MacDonald, McIntyre, McPhedran, Meredith, Poirier et Unger

Service d'information et de recherche parlementaires, Bibliothèque du Parlement :

Sonya Norris et Dillan Theckedath, analystes

Greffière du comité :

Shaila Anwar

Direction des comités du Sénat :

Tracy Amendola, adjointe administrative

INTRODUCTION

Le 25 octobre 2016, le Sénat a adopté un ordre de renvoi autorisant le Comité sénatorial permanent des affaires sociales, des sciences et de la technologie (le comité) à « étudier, en vue d'en faire rapport, le rôle de l'automatisation dans le système de soins de santé, plus particulièrement la robotique, l'intelligence artificielle et l'impression en 3D ». Entre le 1er février et le 15 mai 2017, le comité a tenu 12 réunions, effectué deux visites sur place et entendu plusieurs témoins, dont des chercheurs, des bailleurs de fonds de la recherche, des éthiciens, des entrepreneurs et des fournisseurs de soins de santé.

Le sénateur Kelvin Kenneth Ogilvie (président), tient un cœur imprimé en 3D du Service d'imagerie médicale du département de radiologie du campus général de l'hôpital d'Ottawa.
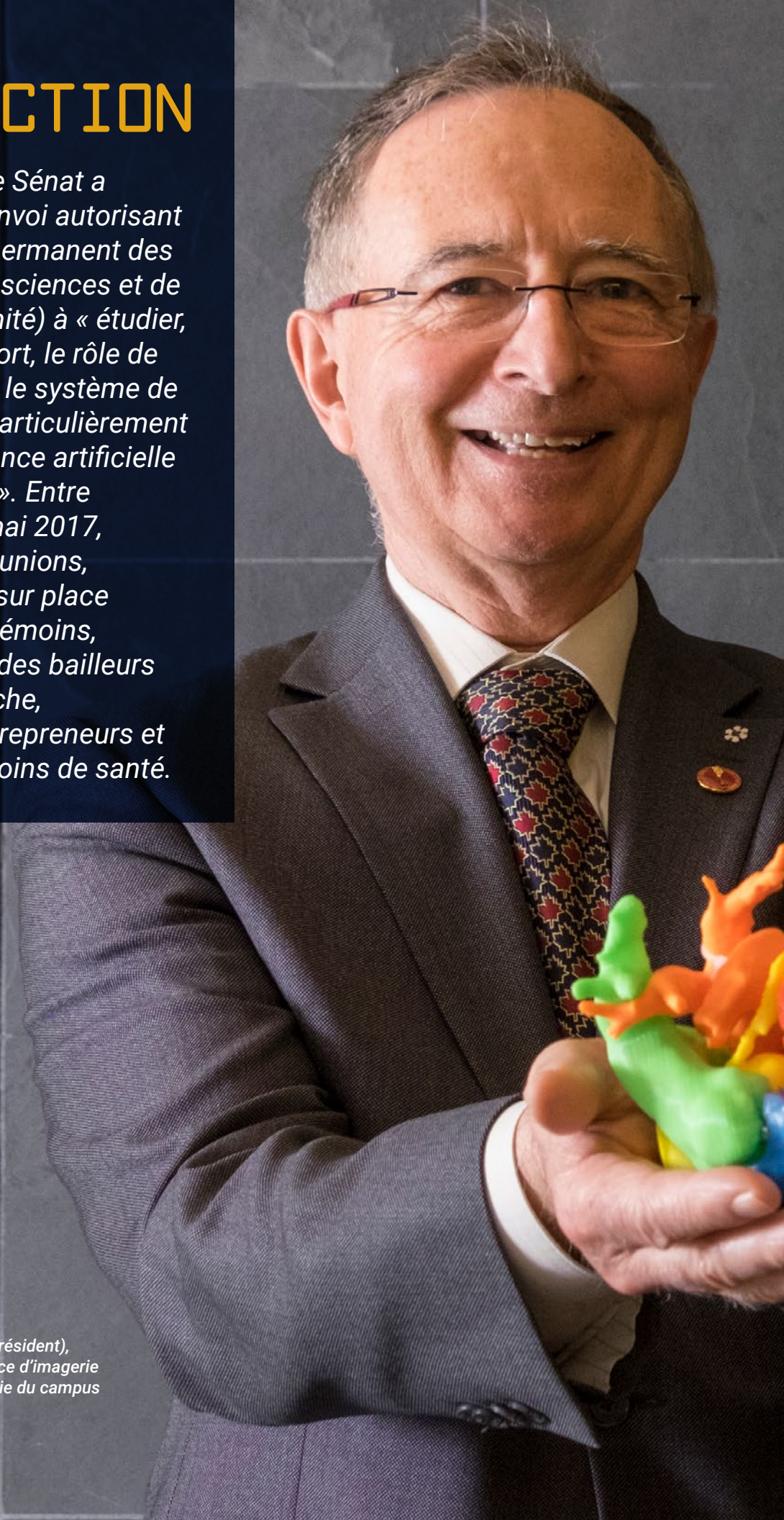
CONTEXTE

Selon les estimations de l'Institut canadien d'information sur la santé (ICIS), les dépenses de santé annuelles totales du Canada devaient atteindre 228 milliards de dollars en 2016 et afficher un taux de croissance de 2,7 %[1]. Les dépenses de santé comprennent à la fois les fonds publics et les fonds privés, les fonds publics représentant environ 70 % des dépenses totales de santé depuis de nombreuses années[2]. Le rapport de l'ICIS souligne également que la hausse des dépenses de santé au cours des dernières années soutient tout juste le rythme de l'inflation et de la croissance de la population, ce qui fait craindre pour la viabilité du système de soins de santé canadien[3].

Au fil des ans, le Comité sénatorial permanent des affaires sociales, des sciences et de la technologie (ce comité) a produit des rapports sur la santé et les soins de santé dans notre pays. Ces rapports ont récemment porté sur :

- la nécessité que les systèmes canadiens de soins de santé s'adaptent et innovent pour assurer leur viabilité[4];

- la complexité de soigner des personnes atteintes de maladies chroniques, en partie évitables grâce à un mode de vie sain[5];

- les besoins croissants de la population vieillissante, particulièrement des personnes atteintes de démence[6].

C'est donc dans le contexte de ses études antérieures, qui visaient à trouver des solutions pour bâtir un Canada en meilleure santé, et de l'essor au cours des dernières années des innovations automatisées applicables à la santé et aux soins de santé, que le comité a entrepris son étude sur le rôle de l'automatisation dans le système des soins de santé.

1 Institut canadien d'information sur la santé (ICIS), **Tendances des dépenses nationales de santé**, 1975 à 2016, 2016, p. 7.

2 *Ibid.*, p. 13.

3 *Ibid.*, p. 9.

4 Sénat, Comité permanent des affaires sociales, des sciences et de la technologie, **Un changement transformateur s'impose : Un examen de l'Accord sur la santé de 2004**, septième rapport, 1re session, 41e législature, mars 2012.

5 Sénat, Comité permanent des affaires sociales, des sciences et de la technologie, **L'obésité au Canada : Une approche pansociétale pour un Canada en meilleure santé**, deuxième rapport, 1re session, 42e législature, mars 2016.

6 Sénat, Comité permanent des affaires sociales, des sciences et de la technologie, **La démence au Canada : Une stratégie nationale pour un Canada sensible aux besoins des personnes atteintes de démence**, sixième rapport, 1re session, 42e législature, novembre 2016.

DÉFI EN VUE : INTÉGRER LES TECHNOLOGIES DE LA ROBOTIQUE, DE L'INTELLIGENCE ARTIFICIELLE ET DE L'IMPRESSION EN 3D DANS LES SYSTÈMES CANADIENS DE SOINS DE SANTÉ

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INFORMATIONS GÉNÉRALES

Le terme « automatisation » fait référence à de nombreuses technologies et peut par conséquent s'appliquer à un vaste éventail d'innovations. L'ordre de renvoi d'une étude sur le rôle de l'automatisation dans le système des soins de santé a obligé le comité à se concentrer sur la robotique, l'intelligence artificielle (IA) et l'impression en 3D afin de réduire la portée de l'étude. Le comité n'avait pas l'intention d'examiner trop en profondeur les aspects scientifiques de ces trois domaines, qui peuvent facilement devenir trop techniques pour les visées de la présente étude. Les témoins ont plutôt présenté le contexte général de ces technologies afin de permettre aux membres de comprendre leur travail et leurs objectifs.

LA ROBOTIQUE

La robotique fait intervenir l'intégration de la saisie d'information dans l'action physique. Cela peut faire appel à l'IA, de sorte que la robotique et l'IA se chevauchent souvent. En santé, les robots sont utilisés en pharmacie et dans les laboratoires, les chirurgies et l'assistance opératoire, les exosquelettes, la rééducation par la thérapie physique, l'aide aux personnes âgées ou ayant de la difficulté à accomplir certaines tâches de la vie quotidienne ainsi que l'aide destinée à prévenir ou à traiter le déclin cognitif [7]. La technologie robotique peut également faire appel à l'innovation de la téléprésence, de sorte que les robots deviennent un outil important dans la prestation des soins de santé dans les régions rurales et éloignées.

L'INTELLIGENCE ARTIFICIELLE

L'origine du terme « intelligence artificielle » remonte à 1956 et fait référence à la reproduction des fonctions cognitives humaines, comme la résolution de problèmes, le raisonnement, la compréhension ou la reconnaissance, par des moyens artificiels, particulièrement par ordinateur. Parmi les applications de l'IA, il y a les jeux, la reconnaissance vocale, la compréhension des langues et la classification heuristique (résolution de problèmes avec des systèmes experts) [8]. Les travaux en IA remontent aux années 1960, mais les avancées dans la capacité informatique, le développement des ordinateurs personnels et l'Internet ont suscité un regain d'intérêt pour l'IA dans les années 1990. Parmi les applications de l'IA dans la médecine, il y a les systèmes experts d'information de laboratoire servant à interpréter notamment l'imagerie diagnostique et les analyses

> *L'intelligence artificielle est de l'intelligence artificielle seulement jusqu'à ce qu'une certaine masse critique comprenne son fonctionnement. Ce n'est alors qu'un programme informatique, rien d'autre.*
>
> - Daniel Silver, directeur, Institut Acadia d'analytique des données, Université Acadia

sanguines, ainsi que les systèmes d'apprentissage en profondeur qui permettent aux ordinateurs de tirer des leçons des expériences.

La robotique et l'IA se recoupent considérablement. En effet, le degré d'autonomie d'un robot, c'est-à-dire le degré auquel le robot a besoin de l'intervention humaine, est directement lié à son intégration de l'IA.

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7   Russell H. Taylor, « **A Perspective on Medical Robotics** », Proceedings of the Institute of Electrical and Electronic Engineers (IEEE), vol. 94, no 9, septembre 2006.

8   Jameela Ali Akrimi et coll., « Review of Artificial Intelligence », International Journal of Science and Research, vol. 2, no 2, 2013, p. 487-505.
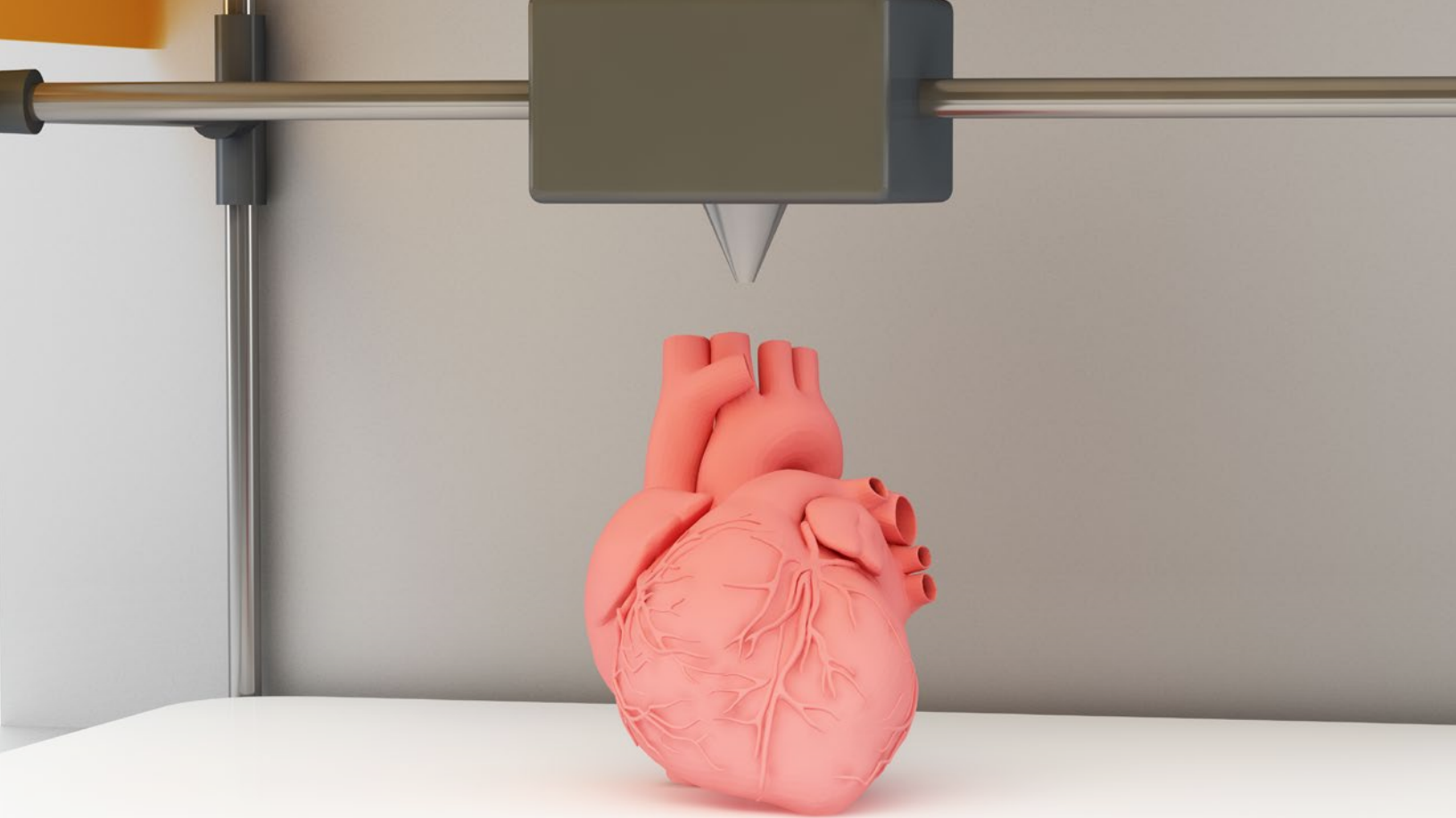
L'IMPRESSION EN 3D

L'impression en 3D consiste à produire plusieurs couches successives les unes sur les autres afin de fabriquer un objet en trois dimensions. Un autre terme utilisé pour décrire l'impression en 3D est « fabrication additive », qui pourrait évoquer plus exactement le processus. Ce dernier utilise divers matériaux, dont des plastiques, des métaux et du biomatériau, à savoir des cellules. La technologie d'impression en 3D a évolué depuis son invention en 1980, au point où il est maintenant économique d'y faire appel pour produire des objets à petite échelle et des solutions sur mesure.

L'imagerie médicale a elle aussi évolué, passant de la création d'images en 2D à des images en 3D. Cependant, avant, la visualisation des images en 3D ne pouvait se faire qu'avec des écrans plats et des imprimantes en 2D. Le développement de l'imagerie en 3D, notamment avec la tomographie par ordinateur et l'imagerie par résonance magnétique, combiné à la technologie d'impression en 3D, permet maintenant la production d'objets en 3D.

Même si, au départ, la technologie était utilisée en génie pour produire des prototypes, les applications de l'impression en 3D en médecine sont nombreuses, notamment la fabrication de prototypes pour la planification chirurgicale; la conception d'implants; la fabrication de prothèses et d'orthèses; la régénération des tissus et des organes; la fabrication d'instruments chirurgicaux et médicaux; et l'avancement de la recherche, de la formation et de l'enseignement dans le domaine de la médecine [9].

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9 F. Rengier et coll., « **3D printing based on imaging data: review of medical applications** », International Journal of Computer-Assisted Radiology and Surgery, vol. 5, 2010, p. 335-341.

LE RÔLE DU GOUVERNEMENT FÉDÉRAL

Le gouvernement fédéral est responsable des soins de santé de certains groupes de population [10], mais la prestation des services de santé relève principalement des provinces et des territoires. Toutefois, le gouvernement fédéral a recours à son pouvoir en matière de droit pénal pour légiférer dans un certain nombre de domaines liés à la santé et à la sécurité [11].

La *Loi sur les aliments et drogues* (la *Loi)* est un exemple de l'application du pouvoir en matière pénale auquel a recours le gouvernement fédéral pour s'assurer de l'innocuité des aliments, des médicaments, des instruments médicaux et des cosmétiques [12]. Conformément à la *Loi, le Règlement sur les instruments médicaux* (le *Règlement*) établit les exigences de l'approbation et de l'homologation de la vente des instruments médicaux au Canada [13]. En vertu de la *Loi* et du *Règlement*, un instrument médical s'entend de tout instrument, appareil, dispositif ou article, ou toute partie de l'un ou l'autre de ceux-ci, pouvant servir au diagnostic, au traitement ou à la prévention d'un trouble, ou utilisé pour la restauration, la correction ou la modification d'une structure corporelle d'un être humain ou de son fonctionnement. Le *Règlement* prévoit un cadre fondé sur les risques et établit des critères d'évaluation des instruments médicaux selon leur caractère effractif ou le risque potentiel qu'ils peuvent poser; c'est à-dire les instruments de classe I, comme les thermomètres, qui posent un risque minime, jusqu'aux instruments de classe IV, comme les simulateurs cardiaques. Bon nombre des innovations examinées durant la présente étude seraient réglementées en tant qu'instruments médicaux par Santé Canada.

Aux termes du *Règlement*, les instruments médicaux de classe I n'ont pas besoin d'être approuvés en vue d'une licence de produit, mais une licence d'établissement est requise pour leurs fabricants, importateurs et distributeurs. Les instruments médicaux de classes II, III et IV doivent être approuvés par le Ministère et une licence de produit est nécessaire de même que, comme pour les instruments de classe I, une licence d'établissement.

Le pouvoir fédéral de dépenser est également utilisé dans divers domaines de la santé. Le gouvernement fédéral y a recours pour financer la recherche en santé par l'intermédiaire de ses organismes subventionnaires de la recherche (les Instituts de recherche en santé du Canada [IRSC], le Conseil de recherches en sciences naturelles et en génie du Canada [CRSNG] et le Conseil de recherches en sciences humaines [CRSH]) et pour financer directement la recherche menée au Conseil national de recherches du Canada.

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10 Le gouvernement fédéral est responsable de veiller à la prestation de services de soins de santé aux populations autochtones et inuites, au personnel des Forces canadiennes, aux anciens combattants, aux détenus sous responsabilité fédérale et aux demandeurs du statut de réfugié.

11 Martha Butler et Marlisa Tiedemann, **Le rôle fédéral dans le domaine de la santé et des soins de santé**, publication no 2011-91-F, Service d'information et de recherche parlementaires, Bibliothèque du Parlement, Ottawa, 20 septembre 2013.

12 **Loi sur les aliments et drogues**, L.R.C., 1985, ch. F-27.

13 **Règlement sur les instruments médicaux**, DORS/98-282

DÉFI EN VUE : INTÉGRER LES TECHNOLOGIES DE LA ROBOTIQUE, DE L'INTELLIGENCE ARTIFICIELLE ET DE L'IMPRESSION EN 3D DANS LES SYSTÈMES CANADIENS DE SOINS DE SANTÉ

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PROGRÈS IMPORTANTS POUR L'AVENIR DES SOINS DE SANTÉ

Le comité a invité deux futurologues à témoigner sur le rôle des technologies novatrices, particulièrement la robotique, l'IA et l'impression en 3D, dans l'avenir des soins de santé. Bertalan Mesko, futurologue médical, et Abishur Prakash, futurologue géopolitique du Centre for Innovating the Future, ont parlé avec enthousiasme du potentiel de ces nouvelles approches. La plupart des témoignages offerts par les témoins subséquents ont confirmé l'avenir prometteur décrit par les futurologues.

Conception d'interactions humain-ordinateur pour le « jumeau numérique » créé au laboratoire de recherche en communications multimédias (MCRLab) de l'Université d'Ottawa.

LES INVESTISSEMENTS FÉDÉRAUX DANS LA RECHERCHE NOVATRICE

La plupart des innovations présentées au comité durant l'étude bénéficient d'un financement public au Canada ainsi que d'investissements du secteur privé. Pour ce qui est du financement fédéral, le comité a appris que les IRSC fournissent des fonds pour l'éventail complet des recherches en santé ainsi que de l'aide pour commercialiser ces innovations. Jane Aubin, chef des affaires scientifiques et vice présidente à la recherche, à l'application des connaissances et à l'éthique aux IRSC, a fait savoir que l'organisme a investi dans chacune des technologies décrites plus haut, que ce soit directement auprès des chercheurs ou indirectement par son appui, conjointement avec le CRSNG et le CRSH, aux réseaux des centres d'excellence et au programme de chaires de recherche du Canada, représentés par de nombreux témoins tout au long de l'étude.

Bettina Hamelin, vice-présidente, Direction des partenariats de recherche au CRSNG, a indiqué dans son témoignage que l'organisme finance la recherche fondamentale ainsi que les partenariats en recherche novatrice. Elle a souligné le soutien du CRSNG à la recherche, comme la robotique de réadaptation dans le traitement post-AVC ou d'une infirmité motrice cérébrale, l'utilisation de l'IA dans les « maisons intelligentes » pour vieillir chez soi et l'impression en 3D avec des encres biologiques pour l'ingénierie tissulaire. Toutefois, elle a indiqué que le budget du CRSNG n'a pas augmenté depuis plusieurs années, en dépit des coûts croissants de la recherche.

Enfin, le comité a entendu les témoignages de Roman Szumski et de Robert Diraddo du CNRC, qui ont expliqué que le Programme d'aide à la recherche industrielle (PARI) du CNRC offre des services de soutien à l'innovation et des services de financement pour aider les innovateurs à commercialiser leurs produits.

Plusieurs des chercheurs et organisations mentionnés par ces organismes publics ont comparu devant le comité pour décrire leurs travaux fascinants. Bien qu'ils aient dit appuyer la participation des organismes dans le financement de la recherche en robotique, en IA et en impression en 3D, plusieurs témoins ont fait valoir que les organismes de financement de la recherche ne sont pas bien positionnés pour collaborer les uns avec les autres. Les RCE constituent un bon modèle de collaboration, mais on a indiqué aux membres que l'amélioration et l'expansion des partenariats entre les organismes de financement permettraient d'accélérer le rythme des innovations et d'encourager l'échange d'idées et de progrès.

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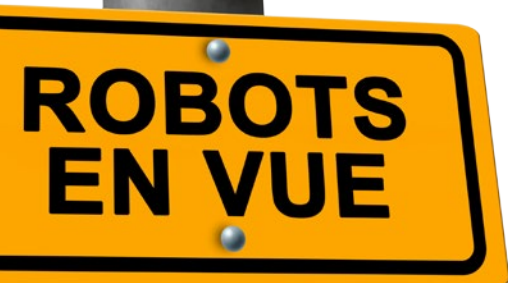
> *Il est important de soutenir et de développer cette innovation robotique au Canada dans les milieux universitaires, industriels et cliniques. […] Nous disposons déjà des spécialistes, de l'expertise et de la motivation nécessaires pour réussir dans ce domaine de la robotique.*
>
> - Goldie Nejat, directrice, Institut de robotique et de mécatronique, Université de Toronto

> *Tangy, l'une des créations de Goldie Nejat, est un robot d'assistance sociale conçu pour faciliter les activités récréatives et promouvoir l'interaction sociale entre des personnes atteintes d'une diminution des capacités cognitives, telles que celles vivant avec la démence.*

LA ROBOTIQUE

Au cours de l'étude, les membres du comité se sont sentis privilégiés d'entendre certains chefs de file canadiens en matière de recherche novatrice sur la robotique. La robotique est un domaine de recherche dynamique partout au Canada, et l'éventail des applications dans le domaine des soins de santé est vaste. Goldie Nejat, directrice de l'Institut de robotique et de mécatronique à l'Université de Toronto et titulaire de la chaire de recherche du Canada sur les robots dans la société, a parlé de ses travaux sur la robotique d'assistance, qui est un exemple de la façon dont certains services de santé à domicile peuvent être offerts grâce à cette technologie novatrice. Elle a expliqué que les robots peuvent être utilisés dans le domaine des soins aux personnes âgées, à la maison et dans des centres et résidences pour aînés. En tant qu'outil pour promouvoir le vieillissement chez soi, les robots permettent de réduire le fardeau de travail des aidants officiels et officieux tout en prodiguant des soins axés sur la personne et adaptés à chaque utilisateur. La D^re Nejat a décrit des robots qui peuvent aider des personnes à réaliser les activités de la vie quotidienne, comme faire leur toilette, se vêtir et préparer des repas, et qui interagissent afin de stimuler les fonctions cognitives et d'accompagner ces personnes. Le comité a appris que cette catégorie de robots, c'est-à-dire les robots d'assistance personnelle, se retrouvera dans des maisons privées en nombre important dans les cinq à 10 prochaines années puisque l'industrie tente d'abaisser leur coût à 5 000 $ ou moins.

NeuroArm, *robot neurochirurgical guidé par l'image mis au point par Garnette Sutherland, est contrôlé par le chirurgien depuis un poste de travail à proximité.*

© Project neuroArm, Université de Calgary, Calgary Canada

Le Dr Sutherland exécute une intervention neurochirurgicale à l'aide du NeuroArm.

Garnette Sutherland, professeur de neurochirurgie à l'Université de Calgary, a renseigné le comité sur le rôle de la robotique dans les soins directs aux patients, en l'occurrence la chirurgie. Le Dr Sutherland a expliqué que la robotique, notamment lorsqu'elle est combinée à la technologie d'imagerie, révolutionne les techniques de chirurgie. Il a comparé l'importance de la robotique chirurgicale guidée par l'image aux avancées faites à la fin des années 1980 et au début des années 1990, lorsque de nombreuses interventions chirurgicales sont devenues moins invasives grâce à la mise au point de l'approche laparoscopique. Les membres du comité ont appris que la technologie mécanique, au moyen de la tomodensitométrie et de l'imagerie par résonance magnétique ainsi que de la technologie GPS pour localiser une cible, est plus précise que la coordination œil-main humaine du chirurgien. Le Dr Sutherland a expliqué qu'il se trouve à quelques pieds seulement du robot guidé par l'image qui

l'assiste dans l'exécution d'une neurochirurgie, mais le comité a également appris que cette approche de la robotique chirurgicale diffère très peu de la chirurgie télérobotique, qui permet l'exécution de gestes chirurgicaux en milieu rural ou éloigné.
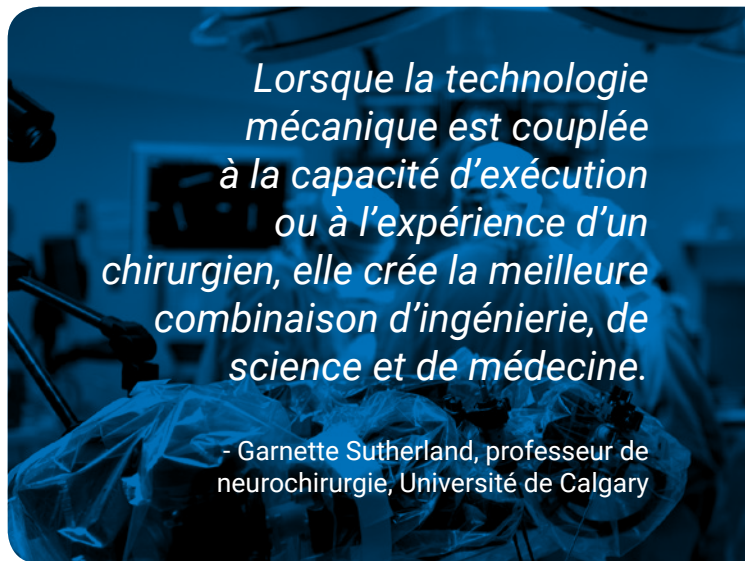
Lorsque la technologie mécanique est couplée à la capacité d'exécution ou à l'expérience d'un chirurgien, elle crée la meilleure combinaison d'ingénierie, de science et de médecine.

- Garnette Sutherland, professeur de neurochirurgie, Université de Calgary

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D'autres technologies robotiques ont dépassé la phase de recherche et ont été approuvées pour être utilisées au Canada. Ivar Mendez, président du département de chirurgie de l'Université de Saskatchewan, a décrit ses travaux en télérobotique, également appelée « téléprésence robotique ». Le Dr Mendez a parlé des difficultés à fournir des soins de santé dans les localités rurales et éloignées du Canada, dont les résidents forment environ 20 % de la population totale canadienne. Plus particulièrement, il a parlé du coût élevé lié au transport des personnes depuis les régions rurales et éloignées vers les centres urbains pour y subir des examens, des tests, des traitements et des interventions chirurgicales. Le Dr Mendez dispose de plusieurs robots de téléprésence

Rosie est un système de robotique à distance qu'utilise Ivar Mendez pour traiter des patients dans des régions rurales ou éloignées de la Saskatchewan.

© Department of Surgery, University of Saskatchewan

à divers endroits en Saskatchewan. Ces systèmes peuvent être activés à distance par un médecin. Le Dr Mendez a expliqué qu'il peut conduire le robot à distance et l'amener à l'infirmerie, puis à la chambre du patient pour l'interroger et l'examiner avec l'aide d'un travailleur de la santé, en attachant de l'équipement périphérique au robot comme de l'équipement ultrason ou un électrocardiogramme. Cette innovation permet à un spécialiste d'examiner des patients, de poser des diagnostics et, éventuellement, d'administrer des traitements à distance, ce qui permet d'économiser le coût du transport vers les centres urbains et d'éviter le dérangement. Le Dr Mendez a souligné que sa technologie de téléprésence représente un important outil qui permettra d'améliorer l'accès aux soins de santé dans les régions rurales ou éloignées, mais le comité note que cette

*Robot de téléprésence et Dr Ivar Mendez.
Cette technologie est utilisée pour fournir l'accès aux soins de santé aux communautés nordiques de la province de la Saskatchewan.*

application nécessite un accès fiable à une connexion haute vitesse pour fonctionner. À cet égard, le comité attire l'attention sur l'investissement de 500 millions de dollars à l'appui de l'expansion des réseaux à large bande dans les régions rurales du Canada annoncé dans le budget fédéral de 2017 [14]. Toutefois, étant donné que ce type de service devient rapidement essentiel à l'accès aux soins de santé et à leur prestation, le comité craint que, à moins de progrès rapides, les Canadiens vivant à l'extérieur des grands centres continuent d'accuser du retard sur le plan de l'accès aux soins de santé. Enfin, on a fait valoir aux membres qu'on pourrait inciter les médecins à adopter cette technologie en leur offrant la même compensation que s'ils offraient une consultation ou un examen en personne.

> *Nous avons utilisé la technologie de pointe des robots de téléprésence pour déterminer si elle peut servir d'outil pour améliorer l'accès des collectivités moins bien desservies, mais qui ont les plus grands besoins.*
>
> - Ivar Mendez, président du département de chirurgie, Université de Saskatchewan

Charles Deguire, cofondateur et président de Kinova Robotics, a conçu et mis au point des bras robotisés installés à des fauteuils roulants électriques qui permettent d'effectuer des tâches routinières, ce qui décharge les fournisseurs de soins de santé de certaines responsabilités et offre aux personnes en fauteuil roulant une autonomie accrue. Cette innovation utilise les commandes du fauteuil, qu'il s'agisse d'un levier de commande, d'une commande au menton ou à la tête ou qui fonctionne avec les yeux, d'un contacteur au souffle ou d'une interface cerveau-machine. M. Deguire a fait remarquer que, aux Pays Bas, où le bras robotisé pour fauteuil roulant conçu par Kinova a été intégré au système de soins de santé public et a permis de réduire le besoin de soignants à domicile, il n'a fallu que deux ans pour obtenir un rendement sur les investissements.

Enfin, les membres ont entendu parler du premier hôpital complètement numérique en Amérique du Nord, l'hôpital Humber River à Toronto, qui a ouvert ses portes en octobre 2015. Barbara Collins, présidente et chef de la direction de l'hôpital, a expliqué que l'établissement a

> *JACO, mis au point par Kinova Robotics, est un bras d'assistance robotisé qu'on utilise au moyen des commandes d'un fauteuil roulant.*

© Kinova Robotics

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14   Gouvernement du Canada, Bâtir une classe moyenne forte, 22 mars 2017, p. 122.

intégré un bon nombre de systèmes robotisés afin de réaliser des tâches relatives à la médication. Par exemple, certains robots peuvent préparer les médicaments des patients en doses unitaires, d'autres peuvent apporter de façon automatisée les médicaments, et d'autres encore ont des responsabilités de gestion des fournitures de l'hôpital. Les membres ont également appris que tous les renseignements sont sous forme électronique à l'hôpital Humber River, ce qui permet d'avoir des données exploitables. Cette approche ouvre la voie à l'établissement d'un centre de commandement où toutes les opérations seront regroupées, ce qui permettra, grâce à l'analyse prédictive (IA), d'optimiser la circulation des patients, de minimiser les erreurs et d'optimiser les résultats des patients. Mme Collins a dit que le nouvel hôpital numérique a permis d'améliorer la satisfaction des patients de 20 %, de diminuer les erreurs liées à la médication et de réduire la durée des séjours à l'hôpital.

Globalement, le Comité s'est fait dire que la robotique, bien qu'il s'agisse d'une technologie coûteuse à mettre au point, entraînera des économies. La robotique chirurgicale étant plus précise et moins invasive que la chirurgie traditionnelle, elle permet de réduire les séjours à l'hôpital. La chirurgie à distance et la télérobotique réduisent les coûts de déplacement. La robotique d'assistance dans les soins à domicile peut être moins coûteuse que les soins à l'hôpital. Les témoins ont également convenu que le coût de la technologie robotique diminue depuis les dernières années et qu'il devrait continuer à baisser.

> *[L']hôpital de l'avenir est un endroit où l'on fournit des soins actifs et des soins intensifs, mais nous devrions éviter le plus possible aux gens de devoir aller à l'hôpital.*
>
> - Barbara Collins, présidente, hôpital Humber River

De gauche à droite : Les sénateurs Art Eggleton (vice-président), Marie-Françoise Mégie et Kelvin Kenneth Ogilvie (président) ont rencontré des spécialistes au campus général de l'hôpital d'Ottawa en mai 2017.

L'INTELLIGENCE ARTIFICIELLE

L'intelligence artificielle, comme l'évoque le terme, a pour but de reproduire la pensée humaine, et la plus grande partie du champ de la robotique décrit plus haut repose sur un certain niveau d'IA. Le principal type de recherche en IA menée au Canada depuis des années porte sur les « réseaux neuronaux » ou l'« apprentissage en profondeur ». On a expliqué aux membres que cet aspect de l'IA consiste simplement à appliquer à des modèles informatiques (réseaux neuronaux artificiels) le mode d'apprentissage du cerveau humain (réseaux neuronaux naturels). L'apprentissage en profondeur applique par conséquent un modèle mathématique, ou numérique, qui imite le processus biologique ou physiologique des neurones (cellules nerveuses), qui forment des synapses (jonctions entre les neurones) lorsqu'on apprend.

Les membres du comité ont appris que l'IA est un secteur de recherche très actif au Canada. Subbarao Kambhampati, de l'Association for the Advancement of Artificial Intelligence, a dit au comité que le Canada a continué d'investir dans la recherche sur l'IA au cours des premières années de la technologie, et en particulier dans l'apprentissage en profondeur, après que d'autres pays eurent abandonné ce domaine. Le comité a appris que l'appui continu du Canada à la recherche fondamentale au cours des premières années de l'IA, particulièrement à l'Institut canadien de recherches avancées (ICRA), s'est traduit par une forte concentration de candidats au doctorat dans le domaine ainsi que par la création d'excellents laboratoires de recherche en IA à Montréal et à Toronto. Ce domaine de recherche progresse en importance, et il est maintenant reconnu que, pour développer l'IA, il faut imiter la fonction cérébrale, qui constitue l'objectif de l'apprentissage en profondeur. Bien que d'autres pays se soient de nouveau engagés à cet égard, les chercheurs canadiens ont une longueur d'avance. Par conséquent, a suggéré M. Kambhampati, le Canada mérite de récolter les fruits des applications novatrices de l'IA.

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Les membres du comité se sont fait dire que l'apprentissage en profondeur transformera la médecine. Daniel Silver, directeur de l'Institut d'analytique des données de l'Université Acadia, a expliqué que l'IA a, et aura, des applications dans : les soins directs aux patients afin d'améliorer la prise de décisions relatives aux diagnostics, les pronostics, le choix des méthodes thérapeutiques et l'exécution de chirurgies et d'examens robotisés; les soins indirects aux patients tels que l'optimisation du déroulement des opérations et une meilleure gestion des stocks à l'hôpital; ainsi que des applications dans les soins à domicile, où des appareils portables et des capteurs serviront à évaluer et à prédire les besoins des patients.

En somme, lorsque vous apprenez quelque chose, vous apprenez essentiellement à prévoir [...]. L'apprentissage profond permet à un ordinateur de faire ce genre de prédictions, comme un être humain.

- Alan Bernstein, président, Institut canadien de recherches avancées

Des témoins ont expliqué que les recherches prometteuses sur l'IA se concentrent dans trois « carrefours de l'IA », c'est-à-dire Montréal, Toronto et Edmonton. Joelle Pineau, professeure au Centre des machines intelligentes de l'Université McGill, a parlé des « robots intelligents », où l'IA est un composant essentiel du robot. Elle a parlé du potentiel des robots dotés d'une intelligence artificielle pour interpréter un ensemble complexe de données sur un patient, déterminer une procédure à prendre et l'appliquer au patient. Elle a donné comme exemple le pancréas artificiel en cours de mise au point à l'Institut de recherches cliniques de Montréal. Ce robot peut calibrer la dose d'insuline qui doit être administrée en fonction de lectures en temps réel des taux de glycémie et de l'apport alimentaire du patient, de son niveau d'activité et de sa physiologie.

Le sénateur Ogilvie met à l'essai un stylo inspiré de la biologie, mécatronique et contrôlé par l'intelligence artificielle au laboratoire de robotique BioIn de l'Université d'Ottawa.
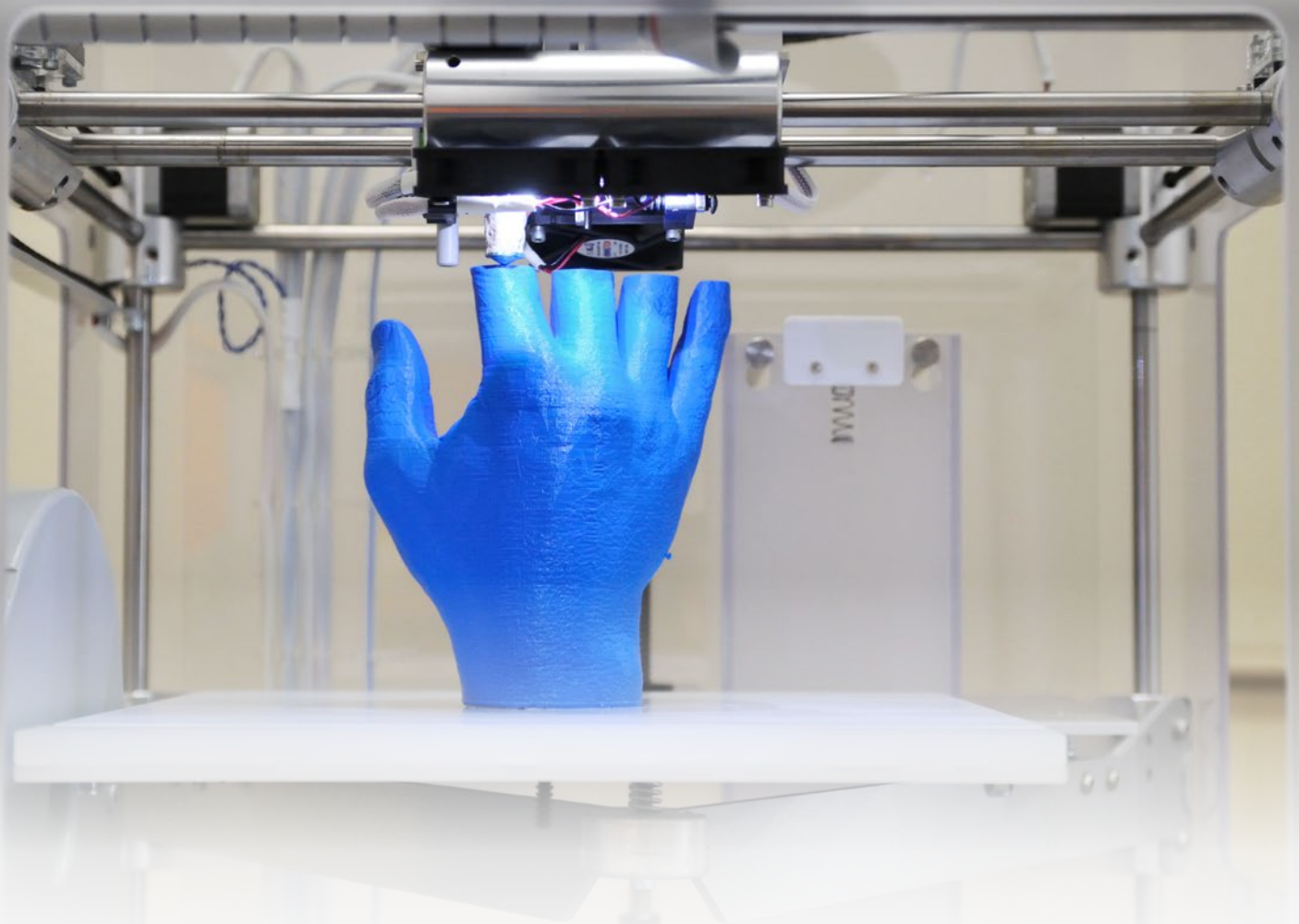
L'IMPRESSION EN 3D

L'impression en 3D, ou fabrication additive, est déjà une technologie importante dans le secteur des soins de santé. Matt Ratto, professeur agréé à la faculté de l'information de l'Université de Toronto, a présenté plusieurs exemples de prothèses et d'orthèses fabriquées au moyen de la fabrication additive. La technologie ne coûte pas cher et peut être appliquée dans des endroits éloignés disposant de ressources limitées. M. Ratto a expliqué que ces dispositifs peuvent être personnalisés à chaque utilisateur. Le fait que l'impression en 3D peut produire des dispositifs conçus expressément pour l'utilisateur serait la principale raison pour laquelle cette technologie est grandement intégrée à la fabrication d'appareils auditifs sur mesure. Les membres ont appris que plus de 10 millions d'appareils auditifs ont été fabriqués grâce à la fabrication additive.

Julielynn Wong, fondatrice de l'entreprise 3D4MD, a expliqué que cette technologie a plusieurs bienfaits. Elle a indiqué que la technologie sur laquelle repose la fabrication des imprimantes 3D a progressé au point où les imprimantes de bureau sont devenues choses courantes, leur prix n'ayant cessé de diminuer au fil des ans pour se situer entre 300 $ et 3000 $. De plus, le coût du plastique utilisé comme matériau d'impression ne coûte que quelques cents le gramme. La Dre Wong a fait valoir que l'impression en 3D est idéalement adaptée à la production d'appareils sur demande et personnalisés. Elle a fait une démonstration aux membres en utilisant une imprimante de bureau pour produire une attelle digitale personnalisée.

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Konrad Walus, professeur agrégé au département de génie électrique et informatique de l'Université de la Colombie-Britannique, a donné un aperçu d'une approche différente de l'impression en 3D – le génie tissulaire dans le cadre de la médecine régénérative. Dans le cas de ce type d'application, « l'encre » est un biomatériau, c'est-à-dire des cellules. Le Dr Walus a expliqué que l'imprimante dépose par couches des cellules, qui sont ensuite incubées pour reconstruire un tissu. Les cellules du tissu communiquent entre elles plutôt que d'exister en tant que simples cellules individuelles. De cette façon, un tissu pourrait être régénéré grâce à l'utilisation des cellules du patient, ce qui ne provoquerait pas de réponse immune et de rejet. Le Dr Walus a également décrit les récentes avancées dans la technologie de la bio impression qui, on l'espère, donnera lieu à l'impression en 3D d'implants au moyen d'une « encre » qui ressemble de très près aux substances trouvées dans les articulations, comme le cartilage et le ménisque du genou. Le Dr Walus a décrit au comité une autre application de la bio impression dans la mise au point de médicaments. Il a indiqué que la bio impression permet d'imprimer et de cultiver des tissus qui expriment certaines maladies. Le tissu ainsi fabriqué recevrait une dose d'un nouveau médicament afin qu'on surveille la réaction. Le Dr Walus a dit que ce modèle d'essai pourrait accélérer la mise au point de médicaments, accroître la sensibilité des essais précoces et réduire la nécessité d'effectuer des études sur les animaux.

VISITES À L'UNIVERSITÉ D'OTTAWA ET AU CAMPUS GÉNÉRAL DE L'HÔPITAL D'OTTAWA

Les membres ont eu l'occasion de visiter un laboratoire de recherche et un hôpital afin d'observer directement ces innovations. Ils ont visité un laboratoire de communication multimédia où des chercheurs de l'Université d'Ottawa ont fait la démonstration d'un logiciel de réalité virtuelle permettant la simulation d'une personne blessée comme instrument de formation médicale et de télémédecine. Les chercheurs ont également présenté des robots intelligents bio inspirés dotés de visages expressifs et de mains robotisées dont la « peau » peut « avoir des sensations » et réagir

à la pression et à la température. Une visite au campus général de l'hôpital d'Ottawa a permis aux membres d'examiner un vaste éventail d'objets imprimés en 3D et de voir la création d'un modèle de cœur en 3D sur l'imprimante 3D commerciale de l'hôpital. Les médecins ont décrit comment cette technologie leur permet de produire des objets pour planifier les interventions chirurgicales et les traitements, installer des implants, expliquer aux patients leur maladie et décrire des maladies rares aux résidents.

Les sénateurs René Cormier, Art Eggleton et Marie-Françoise Mégie interagissent avec un « jumeau numérique » conçu au laboratoire de recherche en communications multimédias (MCRLab) de l'Université d'Ottawa.

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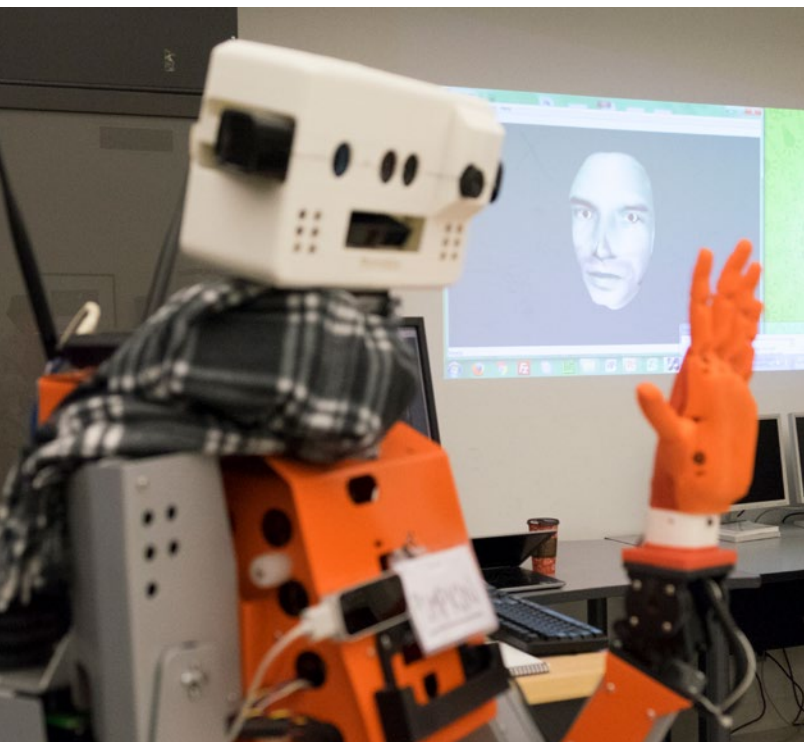
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COUP D'ŒIL SUR L'AVENIR

Comme il est mentionné au début de la présente section, le comité a entendu deux futurologues, qui ont non seulement ouvert la voie aux témoignages inspirants que le comité allait entendre, mais aussi donné un aperçu des soins de santé de l'avenir – advenant que le Canada prenne des mesures pour s'adapter aux nouvelles technologies. Ces témoins ont notamment prédit que la chance jouera un moins grand rôle dans la santé et les soins de santé d'une personne. Les membres se sont fait dire que, actuellement, la santé d'une personne repose sur la chance qu'elle a de reconnaître un symptôme à temps, de consulter un médecin et de recevoir le bon diagnostic ainsi que le bon traitement en temps

Le laboratoire de recherche en communications multimédias (MCRLab) de l'Université d'Ottawa.

opportun. Dans l'avenir, ces variables seront probablement minimisées grâce aux dispositifs portatifs et aux capteurs à domicile pour la reconnaissance des symptômes. L'information recueillie serait transmise immédiatement au fournisseur de soins, qui utiliserait un logiciel d'IA pour poser un diagnostic et proposer des options

de traitement. Ces innovations permettraient également de normaliser considérablement les procédures, ce qui permettrait d'appliquer les procédures des hôpitaux dans des cliniques établies dans la localité, par exemple dans des centres commerciaux.

Le comité s'est également fait dire que le type de travaux effectués par le Dr Walus, c'est-à-dire la bio impression pour produire des tissus vivants, progresseront au point de déboucher sur des systèmes complexes à vaisseaux sanguins et, finalement, sur des organes régénérés, pleinement fonctionnels, pour la transplantation. Enfin, à beaucoup plus long terme, des spécialistes envisagent l'émergence de chirurgiens robotisés totalement autonomes.

Les membres du comité sont impressionnés par les innovations qui leur ont été présentées au cours de l'étude, touchés par le degré d'ingéniosité et renversés par les répercussions potentielles que ces innovations de rupture sont susceptibles de produire sur le système de soins de santé. Bien entendu, aucune de ces avancées ne se concrétisera si le Canada ne s'adapte pas à ces innovations et ne les intègre pas avec succès dans les systèmes de soins de santé.

Cela dit, si ces technologies présentent un énorme potentiel, les membres du comité voient clairement qu'il faut tenir compte des conséquences non voulues de leur intégration dans les systèmes de soins de santé. Parmi les préoccupations soulevées, on compte des considérations éthiques, les répercussions sur l'emploi, la difficulté de commercialiser les innovations, la nécessité de réorienter la formation et l'éducation et la modification du cadre réglementaire visant les appareils médicaux. Pour bien réussir l'intégration de la robotique, de l'IA et de l'impression en 3D dans la prestation des soins de santé, le Canada doit donc relever des obstacles.

RESTER VIGILANT

Malgré les avantages potentiels de la robotique, de l'intelligence artificielle et de l'impression en 3D dans le domaine de la santé qu'ont décrits de nombreux témoins, on a souligné un certain nombre d'éléments dont il faut tenir compte et qu'il faut intégrer dans les plans à mesure que ces innovations s'implantent dans la société.

> *[L]es gens qui interagissent avec les robots ne les traitent souvent pas comme s'ils étaient une autre personne ni comme une machine distributrice [...] mais plutôt comme une espèce à mi-chemin entre l'être humain et la machine.*
>
> – AJung Moon, fondatrice, Open Roboethics Institute

CONSIDÉRATIONS LIÉES À L'ÉTHIQUE, À LA PROTECTION DES RENSEIGNEMENTS PERSONNELS ET À LA CONFIANCE

Les questions éthiques liées à l'intégration de ces technologies novatrices dans le secteur des soins de santé, ainsi que les questions de la protection des renseignements personnels et des facteurs de confiance, ont été abordées par de nombreux spécialistes qui ont comparu au cours de l'étude.

Si l'on veut assurer l'intégration de ces innovations dans le système de soins de santé, tant les professionnels de la santé que les patients doivent avoir confiance envers les nouvelles technologies. L'un des facteurs de confiance dont il faut tenir compte consiste à déterminer si ces nouvelles technologies amélioreront les soins de santé, que ce soit par une innocuité accrue des traitements, l'amélioration de l'efficacité des services ou la réduction des coûts. Un autre facteur de confiance consiste à garantir la protection des renseignements personnels.

Les membres du comité ont appris que le recours à l'intelligence artificielle (IA) lors du diagnostic donne des résultats à tout le moins équivalents aux diagnostics rendus par un médecin seul et que, dans bien des cas, les diagnostics assistés ont des résultats plus fiables. Par exemple, Alan Bernstein, président de l'Institut canadien de recherches avancées (ICRA), a présenté des données montrant que l'IA est plus efficace que les spécialistes des soins de santé dans le diagnostic et la classification du cancer de la peau et du sein ainsi que d'autres maladies. De manière semblable, on considère les chirurgies assistées par robot plus sécuritaires, moins invasives et plus précises que les chirurgies conventionnelles. En outre, les membres ont appris que la chirurgie assistée par robot réduit l'effort et la fatigue des chirurgiens, et que l'on remarque les mêmes effets chez les aidants dans les soins à domicile assistés par robot.

En ce qui concerne la protection des renseignements personnels, la discussion a surtout porté sur le recours à l'IA puisqu'il s'agit d'une technologie qui dépend d'une vaste quantité de données sur les patients. Il est possible que

les robots d'assistance utilisés dans les soins à domicile ou les soins aux personnes âgées soient appelés à surveiller en permanence les patients qu'ils doivent évaluer conformément à leur programmation, ce qui signifie qu'une immense quantité de données est susceptible d'être générée. AJung Moon, fondatrice de l'Open Roboethics Institute, qui a décrit les robots comme la réalisation matérielle de l'IA, a fait valoir que le concept traditionnel de la protection des renseignements personnels pourrait ne pas s'appliquer dans le contexte de ces nouvelles technologies. D'autres témoins ont fait valoir que l'IA dépend des données sur les patients et que plus il y a de données disponibles, mieux elle fonctionnera. À ce sujet, des témoins ont indiqué qu'il est nécessaire d'obtenir la permission avant d'utiliser les données des patients et que celles-ci doivent être chiffrées et rendues anonymes avant d'être intégrées aux algorithmes d'apprentissage profond qui serviront à une foule d'applications.

Enfin, il a été question du déploiement de l'IA de manière éthique afin de séparer les avantages sociétaux des préjudices sociétaux. Les membres ont appris que l'on aborde de façon proactive les questions éthiques entourant ces technologies novatrices. Par exemple, l'Institute of Electric and Electronic Engineers (IEEE), un organisme professionnel qui comprend un volet de normalisation internationale, a lancé en 2016 une initiative nommée « Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems » (initiative mondiale pour les considérations éthiques liées à l'intelligence artificielle et aux systèmes autonomes) afin d'établir des lignes directrices d'ordre éthique. Le comité a appris que les efforts visant à régler les questions éthiques découlant de ces technologies en sont encore à leurs débuts, mais il est encouragé de constater que l'IEEE a mis en place un programme si exhaustif.

Les robots autonomes, c'est-à-dire ceux pouvant fonctionner sans intervention humaine, ont été décrits comme une technologie peut-être éthiquement inacceptable puisqu'ils risqueraient d'éliminer le pouvoir décisionnel des patients et de leurs médecins. En ce qui concerne les robots semi-autonomes, les limites éthiques concernent principalement la quantité et le type de données introduites dans l'algorithme. Prenons l'exemple d'un algorithme pouvant prédire la mort d'un patient cardiaque. Ce type de pronostic peut également être rendu par le spécialiste et n'est pas considéré en soi comme contraire à l'éthique. Cependant, ce genre de prédiction doit toujours respecter les intérêts du patient, notamment lorsqu'on lui présente les solutions de gestion des soins.

Pour de nombreux témoins, la question revient à ceci : si les professionnels des soins de santé et les patients se retrouvent avec des options qui leur offrent de meilleurs résultats, ils accueilleront les nouvelles technologies. Il revient néanmoins à tous les intervenants de tenir compte des considérations éthiques à mesure que les technologies s'intègrent aux services de soins de santé.

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LES EFFETS SUR L'EMPLOI

Le comité a appris que l'automatisation devrait se traduire par des pertes considérables d'emplois au cours des prochaines années. On a indiqué aux membres que, bien que les projections varient d'un pays à l'autre, 42 % des emplois au Canada (ou 7,5 millions d'emplois) sont susceptibles d'être automatisés. Par conséquent, on a abordé à de nombreuses reprises au cours de l'étude les effets néfastes que pourraient avoir ces nouvelles technologies sur le secteur des soins de santé.

Quelques témoins ont fait valoir au comité que des pertes d'emploi pourraient découler de ces innovations, mais la plupart des témoins se sont dit d'avis que de nouveaux emplois seront créés. Par exemple, Reinhard Lafrenz, secrétaire général, euRobotics, est d'avis que la nouvelle économie du savoir engendrera un grand nombre de nouveaux débouchés. D'autres témoins ont indiqué que les emplois actuels seraient modifiés et améliorés de manière à permettre l'intégration de l'automatisation. Certains témoins, comme le Dr Christopher Schlachta, directeur médical à la Canadian Surgical Technologies & Advanced Robotics (CSTAR), considère ces innovations comme des outils permettant d'améliorer les emplois existants.

Cependant, Yoshua Bengio, directeur de l'Institut des algorithmes d'apprentissage de Montréal, a prévenu le comité que les nouveaux emplois créés et les améliorations d'emplois existants exigeront des employés qu'ils acquièrent de nouvelles compétences. Dans la même veine, on a indiqué aux membres qu'il sera nécessaire d'accorder une plus grande importance aux sciences, à la technologie, à l'ingénierie et aux mathématiques (STIM) dans l'éducation secondaire et postsecondaire ainsi qu'au perfectionnement professionnel de la main-d'œuvre actuelle. Selon les futurologues Bertalan Mesko et Abishur Prakash, si les acteurs de l'industrie des soins de la santé craignent que ces innovations mènent à des pertes d'emplois, l'implantation de ces technologies risque de buter contre de la résistance.

Bien qu'il soit impossible en ce moment de prédire avec certitude les effets de la robotique, de l'intelligence artificielle et de l'impression en 3D sur l'emploi, il ne fait pas de doute qu'il faut garder cette question en tête à mesure que le Canada intègre ces innovations au secteur des soins de santé.

[N]ous devons comprendre que ces nouvelles technologies ne sont que des outils […]. Elles ne sont pas censées remplacer les contacts humains qui sont essentiels dans le domaine des soins.

- Alex Mihailidis, directeur scientifique, AGE-WELL, Network of Centres of Excellence

> *[L]a commercialisation d'un produit est un processus très complexe et tortueux.*
>
> - Roman Szumski, vice-président,
> Conseil national de recherches Canada

FAIRE ACCÉDER LES INNOVATIONS AU MARCHÉ

Le comité a appris qu'il existe des programmes financés par le gouvernement fédéral qui aident directement ou indirectement les innovateurs à commercialiser leurs produits. L'IRSC consacre 23 % de son budget annuel de 1 milliard de dollars à des activités de recherche priorisées; selon ce programme, le gouvernement fédéral cible des enjeux de santé urgents et offre du financement aux chercheurs qui mènent des recherches dans ces domaines. Certains des chercheurs qui reçoivent du financement dans le cadre du programme de recherche priorisé sont jumelés à une société œuvrant dans le secteur approprié. Ce partenariat peut faciliter le passage des innovations vers la commercialisation plus tard en cours de route. L'IRSC, en collaboration avec le CRSNG et le CRSH (deux autres organismes de financement fédéraux), gère plusieurs programmes collaboratifs interconseils ou interorganismes.

Parmi les programmes interorganismes, on compte les Réseaux de centres d'excellence (RCE), qui offrent des « programmes qui font appel aux plus grands experts du Canada dans les domaines de la recherche, du développement et de l'entrepreneuriat et qui concentrent leur expertise sur des questions spécifiques et des domaines stratégiques [15] ». Au moins deux RCE touchent à des éléments pertinents à la présente étude, à savoir le réseau Aging Gracefully across Environments using Technology to Support Wellness, Engagement and Long Life, (AGE WELL); et le réseau Centre for Surgical Invention and Innovation (CSii).

Selon Alex Mihailidis, directeur scientifique, AGE-WELL, le RCE rassemble plus de 140 participants représentant l'industrie, les gouvernements, des soignants, des utilisateurs,

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15   Gouvernement du Canada, **À propos des Réseaux de centres d'excellence**.

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des universitaires et des organismes sans but lucratif ainsi que 150 chercheurs de partout au pays. AGE-WELL vise à améliorer la qualité de vie des aînés du Canada par le développement de technologies et de services qui renforcent l'indépendance et l'interaction sociale. Ce RCE a été créé au début de l'année 2016 à l'aide d'un financement de 36,6 millions de dollars sur cinq ans en plus de 22 millions de dollars provenant de partenaires. Les membres du comité ont appris qu'AGE-WELL offre à ses chercheurs de l'aide à la création d'entreprise. À ce jour, le RCE a donné naissance à deux entreprises, et AGE-WELL s'attend à ce que les redevances des entreprises qu'elle aide à fonder lui permettent d'atteindre l'autonomie d'ici 10 ans. Cependant, le Dʳ Mihailidis a noté qu'il est nécessaire de réformer les systèmes de soins de santé provinciaux de manière à ce qu'ils s'adaptent plus facilement aux nouvelles technologies et qu'ils les intègrent plus aisément.

Mehran Anvari, directeur scientifique, CSii, a expliqué que le CSii a pour objectif de créer des robots chirurgicaux intelligents qui améliorent la qualité des chirurgies ainsi que l'accès aux procédures chirurgicales et à d'autres interventions médicales. Le Dʳ Anvari a exprimé des frustrations concernant la commercialisation des produits novateurs au Canada. Il a applaudi le soutien qu'apporte le pays à la recherche, mais a affirmé que ce soutien doit se poursuivre jusqu'à la commercialisation, faute de quoi les recherches ne produiront aucun résultat pour les soins aux patients. Selon lui, l'un des grands obstacles à la commercialisation réside dans le processus d'approvisionnement à l'échelon provincial. Dans la même veine, Charles Deguire, dont l'entreprise, Kinova, détient un permis de Santé Canada pour la vente de ses innovations, a fait part de frustrations concernant l'approvisionnement provincial et l'inscription de ses produits dans les régimes provinciaux d'assurance-maladie, mais également concernant la résistance à leur inclusion dans les régimes d'assurance privés. Il a indiqué que 98 % des revenus de Kinova proviennent de

l'extérieur du Canada, et s'est demandé pourquoi il est en mesure de commercialiser les bras robotiques que fabrique son entreprise dans d'autres pays depuis plusieurs années alors que son propre pays n'accueille pas ses innovations. Certains témoins ont fait valoir qu'il y a peu de facteurs qui incitent les systèmes de soins de santé provinciaux à adopter ces nouvelles technologies, qui peuvent s'avérer coûteuses et qui ont, pour l'instant, peu fait la preuve de leur innocuité et de leur efficacité. On a indiqué que le gouvernement fédéral pourrait jouer un rôle pour inciter les gouvernements provinciaux à adopter les nouvelles technologies dans les systèmes publics.

Au cours de l'étude, les membres ont entendu des témoignages de personnes qui ont joui de l'aide des programmes des RCE ainsi que du PARI du Conseil national de recherches Canada, mentionné précédemment. Ces témoins ont souligné les forces, les faiblesses et les lacunes qui doivent être comblées en ce qui concerne la commercialisation des innovations au Canada. Konrad Walus a salué le PARI et les programmes du CRSNG de même que les partenariats avec les entreprises privées qui, ensemble, facilitent l'accès aux services de conception et de prototypage, étapes essentielles qui permettent aux chercheurs de faire passer leurs innovations à la phase de démarrage du processus de commercialisation. Cependant, Garnette Sutherland s'est montré plus prudent dans sa description du milieu de l'innovation du Canada. Il a reconnu que le Canada investit beaucoup dans la recherche fondamentale et appliquée, mais il a fait valoir que les organismes de financement sous-estiment le coût de la protection par brevet. Il a affirmé que le Canada a un lourd handicap en ce qui concerne le passage de la recherche à la commercialisation, et que de nombreux innovateurs canadiens finissent par commercialiser leurs produits aux États-Unis puisque les Canadiens n'ont pas tendance à investir ou à prendre des risques comme le font les Américains. Plusieurs témoins ont fait valoir que les organismes de financement de la recherche

Comment peut-on prévoir l'innovation?

- Mike Monteith, cofondateur, ThoughtWire

au Canada devraient offrir plus de soutien à la commercialisation des produits novateurs en robotique, en IA et en impression en 3D.

Enfin, Mike Monteith de ThoughtWire, qui a comparu devant le comité à titre de représentant du Council of Canadian Innovators, a convenu qu'il est grandement difficile de commercialiser les produits au Canada. Il a fait valoir que l'accès au capital est trop restreint selon le modèle d'affaires actuel, qui nécessite habituellement un plan d'affaires de deux à cinq ans. Selon lui, un plan ayant un horizon plus vaste, par exemple 20 ans, serait mieux adapté aux innovateurs de technologie de rupture comme la robotique et l'IA.

M. Monteith a également souligné un des problèmes que rencontrent les entreprises qui cherchent à prendre de l'expansion, c'est-à-dire les poursuites frivoles liées aux droits de propriété intellectuelle, ou aux violations de brevet, intentées par de grandes entreprises étrangères qui cherchent à étouffer la concurrence. M. Monteith a fait valoir que les innovateurs tireraient profit d'une stratégie sur la propriété intellectuelle qui appuierait leurs efforts d'expansion et établirait un bassin de ressources communes pour protéger les innovateurs contre les poursuites judiciaires frivoles.

AJUSTEMENTS À LA FORMATION ET À L'ÉDUCATION

Plusieurs témoins ont décrit les besoins liés aux études et à la formation qui découleront de l'introduction de ces nouvelles technologies dans le système de soins de santé. Le comité a appris que l'époque où l'on pouvait faire son entière carrière sans jamais suivre de formation continue est depuis longtemps révolue et que les professionnels de la santé sont bien conscients qu'ils doivent se tenir au fait des avancées progressives de la technologie. On a indiqué au comité que ces nouvelles technologies doivent être intégrées à la pratique avec soin. Par exemple, le Kelman Centre for Advanced Learning de CSTAR offre de la formation par simulation aux professionnels de la santé. En fait, le comité a appris que le rythme du changement est si élevé de nos jours que l'entièreté de la main-d'œuvre des soins de santé nécessitera peut-être une nouvelle formation sur une base régulière.

Comme il a été mentionné précédemment au sujet des craintes de perte d'emplois, certains témoins sont d'avis qu'il faut réorienter l'éducation secondaire et postsecondaire afin d'accorder plus d'importance aux domaines des STIM. Yoshua Bengio a présenté un point de vue différent. Comme il a été mentionné, le Dr Bengio est d'avis que les nouveaux emplois créés nécessiteront fort probablement des compétences différentes de celles que détiennent les personnes dont l'emploi aura été automatisé. Par conséquent, il a proposé que les jeunes

Canadiens reçoivent une formation couvrant une vaste gamme de compétences de manière à ce qu'ils soient bien outillés pour s'ajuster à l'évolution des besoins en main-d'œuvre.

Bien qu'il soit clair que, en raison de ces innovations, la main-d'œuvre devra recevoir l'éducation et la formation appropriées, il faut également souligner que ces nouvelles technologies constituent en soi des outils de formation prometteurs. Les membres ont appris que l'impression en 3D représente désormais un outil important pour les médecins et les chirurgiens non seulement pour planifier les traitements et les chirurgies et pour mieux comprendre des maladies rares, mais aussi pour les aider à former les résidents et à expliquer les traitements aux patients à l'aide de modèles qui reflètent avec exactitude les parties du corps touchées par la maladie. Martin Ferguson-Pell, professeur à la faculté de de médecine de réadaptation de l'Université de l'Alberta, a décrit le potentiel de la planification chirurgicale en réalité augmentée, où le chirurgien peut manipuler des données d'imagerie en 3D, par exemple une IRM ou un tomodensitogramme, ce qui lui permet d'élargir l'imagerie sous forme d'hologramme et d'observer virtuellement la structure anatomique de l'intérieur pour planifier la chirurgie (un processus appelé « holoportation »).

RÉGLEMENTATION DES INSTRUMENTS MÉDICAUX NOVATEURS

Les représentants de Santé Canada ont indiqué que, conformément au *Règlement sur les instruments médicaux*, le Ministère a approuvé des innovations et octroyé des permis dans les trois catégories, soit la robotique, l'IA et l'impression en 3D. Ils ont fait valoir que le cadre de réglementation actuel répond bien à l'évolution des technologies. Cependant, certains témoins ont indiqué que des modifications permettraient d'adapter encore mieux le cadre. Par exemple, conformément au *Règlement*, pour que le Ministère accepte la commercialisation d'un produit, le promoteur de l'instrument doit fournir suffisamment de données découlant d'études expérimentales sur l'innocuité et l'efficacité de l'instrument proposé. Les membres ont appris que, dans le cas de certaines technologies novatrices, les essais randomisés avec témoins, auxquels on a habituellement recours, pourraient ne pas être l'approche la mieux adaptée et que les autorités de réglementation devraient accepter d'autres approches pour confirmer l'innocuité et l'efficacité de l'instrument. On a fait valoir aux membres que le Parlement européen est en train d'établir une approche réglementaire spécifique à la robotique.

UNE OCCASION DE CHANGEMENT PROFOND

RECOMMANDATIONS VISANT À FACILITER L'INTÉGRATION DES TECHNOLOGIES NOVATRICES DANS LES SYSTÈMES DE SOINS DE SANTÉ DU CANADA

La technologie va continuer à se développer sans nous. Il nous incombe de l'adopter ou de la rejeter.

\- Bertalan Mesko, futurologue médical

Des témoins ont indiqué au comité que des investissements fédéraux ont été faits dans la recherche sur l'intelligence artificielle et la formation des chercheurs en intelligence artificielle. Dans le budget fédéral, déposé à la Chambre des communes le 22 mars 2017, on affirme que le Canada doit encourager l'innovation afin de conserver sa compétitivité dans l'économie mondiale [16]. Parmi les mesures du budget liées à l'innovation, on compte la création de la Stratégie pancanadienne en matière d'intelligence artificielle de l'Institut canadien de recherches avancées (ICRA), objet d'un financement ponctuel de 125 millions de dollars. La stratégie sera conçue de manière à attirer et à maintenir en poste des étudiants, des étudiants de cycle supérieur et des chercheurs principalement aux nouveaux instituts des trois carrefours de l'IA du Canada, soit Montréal, Toronto et Edmonton, quoique des fonds seront également versés à d'autres universités souhaitant mettre sur pied des programmes en intelligence artificielle. Cet investissement dans une stratégie pancanadienne en matière d'IA fait suite au financement, en septembre 2016, de trois projets d'intelligence artificielle par l'intermédiaire du Fonds d'excellence en recherche Apogée Canada, qui s'est élevé à 213 millions de dollars répartis entre trois établissements de Montréal (Université de Montréal, Polytechnique Montréal et HEC Montréal) [17].

En outre, le comité a pris connaissance de grands investissements dans l'IA qui auront des effets à la phase de commercialisation des produits novateurs. Element AI, cofondé par Yoshua Bengio, est un laboratoire de recherche et un incubateur de jeunes entreprises qui vise à faciliter la commercialisation des produits. Le Dr Bengio a indiqué que d'importants investissements fédéraux et provinciaux ont attiré d'autres investissements par de grandes entreprises internationales, comme Google, Microsoft et Facebook. Comme il l'a fait remarquer, cet investissement montre que les entreprises viennent désormais au Canada, un changement par rapport aux situations précédentes, où les jeunes entreprises canadiennes se déplaçaient aux États-Unis et en Europe en raison du manque de capital de risque au pays.

Cette mobilisation en faveur de la recherche sur l'intelligence artificielle et de la commercialisation de l'IA crée également de solides fondements pour la robotique en raison des liens étroits entre ces deux technologies, et le comité encourage le gouvernement fédéral à mettre à profit les efforts déployés à l'heure actuelle. À cet égard, le comité recommande au gouvernement fédéral de miser sur le Plan pour l'innovation et les compétences du Canada et la Stratégie pancanadienne sur l'intelligence artificielle annoncés dans le budget 2017 et de jouer un rôle de premier plan par l'organisation d'une rencontre des experts canadiens du domaine. Comme dans d'autres domaines, une « conférence nationale » accomplirait cet objectif. Plus particulièrement, il faudrait une conférence nationale à laquelle participent des représentants de tous les gouvernements ainsi qu'une vaste gamme d'intervenants de manière à lancer la discussion. Cette conférence pourrait être la structure nécessaire pour cerner les professionnels qui pourraient collaborer au sein d'un groupe d'experts consultatifs sur différents sujets. En outre, en raison de la nature perturbatrice des technologies et des avancées rapides et importantes prévues, il serait prudent de tenir des consultations fréquentes auprès des intervenants. Cette approche reposerait sur une conférence nationale, un secrétariat et des groupes d'experts, comme on le décrit par ce qui suit.

Il faut vous préparer à ce qui va arriver.

- Abishur Prakash, futurologue géopolitique, Center for Innovating the Future

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16   Gouvernement du Canada, **Budget 2017 : Bâtir une classe moyenne forte**, 22 mars 2017, page 19.

17   Gouvernement du Canada, **Fonds excellence en recherche Apogée Canada – Résultats des concours**.

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Par conséquent, le comité recommande :

RECOMMANDATION 1

Que le gouvernement du Canada tienne une conférence nationale sur la robotique, l'intelligence artificielle et l'impression en 3D en soins de santé (la Conférence nationale). Cette conférence devrait rassembler un vaste éventail de participants, notamment :

- des représentants des gouvernements fédéral, provinciaux et territoriaux et des administrations municipales œuvrant dans le domaine de l'industrie, de la santé et de l'éducation, en plus de représentants autochtones;

- des intervenants intéressés par les applications de la robotique, de l'intelligence artificielle et de l'impression en 3D dans le domaine des soins de santé, y compris, de manière non exclusive, des chercheurs, des entrepreneurs, des investisseurs, des décideurs et des professionnels de la santé.

La Conférence nationale aurait pour objectif de favoriser une discussion ouverte et franche sur les technologies novatrices et de cerner des manières de faciliter l'intégration de ces technologies dans les systèmes de soins de santé du Canada. Le comité est d'avis que cette initiative tirerait profit du dévouement et de l'enthousiasme déjà palpables dans différents domaines de spécialité et encouragera la tenue de débats constructifs. Des chercheurs et des entrepreneurs ont indiqué au comité qu'ils se dépassent lorsque des défis se dressent sur le chemin, mais qu'il faut modifier les modèles d'affaires ainsi que la méthode de prestation des soins de santé afin que les innovations puissent percer le marché.

Par conséquent, le comité recommande :

RECOMMANDATION 2

Que la Conférence nationale vise à mettre à profit les efforts déployés à l'heure actuelle pour intégrer la robotique, l'intelligence artificielle et l'impression en 3D dans les systèmes de soins de santé au moyen de discussions ouvertes, et qu'elle vise à rassembler, au moyen de groupes de travail d'experts distincts, les intervenants concernés pour aborder, au fil du temps, les domaines d'intérêt ou de préoccupation. Des groupes devraient être formés sur, entre autres, les thèmes suivants :

- les considérations éthiques;
- les préoccupations relatives à la commercialisation;
- le renouvellement de la prestation des soins de santé;
- les soins de santé dans les régions rurales ou éloignées;
- l'égalité d'accès aux technologies émergentes
- le réaménagement des effectifs;
- les besoins en matière d'éducation et de formation;
- la surveillance réglementaire.

RECOMMANDATION 3

Que chaque groupe de travail d'experts formé par la Conférence nationale ait pour rôle d'élaborer son propre plan stratégique pour encourager et faciliter l'intégration, au besoin, des technologies novatrices dans les systèmes de soins de santé du Canada après avoir examiné les enjeux liés à l'éthique, à la protection des renseignements personnels et à la sécurité. Le nombre de groupes de travail ainsi que leur mandat et leur composition respectifs devraient faire l'objet d'un examen périodique.

RECOMMANDATION 4

Que Santé Canada, à titre d'organisme de réglementation de ces technologies, soit représenté au sein des groupes de travail d'experts sur l'éthique et la surveillance réglementaire pour veiller à surveiller et à inclure dans les délibérations les travaux des organismes internationaux responsables d'examiner ces questions et les questions connexes et de formuler des recommandations à leur sujet.

Un secrétariat, composé des présidents de chaque groupe de travail d'experts, permettrait de coordonner les plans et les propositions des groupes. Il servirait en outre de point de contact par l'intermédiaire duquel les groupes de travail d'experts pourraient rendre des comptes au gouvernement fédéral.

Par conséquent, le comité recommande :

RECOMMANDATION 5

Que l'on mette sur pied un secrétariat composé des présidents des groupes de travail d'experts créés par la Conférence nationale. Le secrétariat aura pour mandat :

- de coordonner les travaux des groupes de travail d'experts;
- de recueillir les rapports produits par les groupes de travail d'experts;
- de rendre des comptes au gouvernement fédéral sur les progrès réalisés par les groupes de travail;
- d'offrir un soutien supplémentaire relativement aux travaux de la Conférence nationale et des groupes de travail d'experts.

RECOMMANDATION 6

Que le gouvernement du Canada finance adéquatement les efforts des groupes de travail d'experts et le secrétariat de la Conférence nationale.

RECOMMANDATION 7

Que le ministre de la Santé, le ministre de l'Innovation, des Sciences et du Développement économique et le ministre de l'Emploi, du Développement de la main-d'œuvre et du Travail exigent des rapports réguliers sur les progrès des travaux des groupes de travail d'experts créés par la Conférence nationale et, lorsque nécessaire, discutent des conclusions et des recommandations avec leurs homologues des provinces et des territoires.

DÉFI EN VUE : INTÉGRER LES TECHNOLOGIES DE LA ROBOTIQUE, DE L'INTELLIGENCE ARTIFICIELLE ET DE L'IMPRESSION EN 3D DANS LES SYSTÈMES CANADIENS DE SOINS DE SANTÉ

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RECOMMANDATION 8

Que le ministre de la Santé demande au groupe de travail d'experts sur la surveillance réglementaire créé par la Conférence nationale d'examiner en particulier, sans s'y limiter, si des modifications doivent être apportées au *Règlement sur les instruments médicaux.*

RECOMMANDATION 9

Que le ministre de l'Innovation, des Sciences et du Développement économique demande au groupe de travail d'experts sur la commercialisation créé par la Conférence nationale d'examiner en particulier, sans s'y limiter, les préoccupations liées aux droits de propriété intellectuelle.

Au cours de l'étude, plusieurs témoins ont indiqué que, pour atteindre son plein potentiel, l'intelligence artificielle utilise de vastes quantités de données, plus particulièrement des données numérisées de grande qualité. On a rappelé aux membres que le Canada accuse un retard en ce qui concerne la conversion en formats électroniques des dossiers de patients, y compris les dossiers de santé électroniques (DSE) et les dossiers médicaux électroniques (DME). Dans des rapports précédents, le comité a exhorté Inforoute Santé du Canada (Inforoute), qui est responsable d'accélérer l'introduction de ces systèmes numériques, à veiller à ce que les DSE et les DME soient entièrement mis en œuvre partout au Canada [18]. Selon le rapport annuel d'Inforoute de 2015-2016, 73 % des médecins de famille du Canada utilisaient des DME en 2015, soit une augmentation de 23 % par rapport à 2006. En outre, Inforoute indique que les éléments des DSE, notamment l'imagerie diagnostique et les données de laboratoire, approchent de la couverture complète (100 %) partout au Canada (font exception les systèmes de renseignements sur les médicaments, qui, à 69 %, tirent de l'arrière) [19]. Les membres ont appris que, recueillies au fil de nombreuses années, les données numérisées sur les patients fourniront l'information nécessaire à l'IA pour qu'elle puisse offrir des services de soins de santé prédictifs.

Par conséquent, le comité recommande :

RECOMMANDATION 10

Que Santé Canada, à titre de membre du conseil d'administration d'Inforoute Santé du Canada, demande à ce que Inforoute participe à la Conférence nationale afin de faire le point auprès des participants sur les progrès réalisés dans la numérisation des données sur la santé au Canada et d'obtenir leurs commentaires sur les lacunes que peut combler Inforoute.

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18 Voir Sénat, Comité permanent des affaires sociales, des sciences et de la technologie, **Les produits pharmaceutiques sur ordonnance au Canada, Rapport final - annexes,** 18e rapport, 2e session, 41e législature, mars 2015; et Sénat, Comité permanent des affaires sociales, des sciences et de la technologie, **La démence au Canada : Une stratégie nationale pour un Canada sensible aux besoins des personnes atteintes de démence**, sixième rapport, 1re session, 42e législature, novembre 2016.

19 Inforoute Santé du Canada, **La santé numérique au cœur des discussions**, Rapport annuel 2015-2016, juillet 2016.

Certains témoins ont manifesté leur exaspération concernant les processus d'approvisionnement provinciaux, qui constituent un obstacle considérable lorsqu'on cherche à faire inscrire une innovation sur la liste provinciale des services et des produits financés par les fonds publics. En complément des travaux des groupes de travail d'experts sur la commercialisation et le renouvellement de la prestation des soins de santé, le comité aimerait compter sur la participation de l'Agence canadienne des médicaments et des technologies de la santé (ACMTS) à la Conférence nationale sur la robotique, l'intelligence artificielle et l'impression en 3D. L'ACMTS, qui formule aux provinces des recommandations d'ajout de médicaments et d'instruments aux listes en fonction d'analyses de rentabilité, pourrait décrire aux intervenants son rôle et ses activités en ce qui a trait à la robotique, à l'intelligence artificielle et à l'impression en 3D.

Par conséquent, le comité recommande :

RECOMMANDATION 11

Que Santé Canada, à titre de membre du conseil d'administration de l'Agence canadienne des médicaments et des technologies de la santé, demande que cette dernière participe à la Conférence nationale et à tout groupe de travail d'experts qui convient.

Afin d'assurer l'intégration continue des technologies novatrices dans le secteur des soins de la santé, la Conférence nationale devrait être tenue annuellement.

Par conséquent, le comité recommande :

RECOMMANDATION 12

Que le gouvernement du Canada tienne chaque année la Conférence nationale afin d'évaluer l'intégration globale de la robotique, de l'intelligence artificielle et de l'impression en 3D dans les systèmes de soins de santé partout au Canada et de cerner et de surmonter les nouveaux défis à mesure qu'ils se présentent.

DÉFI EN VUE : INTÉGRER LES TECHNOLOGIES DE LA ROBOTIQUE, DE L'INTELLIGENCE ARTIFICIELLE ET DE L'IMPRESSION EN 3D DANS LES SYSTÈMES CANADIENS DE SOINS DE SANTÉ

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Le comité félicite les organismes fédéraux de financement de la recherche pour leurs investissements dans la robotique, l'intelligence artificielle et l'impression en 3D. Toutefois, d'après les témoignages, il estime que les programmes collaboratifs auxquels participent les IRSC, le CRSNG et le CRSH pourraient faire l'objet d'un examen et d'une analyse continus de façon à ce que soient cernées et comblées les lacunes en matière de recherche.

Par conséquent, le comité recommande :

RECOMMANDATION 13

Que les présidents des Instituts de recherche en santé du Canada, du Conseil de recherches en sciences naturelles et en génie du Canada et du Conseil de recherches en sciences humaines se rencontrent régulièrement pour discuter de mécanismes de collaboration qui pourraient être mis en œuvre afin d'accélérer la recherche sur la robotique, l'intelligence artificielle et l'impression en 3D.

De nombreuses innovations en matière de soins de santé sont déjà appliquées au Canada, et de nombreux autres prototypes et concepts sont en phase de conception. Cela signifie que les bouleversements du modèle de prestation de soins de santé traditionnel se poursuivront en raison de l'adoption de ces nouvelles technologies de rupture, alimentée par les attentes de la population, laquelle exigera l'accès aux traitements de pointe les plus efficaces.

Toutefois, des entrepreneurs ont appris au comité que deux avenues permettraient d'accélérer l'innovation et l'adoption des nouvelles technologies par le système de soins de santé. La première de ces avenues est la mise en place d'une plateforme nationale, d'un forum de découverte où les intervenants canadiens dans le domaine des soins de la santé ainsi que le grand public auraient l'occasion de s'informer au sujet des nouvelles innovations canadiennes et de rencontrer leurs créateurs. Ce forum susciterait l'intérêt et la demande. La seconde avenue, a appris le comité, réside dans le fait que les entreprises d'innovation accepteraient de relever un défi visant à résoudre un problème précis. On a fait valoir au comité qu'il serait possible de changer l'avenir de chaque système de soins de santé au pays si on lançait un défi en matière de soins de santé qui touche toutes les provinces et tous les territoires. Selon des entrepreneurs, le gouvernement fédéral gagnerait à organiser un événement portant sur ces deux questions.

Par conséquent, le comité recommande :

RECOMMANDATION 14

Que le gouvernement du Canada tienne un Forum de découverte sur les soins de santé. Ce dernier encouragerait les innovateurs et les entrepreneurs intéressés à :

- **faire connaître leurs découvertes au public et aux intervenants du domaine des soins de santé;**
- **prendre connaissance de nouveaux défis en matière de soins de santé qui pourraient être relevés grâce à leur ingéniosité et à leur concours.**

CONCLUSION

[L]'avenir des soins de santé au Canada dépend de notre capacité d'innover.

- Jane Aubin, chef des affaires scientifiques,
Instituts de recherche en santé du Canada

[L]'automatisation, particulièrement l'intelligence artificielle, la robotique et l'impression 3D, est un élément essentiel pour rendre les soins de santé viables.

- Bertalan Mesko, futurologue médical

Les technologies novatrices abordées dans le présent rapport sont celles qui offrent, ou qui ont le potentiel d'offrir, des soins de santé axés sur la personne. Qu'il s'agisse d'un modèle en 3D de l'organe atteint d'un patient, d'un diagnostic rendu au moyen de l'intelligence artificielle en fonction des symptômes et des circonstances propres au patient ou d'un bras robotisé qui s'adapte aux besoins spécifiques de chaque utilisateur, ces technologies viendront jouer un rôle important dans l'avenir de la formation et de l'éducation, des services offerts dans les régions rurales ou éloignées, des soins à domiciles et de la médecine personnalisée.

Le comité reconnaît et respecte la compétence provinciale et territoriale en matière de prestation de services de soins de santé. Cependant, le gouvernement fédéral doit rendre des comptes aux Canadiens en ce qui a trait à l'accès équitable aux soins de santé. À cet égard, il a l'occasion de jouer un rôle de chef de file, en collaboration avec les gouvernements provinciaux et territoriaux, afin d'établir la structure nécessaire pour que les provinces et les territoires puissent rester au fait des innovations disponibles et des avantages que celles-ci représentent pour les soins de la santé tout en soulignant les enjeux qui nécessitent une attention particulière.

Ces technologies vont profondément transformer la vie des Canadiens et, en particulier, la prestation des soins de santé. Le Canada est déjà un chef de file de la théorie et de la recherche qui soutiennent ces technologies de rupture et pourrait occuper un rôle semblable dans le domaine des questions éthiques, de l'emploi, de l'éducation et de la formation, de la commercialisation et des modifications réglementaires. Le Canada peut miser sur la perspicacité de ses investissements dans ces domaines de recherche en mobilisant le talent et les structures sociales nécessaires pour que la société puisse en récolter les fruits.

ANNEXE 1 :
LISTE DES RECOMMANDATIONS

RECOMMANDATION 1

Que le gouvernement du Canada tienne une conférence nationale sur la robotique, l'intelligence artificielle et l'impression en 3D en soins de santé (la Conférence nationale). Cette conférence devrait rassembler un vaste éventail de participants, notamment :

- des représentants des gouvernements fédéral, provinciaux et territoriaux et des administrations municipales œuvrant dans le domaine de l'industrie, de la santé et de l'éducation, en plus de représentants autochtones;

- des intervenants intéressés par les applications de la robotique, de l'intelligence artificielle et de l'impression en 3D dans le domaine des soins de santé, y compris, de manière non exclusive, des chercheurs, des entrepreneurs, des investisseurs, des décideurs et des professionnels de la santé.

RECOMMANDATION 2

Que la Conférence nationale vise à mettre à profit les efforts déployés à l'heure actuelle pour intégrer la robotique, l'intelligence artificielle et l'impression en 3D dans les systèmes de soins de santé au moyen de discussions ouvertes, et qu'elle vise à rassembler, au moyen de groupes de travail d'experts distincts, les intervenants concernés pour aborder, au fil du temps, les domaines d'intérêt ou de préoccupation. Des groupes devraient être formés sur, entre autres, les thèmes suivants :

- les considérations éthiques;

- les préoccupations relatives à la commercialisation;

- le renouvellement de la prestation des soins de santé;

- les soins de santé dans les régions rurales ou éloignées;

- l'égalité d'accès aux technologies émergentes

- le réaménagement des effectifs;

- les besoins en matière d'éducation et de formation;

- la surveillance réglementaire.

RECOMMANDATION 3

Que chaque groupe de travail d'experts formé par la Conférence nationale ait pour rôle d'élaborer son propre plan stratégique pour encourager et faciliter l'intégration, au besoin, des technologies novatrices dans les systèmes de soins de santé du Canada après avoir examiné les enjeux liés à l'éthique, à la protection des renseignements personnels et à la sécurité. Le nombre de groupes de travail ainsi que leur mandat et leur composition respectifs devraient faire l'objet d'un examen périodique.

RECOMMANDATION 4

Que Santé Canada, à titre d'organisme de réglementation de ces technologies, soit représenté au sein des groupes de travail d'experts sur l'éthique et la surveillance réglementaire pour veiller à surveiller et à inclure dans les délibérations les travaux des organismes internationaux responsables d'examiner ces questions et les questions connexes et de formuler des recommandations à leur sujet.

RECOMMANDATION 5

Que l'on mette sur pied un secrétariat composé des présidents des groupes de travail d'experts créés par la Conférence nationale. Le secrétariat aura pour mandat :

- de coordonner les travaux des groupes de travail d'experts;

- de recueillir les rapports produits par les groupes de travail d'experts;

- de rendre des comptes au gouvernement fédéral sur les progrès réalisés par les groupes de travail;
- d'offrir un soutien supplémentaire relativement aux travaux de la Conférence nationale et des groupes de travail d'experts.

RECOMMANDATION 6

Que le gouvernement du Canada finance adéquatement les efforts des groupes de travail d'experts et le secrétariat de la Conférence nationale.

RECOMMANDATION 7

Que le ministre de la Santé, le ministre de l'Innovation, des Sciences et du Développement économique et le ministre de l'Emploi, du Développement de la main-d'œuvre et du Travail exigent des rapports réguliers sur les progrès des travaux des groupes de travail d'experts créés par la Conférence nationale et, lorsque nécessaire, discutent des conclusions et des recommandations avec leurs homologues des provinces et des territoires.

RECOMMANDATION 8

Que le ministre de la Santé demande au groupe de travail d'experts sur la surveillance réglementaire créé par la Conférence nationale d'examiner en particulier, sans s'y limiter, si des modifications doivent être apportées au *Règlement sur les instruments médicaux*.

RECOMMANDATION 9

Que le ministre de l'Innovation, des Sciences et du Développement économique demande au groupe de travail d'experts sur la commercialisation créé par la Conférence nationale d'examiner en particulier, sans s'y limiter, les préoccupations liées aux droits de propriété intellectuelle.

RECOMMANDATION 10

Que Santé Canada, à titre de membre du conseil d'administration d'Inforoute Santé du Canada, demande à ce que Inforoute participe à la Conférence nationale afin de faire le point auprès des participants sur les progrès réalisés dans la numérisation des données sur la santé au Canada et d'obtenir leurs commentaires sur les lacunes que peut combler Inforoute.

RECOMMANDATION 11

Que Santé Canada, à titre de membre du conseil d'administration de l'Agence canadienne des médicaments et des technologies de la santé, demande que cette dernière participe à la Conférence nationale et à tout groupe de travail d'experts qui convient.

RECOMMANDATION 12

Que le gouvernement du Canada tienne chaque année la Conférence nationale afin d'évaluer l'intégration globale de la robotique, de l'intelligence artificielle et de l'impression en 3D dans les systèmes de soins de santé partout au Canada et de cerner et de surmonter les nouveaux défis à mesure qu'ils se présentent.

RECOMMANDATION 13

Que les présidents des Instituts de recherche en santé du Canada, du Conseil de recherches en sciences naturelles et en génie du Canada et du Conseil de recherches en sciences humaines se rencontrent régulièrement pour discuter de mécanismes de collaboration qui pourraient être mis en œuvre afin d'accélérer la recherche sur la robotique, l'intelligence artificielle et l'impression en 3D.

RECOMMANDATION 14

Que le gouvernement du Canada tienne un Forum de découverte sur les soins de santé. Ce dernier encouragerait les innovateurs et les entrepreneurs intéressés à :

- faire connaître leurs découvertes au public et aux intervenants du domaine des soins de santé;
- prendre connaissance de nouveaux défis en matière de soins de santé qui pourraient être relevés grâce à leur ingéniosité et à leur concours.

ANNEXE 2 :
LISTE DES TÉMOINS

Le mercredi 1er février 2017	
Instituts de recherche en santé du Canada (IRSC)	Jane E. Aubin, chef des affaires scientifiques et vice-présidente à la recherche, à l'application des connaissances et à l'éthique
Conseil de recherches en sciences naturelles et en génie du Canada	Bettina Hamelin, vice-présidente, Direction des partenariats de recherche
	Pamela Moss, directrice, Fabrication, communications et technologies (FCT), Direction des partenariats de recherche
Conseil national de recherches Canada	Dr Roman Szumski, vice-président, Sciences de la vie
	Robert Diraddo, chef du groupe, Simulation et santé numérique, Dispositifs médicaux

Le mardi 2 février 2017	
Center for Innovating the Future	Abishur Prakash, futurologue géopolitique
À titre personnel	Bertalan Mesko, futurologue médical

Le mercredi 8 février 2017	
À titre personnel	Dr Garnette Sutherland, professeur de neurochirurgie, Université de Calgary
À titre personnel	Goldie Nejat, directrice de l'Institut de robotique et de mécatronique, titulaire de la Chaire de recherche du Canada sur les robots dans la société

Le jeudi 9 février 2017	
À titre personnel	Joelle Pineau, professeure agrégée, Centre des machines intelligentes, Université McGill
À titre personnel	Daniel L. Silver, professeur, directeur, Institut Acadia d'analytique des données, Université Acadia

Le mercredi 8 mars 2017	
3D4MD	Dre Julielynn Wong, fondatrice, directrice générale et chef de la direction
À titre personnel	Matt Ratto, professeur agrégé, Faculté de l'information, Université de Toronto

À titre personnel	Konrad Walus, professeur agrégé, Génie électrique et informatique, Université de la Colombie-Britannique
Le jeudi 9 mars 2017	
AGE-WELL Network of Centres of Excellence Inc.	Alex Mihailidis, directeur scientifique et professeur agrégé
Centre for Surgical Invention and Innovation	Dr Mehran Anvari, directeur scientifique
Le mercredi 29 mars 2017	
Institut canadien de recherches avancées (ICRA)	Dr Alan Bernstein, président et chef de la direction
À titre personnel	Dr Christopher Schlachta, directeur médical, Canadian Surgical Technologies & Advanced Robotics (CSTAR)
Le jeudi 30 mars 2017	
SPARC (Partnership for Robotics in Europe)	Reinhard Lafrenz, secrétaire général, euRobotics (par vidéoconférence)
Association for the Advancement of Artificial Intelligence (AAAI)	Subbarao Kambhampati, professeur, Université de l'État de l'Arizona (par vidéoconférence)
Le mercredi 3 mai 2017	
Institut des algorithmes d'apprentissage de Montréal	Yoshua Bengio, directeur, professeur, Université de Montréal
À titre personnel	Martin Ferguson-Pell, professeur, Université de l'Alberta
Le jeudi 4 mai 2017	
Open Roboethics Institute	AJung Moon, fondatrice
Le mercredi 10 mai 2017	
Council of Canadian Innovators	Mike Monteith, représentant, cofondateur et directeur général, Thoughtwire
Kinova Robotics	Charles Deguire, cofondateur et président
Le jeudi 11 mai 2017	
Humber River Hospital	Barbara Collins, présidente et chef de la direction
	Peter Bak, dirigeant principal de l'information
À titre personnel	Dr Ivar Mendez, président de la chirurgie, Université de Saskatchewan

- AGE-WELL
- Instituts de recherche en santé du Canada (IRSC)
- Santé Canada (réponse écrite)
- Martin Ferguson Pell

TAB 22

ESTONIA, THE DIGITAL REPUBLIC

Its government is virtual, borderless, blockchained, and secure. Has this tiny post–Soviet nation found the way of the future?

By Nathan Heller

▶

Audio: *Listen to this story. To hear more feature stories,* *download the Audm app for your iPhone.*

Up the Estonian coast, a five-lane highway bends with the path of the sea, then breaks inland, leaving cars to follow a thin road toward the houses at the water's edge. There is a gated community here, but it is not the usual kind. The gate is low—a picket fence—as if to prevent the dunes from riding up into the street. The entrance is blocked by a railroad-crossing arm, not so much to keep out strangers as to make sure they come with intent. Beyond the gate, there is a schoolhouse, and a few homes line a narrow drive. From Tallinn, Estonia's capital, you arrive dazed: trees trace the highway, and the cars go fast, as if to get in front of something that no one can see.

Within this gated community lives a man, his family, and one vision of the future. Taavi Kotka, who spent four years as Estonia's chief information officer, is one of the leading public faces of a project known as e-Estonia: a coördinated governmental effort to transform the country from a state into a digital society.

E-Estonia is the most ambitious project in technological statecraft today, for it includes all members of the government, and alters citizens' daily lives. The normal services that government is involved with—legislation, voting, education, justice, health care, banking, taxes, policing, and so on—have been digitally linked across one platform, wiring up the nation. A lawn outside Kotka's large house was being trimmed by a small robot, wheeling itself forward and nibbling the grass.

"Everything here is robots," Kotka said. "Robots here, robots there." He sometimes felt that the lawnmower had a soul. "At parties, it gets *close* to people," he explained.

A curious wind was sucking in a thick fog from the water, and Kotka led me inside. His study was cluttered, with a long table bearing a chessboard and a bowl of foil-wrapped wafer chocolates (a mark of hospitality at Estonian meetings). A four-masted model ship was perched near the window; in the corner was a pile of robot toys.

"We had to set a goal that resonates, large enough for the society to believe in," Kotka went on.

He is tall with thin blond hair that, kept shaggy, almost conceals its recession. He has the liberated confidence, tinged with irony, of a cardplayer who has won a lot of hands and can afford to lose some chips.

It was during Kotka's tenure that the e-Estonian goal reached its fruition. Today, citizens can vote from their laptops and challenge parking tickets from home. They do so through the "once only" policy, which dictates that no single piece of information should be entered twice. Instead of having to "prepare" a loan application, applicants have their data—income, debt, savings—pulled from elsewhere in the system. There's nothing to fill out in doctors' waiting rooms, because physicians can access their patients' medical histories. Estonia's system is keyed to a chip-I.D. card that reduces typically onerous, integrative processes—such as doing taxes—to quick work. "If a couple in love would like to marry, they still have to visit the government location and express their will," Andrus Kaarelson, a director at the Estonian Information Systems Authority, says. But, apart from transfers of physical property, such as buying a house, all bureaucratic processes can be done online.

Estonia is a Baltic country of 1.3 million people and four million hectares, half of which is forest. Its government presents this digitization as a cost-saving efficiency and an equalizing force. Digitizing processes reportedly saves the state two per cent of its G.D.P. a year in salaries and expenses. Since that's the same amount it pays to meet the NATO threshold for protection (Estonia—which has a notably vexed relationship with Russia—has a comparatively small military), its former President Toomas Hendrik Ilves liked to joke that the country got its national security for free.

Other benefits have followed. "If everything is digital, and location-independent, you can run a borderless country," Kotka said. In 2014, the government launched a digital "residency" program, which allows logged-in foreigners to partake of some Estonian

services, such as banking, as if they were living in the country. Other measures encourage international startups to put down virtual roots; Estonia has the lowest business-tax rates in the European Union, and has become known for liberal regulations around tech research. It is legal to test Level 3 driverless cars (in which a human driver can take control) on all Estonian roads, and the country is planning ahead for Level 5 (cars that take off on their own). "We believe that innovation happens anyway," Viljar Lubi, Estonia's deputy secretary for economic development, says. "If we close ourselves off, the innovation happens somewhere else."

"It makes it so that, if one country is not performing as well as another country, people are going to the one that is performing better—competitive governance is what I'm calling it," Tim Draper, a venture capitalist at the Silicon Valley firm Draper Fisher Jurvetson and one of Estonia's leading tech boosters, says. "We're about to go into a very interesting time where a lot of governments can become virtual."

Previously, Estonia's best-known industry was logging, but Skype was built there using mostly local engineers, and countless other startups have sprung from its soil. "It's not an offshore paradise, but you can capitalize a lot of money," Thomas Padovani, a Frenchman who co-founded the digital-ad startup Adcash in Estonia, explains. "And the administration is light, all the way." A light touch does not mean a restricted one, however, and the guiding influence of government is everywhere.

As an engineer, Kotka said, he found the challenge of helping to construct a digital nation too much to resist. "Imagine that it's your task to build the Golden Gate Bridge," he said excitedly. "You have to change the whole way of thinking about society." So far, Estonia is past halfway there.

One afternoon, I met a woman named Anna Piperal at the e-Estonia Showroom. Piperal is the "e-Estonia ambassador"; the showroom is a permanent exhibit on the glories of digitized Estonia, from Skype to Timbeter, an app designed to count big piles of logs. (Its founder told me that she'd struggled to win over the wary titans of Big Log, who preferred to count the inefficient way.) Piperal has blond hair and an air of brisk, Northern European professionalism. She pulled out her I.D. card; slid it into her laptop, which, like the walls of the room, was faced with blond wood; and typed in her secret code, one of two that went with her I.D. The other code issues her digital signature—a seal that, Estonians point out, is much harder to forge than a scribble.

"This PIN code just starts the whole decryption process," Piperal explained. "I'll start with my personal data from the population registry." She gestured toward a box on the screen. "It has my document numbers, my phone number, my e-mail account. Then there's real estate, the land registry." Elsewhere, a box included all of her employment information; another contained her traffic records and her car insurance. She pointed at the tax box. "I have no tax debts; otherwise, that would be there. And I'm finishing a master's at the Tallinn University of Technology, so here"—she pointed to the education box—"I have my student information. If I buy a ticket, the system can verify, automatically, that I'm a student." She clicked into the education box, and a detailed view came up, listing her previous degrees.

"My cat is in the pet registry," Piperal said proudly, pointing again. "We are done with the vaccines."

Data aren't centrally held, thus reducing the chance of Equifax-level breaches. Instead, the government's data platform, X-Road, links individual servers through end-to-end encrypted pathways, letting information live locally. Your dentist's practice holds its own data; so does your high school and your bank. When a user requests a piece of information, it is delivered like a boat crossing a canal via locks.

Although X-Road is a government platform, it has become, owing to its ubiquity, the network that many major private firms build on, too. Finland, Estonia's neighbor to the north, recently began using X-Road, which means that certain data—for instance, prescriptions that you're able to pick up at a local pharmacy—can be linked between the nations. It is easy to imagine a novel internationalism taking shape in this form. Toomas Ilves, Estonia's former President and a longtime driver of its digitization efforts, is currently a distinguished visiting fellow at Stanford, and says he was shocked at how retrograde U.S. bureaucracy seems even in the heart of Silicon Valley. "It's like the nineteen-fifties—I had to provide an electrical bill to prove I live here!" he exclaimed. "You can get an iPhone X, but, if you have to register your car, forget it."

X-Road is appealing due to its rigorous filtering: Piperal's teachers can enter her grades, but they can't access her financial history, and even a file that's accessible to medical specialists can be sealed off from other doctors if Piperal doesn't want it seen.

"I'll show you a digital health record," she said, to explain. "A doctor from here"—a file from one clinic—"can see the research that this doctor"—she pointed to another —"does." She'd locked a third record, from a female-medicine practice, so that no other doctor would be able to see it. A tenet of the Estonian system is that an individual owns all information recorded about him or her. Every time a doctor (or a border guard, a police officer, a banker, or a minister) glances at any of Piperal's secure data online, that look is recorded and reported. Peeping at another person's secure data for no reason is a criminal offense. "In Estonia, we don't have Big Brother; we have Little Brother," a local told me. "You can tell him what to do and maybe also beat him up."

Business and land-registry information is considered public, so Piperal used the system to access the profile of an Estonian politician. "Let's see his land registry," she said, pulling up a list of properties. "You can see there are three land plots he has, and this one is located"—she clicked, and a satellite photograph of a sprawling beach house appeared—"on the sea."

The openness is startling. Finding the business interests of the rich and powerful—a hefty field of journalism in the United States—takes a moment's research, because every business connection or investment captured in any record in Estonia becomes searchable public information. (An online tool even lets citizens map webs of connection, follow-the-money style.) Traffic stops are illegal in the absence of a moving violation, because officers acquire records from a license-plate scan. Polling-place intimidation is a non-issue if people can vote—and then change their votes, up to the deadline—at home, online. And heat is taken off immigration because, in a borderless society, a resident need not even have visited Estonia in order to work and pay taxes under its dominion.

Soon after becoming the C.I.O., in 2013, Taavi Kotka was charged with an unlikely project: expanding Estonia's population. The motive was predominantly economic. "Countries are like enterprises," he said. "They want to increase the wealth of their own people."

Tallinn, a harbor city with a population just over four hundred thousand, does not seem to be on a path toward outsized growth. Not far from the cobbled streets of the hilly Old Town is a business center, where boxy Soviet structures have been supplanted by stylish buildings of a Scandinavian cast. Otherwise, the capital seems pleasantly

preserved in time. The coastal daylight is bright and thick, and, when a breeze comes off the Baltic, silver-birch leaves shimmer like chimes. "I came home to a great autumn / to a luminous landscape," the Estonian poet Jaan Kaplinski wrote decades ago. This much has not changed.

Kotka, however, thought that it was possible to increase the population just by changing how you thought of what a population was. Consider music, he said. Twenty years ago, you bought a CD and played the album through. Now you listen track by track, on demand. "If countries are competing not only on physical talent moving to their country but also on how to get the best virtual talent *connected* to their country, it becomes a disruption like the one we have seen in the music industry," he said. "And it's basically a zero-cost project, because we already have this infrastructure for our own people."

The program that resulted is called e-residency, and it permits citizens of another country to become residents of Estonia without ever visiting the place. An e-resident has no leg up at the customs desk, but the program allows individuals to tap into Estonia's digital services from afar.

I applied for Estonian e-residency one recent morning at my apartment, and it took about ten minutes. The application cost a hundred euros, and the hardest part was finding a passport photograph to upload, for my card. After approval, I would pick up my credentials in person, like a passport, at the Estonian Consulate in New York.

This physical task proved to be the main stumbling block, Ott Vatter, the deputy director of e-residency, explained, because consulates were reluctant to expand their workload to include a new document. Mild xenophobia made some Estonians at home wary, too. "Inside Estonia, the mentality is kind of 'What is the gain, and where is the money?' " he said. The physical factor still imposes limitations—only thirty-eight consulates have agreed to issue documents, and they are distributed unevenly. (Estonia has only one embassy in all of Africa.) But the office has made special accommodations for several popular locations. Since there's no Estonian consulate in San Francisco, the New York consulate flies personnel to California every three months to batch-process Silicon Valley applicants.

"I had a deal that I did with Funderbeam, in Estonia," Tim Draper, who became Estonia's second e-resident, told me. "We decided to use a 'smart contract'—the first ever in a venture deal!" Smart contracts are encoded on a digital ledger and, notably, don't require an outside administrative authority. It was an appealing prospect, and Draper, with his market investor's gaze, recognized a new market for élite tech brainpower and capital. "I thought, Wow! Governments are going to have to compete with each other for us," he said.

So far, twenty-eight thousand people have applied for e-residency, mostly from neighboring countries: Finland and Russia. But Italy and Ukraine follow, and U.K. applications spiked during Brexit. (Many applicants are footloose entrepreneurs or solo venders who want to be based in the E.U.) Because eighty-eight per cent of applicants are men, the United Nations has begun seeking applications for female entrepreneurs in India.

"There are so many companies in the world for whom working across borders is a big hassle and a source of expense," Siim Sikkut, Estonia's current C.I.O., says. Today, in Estonia, the weekly e-residency application rate exceeds the birth rate. "We tried to make more babies, but it's not that easy," he explained.

With so many businesses abroad, Estonia's startup-ism hardly leaves an urban trace. I went to visit one of the places it does show: a co-working space, Lift99, in a complex called the Telliskivi Creative City. The Creative City, a former industrial park, is draped with trees and framed by buildings whose peeling exteriors have turned the yellows of a worn-out sponge. There are murals, outdoor sculptures, and bills for coming shows; the space is shaped by communalism and by the spirit of creative unrule. One art work consists of stacked logs labelled with Tallinn startups: Insly, LeapIN, Photry, and something called 3D Creationist.

The office manager, Elina Kaarneem, greeted me near the entrance. "Please remove your shoes," she said. Lift99, which houses thirty-two companies and five freelancers, had industrial windows, with a two-floor open-plan workspace. Both levels also included smaller rooms named for techies who had done business with Estonia. There was a Zennström Room, after Niklas Zennström, the Swedish entrepreneur who co-founded Skype, in Tallinn. There was a Horowitz Room, for the venture capitalist Ben Horowitz, who has invested in Estonian tech. There was also a Tchaikovsky Room,

because the composer had a summer house in Estonia and once said something nice about the place.

"This is not the usual co-working space, because we choose every human," Ragnar Sass, who founded Lift99, exclaimed in the Hemingway Room. Hemingway, too, once said something about Estonia; a version of his pronouncement—"No well-run yacht basin is complete without at least two Estonians"—had been spray-stencilled on the wall, along with his face.

The room was extremely small, with two cushioned benches facing each other. Sass took one; I took the other. "Many times, a miracle can happen if you put talented people in one room," he said as I tried to keep my knees inside my space. Not far from the Hemingway Room, Barack Obama's face was also on a wall. Obama Rooms are booths for making cell-phone calls, following something he once said about Estonia. ("I should have called the Estonians when we were setting up our health-care Web site.") That had been stencilled on the wall as well.

Some of the companies at Lift99 are local startups, but others are international firms seeking an Estonian foothold. In something called the Draper Room, for Tim Draper, I met an Estonian engineer, Margus Maantoa, who was launching the Tallinn branch of the German motion-control company Trinamic. Maantoa shares the room with other companies, and, to avoid disturbing them, we went to the Iceland Room. (Iceland was the first country to recognize Estonian independence.) The seats around the table in the Iceland Room were swings.

I took a swing, and Maantoa took another. He said, "I studied engineering and physics in Sweden, and then, seven years ago, I moved back to Estonia because so much is going on." He asked whether I wanted to talk with his boss, Michael Randt, at the Trinamic headquarters, in Hamburg, and I said that I did, so he opened his laptop and set up a conference call on Skype. Randt was sitting at a table, peering down at us as if we were a mug of coffee. Tallinn had a great talent pool, he said: "Software companies are absorbing a lot of this labor, but, when it comes to hardware, there are only a few companies around." He was an e-resident, so opening a Tallinn office was fast.

Maantoa took me upstairs, where he had a laboratory space that looked like a janitor's closet. Between a water heater and two large air ducts, he had set up a desk with a 3-D

printer and a robotic motion-control platform. I walked him back to Draper and looked up another startup, an Estonian company called Ööd, which makes one-room, two-hundred-square-foot huts that you can order prefab. The rooms have floor-to-ceiling windows of one-way glass, climate control, furniture, and lovely wood floors. They come in a truck and are dropped into the countryside.

"Sometimes you want something small, but you don't want to be in a tent," Kaspar Kägu, the head of Ööd sales, explained. "You want a shower in the morning and your coffee and a beautiful landscape. Fifty-two per cent of Estonia is covered by forestland, and we're rather introverted people, so we want to be—uh, *not* near everybody else." People of a more sociable disposition could scatter these box homes on their property, he explained, and rent them out on services like Airbnb.

"We like to go to nature—but comfortably," Andreas Tiik, who founded Ööd with his carpenter brother, Jaak, told me. The company had queued preorders from people in Silicon Valley, who also liked the idea, and was tweaking the design for local markets. "We're building a sauna in it," Kägu said.

In the U.S., it is generally assumed that private industry leads innovation. Many ambitious techies I met in Tallinn, though, were leaving industry to go work for the state. "If someone had asked me, three years ago, if I could imagine myself working for the government, I would have said, 'Fuck no,' " Ott Vatter, who had sold his own business, told me. "But I decided that I could go to the U.S. at any point, and work in an average job at a private company. This is so much bigger."

The bigness is partly inherent in the government's appetite for large problems. In Tallinn's courtrooms, judges' benches are fitted with two monitors, for consulting information during the proceedings, and case files are assembled according to the once-only principle. The police make reports directly into the system; forensic specialists at the scene or in the lab do likewise. Lawyers log on—as do judges, prison wardens, plaintiffs, and defendants, each through his or her portal. The Estonian courts used to be notoriously backlogged, but that is no longer the case.

"No one was able to say whether we should increase the number of courts or increase the number of judges," Timo Mitt, a manager at Netgroup, which the government hired to build the architecture, told me. Digitizing both streamlined the process and

helped identify points of delay. Instead of setting up prisoner transport to trial—fraught with security risks—Estonian courts can teleconference defendants into the courtroom from prison.

For doctors, a remote model has been of even greater use. One afternoon, I stopped at the North Estonia Medical Center, a hospital in the southwest of Tallinn, and met a doctor named Arkadi Popov in an alleyway where ambulances waited in line.

"Welcome to our world," Popov, who leads emergency medical care, said grandly, gesturing with pride toward the chariots of the sick and maimed. "Intensive care!"

In a garage where unused ambulances were parked, he took an iPad Mini from the pocket of his white coat, and opened an "e-ambulance" app, which Estonian paramedics began using in 2015. "This system had some childhood diseases," Popov said, tapping his screen. "But now I can say that it works well."

E-ambulance is keyed onto X-Road, and allows paramedics to access patients' medical records, meaning that the team that arrives for your chest pains will have access to your latest cardiology report and E.C.G. Since 2011, the hospital has also run a telemedicine system—doctoring at a distance—originally for three islands off its coast. There were few medical experts on the islands, so the E.M.S. accepted volunteer paramedics. "Some of them are hotel administrators, some of them are teachers," Popov said. At a command center at the hospital in Tallinn, a doctor reads data remotely.

"On the screen, she or he can see all the data regarding the patient—physiological parameters, E.C.G.s," he said. "Pulse, blood pressure, temperature. In case of C.P.R., our doctor can see how deep the compression of the chest is, and can give feedback." The e-ambulance software also allows paramedics to pre-register a patient en route to the hospital, so that tests, treatments, and surgeries can be prepared for the patient's arrival.

To see what that process looks like, I changed into scrubs and a hairnet and visited the hospital's surgery ward. Rita Beljuskina, a nurse anesthetist, led me through a wide hallway lined with steel doors leading to the eighteen operating theatres. Screens above us showed eighteen columns, each marked out with twenty-four hours. Surgeons book their patients into the queue, Beljuskina explained, along with urgency levels and any

machinery or personnel they might need. An on-call anesthesiologist schedules them in order to optimize the theatres and the equipment.

"Let me show you how," Beljuskina said, and led me into a room filled with medical equipment and a computer in the corner. She logged on with her own I.D. If she were to glance at any patient's data, she explained, the access would be tagged to her name, and she would get a call inquiring why it was necessary. The system also scans for drug interactions, so if your otolaryngologist prescribes something that clashes with the pills your cardiologist told you to take, the computer will put up a red flag.

The putative grandfather of Estonia's digital platform is Tarvi Martens, an enigmatic systems architect who today oversees the country's digital-voting program from a stone building in the center of Tallinn's Old Town. I went to visit him one morning, and was shown into a stateroom with a long conference table and French windows that looked out on the trees. Martens was standing at one window, with his back to me, commander style. For a few moments, he stayed that way; then he whirled around and addressed a timid greeting to the buttons of my shirt.

Martens was wearing a red flannel button-down, baggy jeans, black socks, and the sort of sandals that are sold at drugstores. He had gray stubble, and his hair was stuck down on his forehead in a manner that was somehow both rumpled and flat. This was the busiest time of the year, he said, with the fall election looming. He appeared to run largely on caffeine and nicotine; when he put down a mug of hot coffee, his fingers shook.

For decades, he pointed out, digital technology has been one of Estonia's first recourses for public ailments. A state project in 1970 used computerized data matching to help singles find soul mates, "for the good of the people's economy." In 1997, the government began looking into newer forms of digital documents as a supplement.

"They were talking about chip-equipped bar codes or something," Martens told me, breaking into a nerdy snicker-giggle. "Totally ridiculous." He had been doing work in cybernetics and security as a private-sector contractor, and had an idea. When the cards were released, in 2002, Martens became convinced that they should be both mandatory and cheap.

"Finland started two years earlier with an I.D. card, but it's still a sad story," he said. "Nobody uses it, because they put a hefty price tag on the card, and it's a voluntary document. We sold it for ten euros at first, and what happened? Banks and application providers would say, 'Why should I support this card? Nobody has it.' It was a dead end." In what may have been the seminal insight of twenty-first-century Estonia, Martens realized that whoever offered the most ubiquitous and secure platform would run the country's digital future—and that it should be an elected leadership, not profit-seeking Big Tech. "The only thing was to push this card to the people, without them knowing what to do with it, and then say, 'Now people have a card. Let's start some applications,' " he said.

The first "killer application" for the I.D.-card-based system was the one that Martens still works on: i-voting, or casting a secure ballot from your computer. Before the first i-voting period, in 2005, only five thousand people had used their card for anything. More than nine thousand cast an i-vote in that election, however—only two per cent of voters, but proof that online voting was attracting users—and the numbers rose from there. As of 2014, a third of all votes have been cast online.

That year, seven Western researchers published a study of the i-voting system which concluded that it had "serious architectural limitations and procedural gaps." Using an open-source edition of the voting software, the researchers approximated a version of the i-voting setup in their lab and found that it was possible to introduce malware. They were not convinced that the servers were entirely secure, either.

Martens insisted that the study was "ridiculous." The researchers, he said, gathered data with "a lot of assumptions," and misunderstood the safeguards in Estonia's system. You needed both the passwords and the hardware (the chip in your I.D. card or, in the newer "mobile I.D." system, the sim card in your phone) to log in, blocking most paths of sabotage. Estonian trust was its own safeguard, too, he told me. Earlier this fall, when a Czech research team found a vulnerability in the physical chips used in many I.D. cards, Siim Sikkut, the Estonian C.I.O., e-mailed me the finding. His office announced the vulnerability, and the cards were locked for a time. When Sikkut held a small press conference, reporters peppered him with questions: What did the government gain from disclosing the vulnerability? How disastrous *was* it?

Sikkut looked bemused. Many upgrades to phones and computers resolve vulnerabilities that have never even been publicly acknowledged, he said—and think how much data we entrust to those devices. ("There is no government that knows more about you than Google or Facebook," Taavi Kotka says dryly.) In any case, the transparency seemed to yield a return; a poll conducted after the chip flaw was announced found that trust in the system had fallen by just three per cent.

From time to time, Russian military jets patrolling Estonia's western border switch off their G.P.S. transponders and drift into the country's airspace. What follows is as practiced as a pas de deux at the Bolshoi. NATO troops on the ground scramble an escort. Estonia calls up the Russian Ambassador to complain; Russia cites an obscure error. The dance lets both parties show that they're alert, and have not forgotten the history of place.

Since the eleventh century, Estonian land has been conquered by Russia five times. Yet the country has always been an awkward child of empire, partly owing to its proximity to other powers (and their airwaves) and partly because the Estonian language, which belongs to the same distinct Uralic family as Hungarian and Finnish, is incomprehensible to everyone else. Plus, the greatest threat, these days, may not be physical at all. In 2007, a Russian cyberattack on Estonia sent everything from the banks to the media into chaos. Estonians today see it as the defining event of their recent history.

The chief outgrowth of the attack is the NATO Coöperative Cyber Defense Center of Excellence, a think tank and training facility. It's on a military base that once housed the Soviet Army. You enter through a gatehouse with gray walls and a pane of mirrored one-way glass.

"Document, please!" the mirror boomed at me when I arrived one morning. I slid my passport through on a tray. The mirror was silent for two full minutes, and I backed into a plastic chair.

"You have to wait here!" the mirror boomed back.

Some minutes later, a friendly staffer appeared at the inner doorway and escorted me across a quadrangle trimmed with NATO-member flags and birch trees just fading to

gold. Inside a gray stone building, another mirror instructed me to stow my goods and to don a badge. Upstairs, the center's director, Merle Maigre, formerly the national-security adviser to the Estonian President, said that the center's goal was to guide other NATO nations toward vigilance.

"This country is located—just where it is," she said, when I asked about Russia. Since starting, in 2008, the center has done research on digital forensics, cyber-defense strategy, and similar topics. (It publishes the "Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations" and organizes a yearly research conference.) But it is best known for its training simulations: an eight-hundred-person cyber "live-fire" exercise called Locked Shields was run this year alongside CYBRID, an exercise for defense ministers of the E.U. "This included aspects such as fake news and social media," Maigre said.

Not all of Estonia's digital leadership in the region is as openly rehearsed. Its experts have consulted on Georgia's efforts to set up its own digital registry. Estonia is also building data partnerships with Finland, and trying to export its methods elsewhere across the E.U. "The vision is that I will go to Greece, to a doctor, and be able to get everything," Toomas Ilves explains. Sandra Roosna, a member of Estonia's E-Governance Academy and the author of the book "eGovernance in Practice," says, "I think we need to give the European Union two years to do cross-border transactions and to recognize each other digitally." Even now, though, the Estonian platform has been adopted by nations as disparate as Moldova and Panama. "It's very popular in countries that want—and not all do—transparency against corruption," Ilves says.

Beyond X-Road, the backbone of Estonia's digital security is a blockchain technology called K.S.I. A blockchain is like the digital version of a scarf knitted by your grandmother. She uses one ball of yarn, and the result is continuous. Each stitch depends on the one just before it. It's impossible to remove part of the fabric, or to substitute a swatch, without leaving some trace: a few telling knots, or a change in the knit.

In a blockchain system, too, every line is contingent on what came before it. Any breach of the weave leaves a trace, and trying to cover your tracks leaves a trace, too. "Our No. 1 marketing pitch is Mr. Snowden," Martin Ruubel, the president of Guardtime, the Estonian company that developed K.S.I., told me. (The company's

biggest customer group is now the U.S. military.) Popular anxiety tends to focus on data security—who can see my information?—but bits of personal information are rarely truly compromising. The larger threat is data integrity: whether what looks secure has been changed. (It doesn't really matter who knows what your blood type is, but if someone switches it in a confidential record your next trip to the emergency room could be lethal.) The average time until discovery of a data breach is two hundred and five days, which is a huge problem if there's no stable point of reference. "In the Estonian system, you don't have paper originals," Ruubel said. "The question is: Do I know about this problem, and how quickly can I react?"

The blockchain makes every footprint immediately noticeable, regardless of the source. (Ruubel says that there is no possibility of a back door.) To guard secrets, K.S.I. is also able to protect information without "seeing" the information itself. But, to deal with a full-scale cyberattack, other safeguards now exist. Earlier this year, the Estonian government created a server closet in Luxembourg, with a backup of its systems. A "data embassy" like this one is built on the same body of international law as a physical embassy, so that the servers and their data are Estonian "soil." If Tallinn is compromised, whether digitally or physically, Estonia's locus of control will shift to such mirror sites abroad.

"*If* Russia comes—not when—and if our systems shut down, we will have copies," Piret Hirv, a ministerial adviser, told me. In the event of a sudden invasion, Estonia's elected leaders might scatter as necessary. Then, from cars leaving the capital, from hotel rooms, from seat 3A at thirty thousand feet, they will open their laptops, log into Luxembourg, and—with digital signatures to execute orders and a suite of tamper-resistant services linking global citizens to their government—continue running their country, with no interruption, from the cloud.

The history of nationhood is a history of boundaries marked on land. When, in the fourteenth century, peace arrived after bloodshed among the peoples of Mexico's eastern altiplano, the first task of the Tlaxcaltecs was to set the borders of their territory. In 1813, Ernst Moritz Arndt, a German nationalist poet before there was a Germany to be nationalistic about, embraced the idea of a "Vaterland" of shared history: "Which is the German's fatherland? / So tell me now at last the land!— / As far's the German's accent rings / And hymns to God in heaven sings."

Today, the old fatuities of the nation-state are showing signs of crisis. Formerly imperialist powers have withered into nationalism (as in Brexit) and separatism (Scotland, Catalonia). New powers, such as the Islamic State, have redefined nationhood by ideological acculturation. It is possible to imagine a future in which nationality is determined not so much by where you live as by what you log on to.

Estonia currently holds the presidency of the European Union Council—a bureaucratic role that mostly entails chairing meetings. (The presidency rotates every six months; in January, it will go to Bulgaria.) This meant that the autumn's E.U. Digital Summit was held in Tallinn, a convergence of audience and expertise not lost on Estonia's leaders. One September morning, a car pulled up in front of the Tallinn Creative Hub, a former power station, and Kersti Kaljulaid, the President of Estonia, stepped out. She is the country's first female President, and its youngest. Tall and lanky, with chestnut hair in a pixie cut, she wore an asymmetrical dress of Estonian blue and machine gray. Kaljulaid took office last fall, after Estonia's Presidential election yielded no majority winner; parliamentary representatives of all parties plucked her out of deep government as a consensus candidate whom they could all support. She had previously been an E.U. auditor.

"I am President to a digital society," she declared in her address. The leaders of Europe were arrayed in folding chairs, with Angela Merkel, in front, slumped wearily in a red leather jacket. "Simple people suffer in the hands of heavy bureaucracies," Kaljulaid told them. "We must go for inclusiveness, not high end. And we must go for reliability, not complex."

Kaljulaid urged the leaders to consider a transient population. Theresa May had told her people, after Brexit, "If you believe you're a citizen of the world, you're a citizen of nowhere." With May in the audience, Kaljulaid staked out the opposite view. "Our citizens will be global soon," she said. "We have to fly like bees from flower to flower to gather those taxes from citizens working in the morning in France, in the evening in the U.K., living half a year in Estonia and then going to Australia." Citizens had to remain connected, she said, as the French President, Emmanuel Macron, began nodding vigorously and whispering to an associate. When Kaljulaid finished, Merkel came up to the podium.

"You're so much further than we are," she said. Later, the E.U. member states announced an agreement to work toward digital government and, as the Estonian Prime Minister put it in a statement, "rethink our entire labor market."

Before leaving Tallinn, I booked a meeting with Marten Kaevats, Estonia's national digital adviser. We arranged to meet at a café near the water, but it was closed for a private event. Kaevats looked unperturbed. "Let's go somewhere beautiful!" he said. He led me to an enormous terraced concrete platform blotched with graffiti and weeds.

We climbed a staircase to the second level, as if to a Mayan plateau. Kaevats, who is in his thirties, wore black basketball sneakers, navy trousers, a pin-striped jacket from a different suit, and a white shirt, untucked. The fancy dress was for the digital summit. "I have to introduce the President of Estonia," he said merrily, crabbing a hand through his strawberry-blond hair, which stuck out in several directions. "I don't know what to say!" He fished a box of Marlboro Reds out of his pocket and tented into himself, twitching a lighter.

It was a cloudless morning. Rounded bits of gravel in the concrete caught a glare. The structure was bare and weather-beaten, and we sat on a ledge above a drop facing the harbor. The Soviets built this "Linnahall," originally as a multipurpose venue for sailing-related sports of the Moscow Summer Olympics. It has fallen into disrepair, but there are plans for renovation soon.

For the past year, Kaevats's main pursuit has been self-driving cars. "It basically embeds all the difficult questions of the digital age: privacy, data, safety—everything," he said. It's also an idea accessible to the man and woman (literally) in the street, whose involvement in regulatory standards he wants to encourage. "What's difficult is the ethical and emotional side," he said. "It's about values. What do we want? Where are the borders? Where are the red lines? These cannot be decisions made only by specialists."

To support that future, he has plumbed the past. Estonian folklore includes a creature known as the *kratt:* an assembly of random objects that the Devil will bring to life for you, in exchange for a drop of blood offered at the conjunction of five roads. The Devil gives the *kratt* a soul, making it the slave of its creator.

"Each and every Estonian, even children, understands this character," Kaevats said. His office now speaks of *kratt* instead of robots and algorithms, and has been using the word to define a new, important nuance in Estonian law. "Basically, a *kratt* is a robot with representative rights," he explained. "The idea that an algorithm can buy and sell services *on your behalf* is a conceptual upgrade." In the U.S., where we lack such a distinction, it's a matter of dispute whether, for instance, Facebook is responsible for algorithmic sales to Russian forces of misinformation. #KrattLaw—Estonia's digital shorthand for a new category of legal entity comprising A.I., algorithms, and robots—will make it possible to hold accountable whoever gave a drop of blood.

"In the U.S. recently, smart toasters and Teddy bears were used to attack Web sites," Kaevats said. "Toasters should not be making attacks!" He squatted and emptied a pocket onto the ledge: cigarettes, lighter, a phone. "Wherever there's a smart device, around it there are other smart devices," he said, arranging the items on the concrete. "This smart street light"—he stood his lighter up—"asks the self-driving car"—he scooted his phone past it—" 'Are you O.K.? Is everything O.K. with you?' "The Marlboro box became a building whose appliances made checks of their own, scanning one another for physical and blockchain breaches. Such checks, device to device, have a distributed effect. To commandeer a self-driving car on a street, a saboteur would, in theory, also have to hack every street lamp and smart toaster that it passed. This "mesh network" of devices, Kaevats said, will roll out starting in 2018.

Is everything O.K. with you? It's hard to hear about Estonians' vision for the robots without thinking of the people they're blood-sworn to serve. I stayed with Kaevats on the Linnahall for more than an hour. He lit several cigarettes, and talked excitedly of "building a digital society." It struck me then how long it had been since anyone in America had spoken of society-building of any kind. It was as if, in the nineties, Estonia and the U.S. had approached a fork in the road to a digital future, and the U.S. had taken one path—personalization, anonymity, information privatization, and competitive efficiency—while Estonia had taken the other. Two decades on, these roads have led to distinct places, not just in digital culture but in public life as well.

Kaevats admitted that he didn't start out as a techie for the state. He used to be a protester, advocating cycling rights. It had been dispiriting work. "I felt as if I was constantly beating my head against a big concrete wall," he said. After eight years, he

began to resent the person he'd become: angry, distrustful, and negative, with few victories to show.

"My friends and I made a conscious decision then to say 'Yes' and not 'No'—to be proactive rather than destructive," he explained. He started community organizing ("analog, not digital") and went to school for architecture, with an eye to structural change through urban planning. "I did that for ten years," Kaevats said. Then he found architecture, too, frustrating and slow. The more he learned of Estonia's digital endeavors, the more excited he became. And so he did what seemed the only thing to do: he joined his old foe, the government of Estonia.

Kaevats told me it irked him that so many Westerners saw his country as a tech haven. He thought they were missing the point. "This enthusiasm and optimism around technology is like a value of its own," he complained. "This gadgetry that I've been ranting about? This is not *important*." He threw up his hands, scattering ash. "It's about the mind-set. It's about the culture. It's about the human relations—what it enables us to *do*."

Seagulls riding the surf breeze screeched. I asked Kaevats what he saw when he looked at the U.S. Two things, he said. First, a technical mess. Data architecture was too centralized. Citizens didn't control their own data; it was sold, instead, by brokers. Basic security was lax. "For example, I can tell you my I.D. number—I don't fucking care," he said. "You have a Social Security number, which is, like, a big secret." He laughed. "This does not work!" The U.S. had backward notions of protection, he said, and the result was a bigger problem: a systemic loss of community and trust. "Snowden things and whatnot have done a lot of damage. But they have also proved that these fears are justified.

"To regain this trust takes quite a lot of time," he went on. "There also needs to be a vision from the political side. It needs to be there always—a policy, not politics. But the politicians need to live it, because, in today's world, everything will be public at some point."

We gazed out across the blinding sea. It was nearly midday, and the morning shadows were shrinking to islands at our feet. Kaevats studied his basketball sneakers for a

moment, narrowed his eyes under his crown of spiky hair, and lifted his burning cigarette with a smile. "You need to constantly be who you are," he said. ♦

This article appears in the print edition of the December 18 & 25, 2017, issue, with the headline "The Digital Republic."

Nathan Heller began contributing to The New Yorker in 2011, and joined the magazine as a staff writer in 2013. *Read more »*

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