TRANSFORMATIVE TECHNOLOGIES AND JOBS OF THE FUTURE

Background report for the Canadian G7 Innovation Ministers’ Meeting

MONTREAL, CANADA 27-28 MARCH 2018
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List of acronyms

AI     artificial intelligence
GB    gigabyte
GDP   gross domestic product
ICT   information and communication technology
IoT   Internet of Things
IP    intellectual property
IPS   Five Intellectual Property Offices
NEET  not in employment, education or training
NFI   Nouvelle France industrielle
NSS   National Security Strategy (United States)
R&D   research and development
R&I   research and innovation
SMEs  small and medium-sized enterprises
STEM  Science, technology, engineering and mathematics
Summary and recommendations

This report focuses on the impacts of digital transformation on jobs and productivity and is intended as an input to discussion in the G7 Innovation Ministers track of the 2018 G7 Innovation and Employment Ministerial “Preparing for Jobs of the Future”. It complements the Discussion Note on the Future of Work prepared by the OECD to support the parallel meeting of G7 Employment Ministers, which looks specifically at how policies and practices designed for a world of work of the 20th century need to be adapted to ensure fair and rewarding employment opportunities for all in the future.

The G7 has an important role to play in raising awareness of the transformation underway and can share experiences on how best to exploit the opportunities while effectively addressing the challenges. Such an exchange could focus on the design, implementation and evaluation of policies. The OECD can assist in this exchange and act as a clearing house in the dissemination of evidence and best practices.

Beyond information sharing, the G7 can work on shared challenges that are international in nature. Four have risen up on the policy agenda: i) ensuring the strongest possible benefits of transformative technologies on economies and societies, including the growing importance of data; ii) developing a common approach to artificial intelligence (AI); iii) fostering inclusive innovation; and iv) preparing for the jobs of the future. There is also an overarching need to enhance measurement of the digital transformation so that an evidence base is established for effective policy making across these four policy challenges. The OECD stands ready to contribute to G7 discussions, facilitate further dialogue with stakeholders and support the implementation of evidence-based policies in these areas. Key messages from the report follow below.

The impact of transformative technologies on economies and societies

- **A wide-ranging digital transformation** is underway, affecting all economic sectors, characterised by almost universal connectivity and ubiquitous computing, and drawing on the generation and utilisation of vast amounts of data.

- This transformation has positive **impacts on productivity** for many firms, but has not yet translated into stronger productivity growth at the economy-wide level. Larger impacts could result from policy efforts to foster a more wide-spread diffusion of digital technologies to all firms, notably to small and medium-sized enterprises (SMEs); greater investments in critical complementary assets such as firm-level skills, organisational change and process innovation; as well as support for further structural change to enable the growth of new business models and digitally-intensive businesses.

- The wide scope of technological changes creates significant **uncertainty** about their future directions and impacts. Indeed, predictions about technological timelines are often inaccurate and overestimation of their short-run impacts is common.

- The list of transformative technologies is long, but some technologies have the potential to be particularly **far-reaching**, notably AI, the Internet of Things (IoT) and blockchain. These three transformative technologies present some common features, notably their dependence on large data sets and a range of digital technologies. They also have a strong potential to improve the design, implementation and evaluation of public policies.

- **Greater technology convergence** can be supported by cross-disciplinary co-operation, such as interdisciplinary research and development (R&D) and training. More needs to be done in G7 countries to overcome long-established mono-disciplinary institutional and organisational arrangements for funding and performing R&D. New cross-disciplinary spaces, e.g. clusters, can support such convergence.

- **Public sector research** is often critical in supporting the development of transformative technologies. Emerging technologies carry several risks and uncertainties, and many also raise ethical issues.
TRANSFORMATIVE TECHNOLOGIES AND JOBS OF THE FUTURE

- Not only the development but the **effective diffusion of technology** is important. Certain institutions, such as technology extension services, can play an important role in supporting the diffusion process but tend to receive low priority in existing innovation policies.

- **Data is the essence of the digital transformation** and increasingly underpins trade and the global economy, as well as science and innovation. Countries have different approaches to digital security risk management and privacy, as well as common challenges in bringing their regulatory environments up to speed with the digital age. The value of multilateral and multi-stakeholder discussion on data and its governance cannot be underestimated.

**Artificial intelligence**

- The **international debate on AI** has gained significant momentum in recent years. In the Takamatsu Ministerial Declaration of April 2016 (G7, 2016), G7 ICT Ministers agreed on the need to facilitate R&D and the adoption of emerging technologies including AI, and to ensure policy frameworks take into account the broader societal and economic implications of such technologies as they are developed.

- In September 2017, G7 ICT and Industry Ministers in Turin committed to a multi-stakeholder exchange on human centric AI for societies, reiterating the need for further information sharing and discussion to deepen the understanding of the broader potential effects of AI technologies on society and economies, ranging from issues of privacy, transparency and accountability, to ethics, job creation and cybersecurity, and to explore multi-stakeholder approaches to AI-related policy and regulatory issues. G7 countries agreed to continue to lead the effort towards a socially beneficial AI, with the support of the OECD.

- OECD work shows that AI is not constrained to the digital world, with significant patenting activity taking place also in sectors such as transport and machinery, and with wide potential for deployment in a range of services such as healthcare and finance. Reaping the benefits of AI will require policy action in a number of fields, however, and education and training systems will need to ensure young people and in-work adults are equipped with the right skills to perform in an AI-enabled environment.

**Inclusive innovation**

- In 2016, between 73% and 98% of adults in G7 countries accessed the Internet, with access almost universal in Japan and the United Kingdom. But despite the rapid uptake of digital technologies, **divides remain**, and the uptake of digital technologies still differs by age, geography, education and income levels, although these gaps are closing with time.

- **Gender** is particularly important in ensuring an inclusive transformation. Although women are underrepresented in many areas of the digital transformation, there are also new opportunities to empower women and strengthen their position in the labour market and in driving the digital transformation.

- **Skills** provide an important safeguard against the risk of automation. Fewer than 5% of workers with a tertiary degree are at a high risk of losing their job due to automation compared to 40% of workers with a lower secondary degree. To thrive in the digital era, all workers will need to be equipped with a wide set of skills, encompassing cognitive as well as non-cognitive and social skills (notably information and communication technology [ICT] skills; science, technology, engineering and mathematics [STEM] skills; and self-organisation skills).

- Beyond these general initiatives, **measures targeted at underrepresented groups** will be needed. This includes not only women, but also indigenous people, early school leavers; those not in employment, education or training (NEETs), long-term unemployed and unemployed youth, as well as ethnic minorities, many of whom display a lower level of skill endowments.
Digital technologies can potentially also *promote social inclusion* by creating better access to quality education, offer new opportunities for skills development, enhance access to health care, or improve access to free and low-cost information, knowledge and data.

Enhancing access to technology to all groups in society can help *ensure inclusive innovation*, as can the application of new technologies for enhanced well-being. Industry and innovation policies in G7 countries can also help, in particular if these engage SMEs and sub-national regions.

While *SMEs face challenges in the use of ICT, they also have important opportunities*, such as the development of small firms that are "born global" (for instance, with owners located in several countries), global e-commerce, better access to a range of financing instruments, or the outsourcing of key business functions, all of which can help improve performance.

As the *digital economy may exacerbate geographic disparities* in income, regional and local development policies are important in ensuring inclusive growth.

More generally, inclusive innovation calls for *inclusive, anticipatory governance of technological change* that includes assessment of benefits and costs and an active shaping of future development. Such governance arrangements remain under-developed in G7 countries.

**Preparing for jobs of the future**

OECD estimates suggest that about 14% of workers are at a high risk of having most of their existing tasks automated over the next 15 years. Another 30% will face major changes in the tasks required in their job and, consequently, the skills required. About *half of all workers* will confront the need to significantly adapt to the new workplace environment.

While there is uncertainty about the speed of these changes, it is clear that *the types of jobs that are being created are not the same as those that are being lost*. Moreover, the workers affected by job loss in declining activities may not be those benefitting from the new job opportunities emerging in expanding areas.

Labour markets appear to be polarising, with middle-skilled jobs declining and low- and high-skilled jobs growing. Going forward, low-skilled workers are most likely to bear the costs of digital transformation, but are currently the least likely to receive training.

In particular, policy will need to facilitate worker redeployment, invest in skills, strengthen social protection, future-proof labour market regulations and promote social dialogue:

- **Facilitating worker redeployment.** Adapting to technological progress will require policies facilitating the redeployment of workers across businesses, industries and regions.
- **Investing in skills.** People, especially youth, need to prepare for the jobs of the future by being equipped with the right mix of skills required to successfully navigate ever-changing, technology-rich work environments. Skills development is not just about schools, but increasingly involves *lifelong learning* that requires re-thinking and better targeting and incentivising the beneficiaries of training programmes.
- **Strengthening social protection.** Adequate social protection is crucial to help workers transit smoothly between jobs, especially when they have been displaced.
- **Future-proofing labour market regulation.** Maintaining and improving labour market performance in the future world of work also requires a fresh look at existing labour market regulations to ensure that they are still fit for purpose.
- **Fostering social dialogue.** The future world of work can be shaped more easily and effectively if employers, workers and their representatives work closely together with governments in a spirit of co-operation and mutual trust.
A people-centred “adaptation agenda” needs to be formulated so that all individuals may benefit from a positive, forward-looking plan that does not leave anybody behind and puts welfare at the forefront. This is akin to the Nordic “flexi-security” approach but needs to be adapted to the institutions, history and norms of individual countries.

**Improving measurement of the digital transformation**

**Better understanding** the likely scope of the digital transformation, the sectors, jobs and regions likely to be affected, as well as the likely time frame, can help in devising better policies. The evidence base is lacking in many areas, including the uptake of digital technologies; the growth of the gig economy; or the impacts on productivity. The **growing role of data**, including in international trade, is a particularly important area where sound data (i.e. “data on data flows”) is lacking. Improving data and statistics on these questions could be an important contribution of the G7.
1. Setting the scene

G7 countries are in transition towards a digital economy and society. In contrast to some of the popular rhetoric, this digital transformation is not new and has been underway for nearly half a century. The impacts of ICT have already contributed to significant structural changes and productivity gains that many firms in G7 countries have successfully reaped. The main difference with earlier eras of digital transformation are three demarcations that have propelled this issue to the top of the agenda in the G7, the G20, the OECD and many other international fora.

The first is the expansion of connectivity to almost every firm in the G7. Already 95% of firms in G7 countries have a high-speed connection to the Internet. Although there are still large differences in digital intensity across sectors (OECD, 2017a), every firm in every sector in the economy is now being affected by the digital transformation, expanding its scope and its potential benefits.

The second has been the advent of the “always connected” smart phone and with it the era of universal connectivity and ubiquitous computing. By June 2017, Japan led the G7 (and the OECD countries) with 157 mobile broadband subscriptions per 100 inhabitants (Figure 1). This trend towards increased connectivity is expected to further expand as more objects are connected to networks (the IoT).

Figure 1. Mobile broadband subscriptions and mobile data usage in G7 countries

Third, these devices and many of the services that operate on the open architecture of the Internet generate vast amounts of data. In the well-connected Nordic countries, for example, monthly data flows per mobile subscriber have grown by 60% between 2014 and 2016 in Sweden, 180% in Denmark and 185% in Finland where the average monthly usage is nearly 11 gigabytes (GB) (OECD, 2018). These flows are still somewhat lower in the G7 countries (Figure 1), but growing also there. They will grow further as connected devices such as automated vehicles become common.

Data combined with steady advances in the power of computing are leading to the emergence of data-driven innovation: online activity and networked things generate “big data” which feed machine learning that enables AI, which in turn leads to advances in intelligent machines (robotics, automated vehicles) as well as new techniques in science which can spur further innovation. The growth of the volume, variety and velocity of data and the ability to analyse and use it is a significant departure from the past and marks the emergence of a new factor of production that augments traditional capital and labour, but with unique properties of its own.
Whether these changes are of the same magnitude as earlier industrial transformations propelled by general-purpose technologies like steam or electricity, is an open question hotly debated in the academic community. There is a pessimistic view, reflected in some of the work of Robert Gordon (Gordon, 2012), which holds that the recent slowdown is a permanent phenomenon and that the types of innovations that took place in the first half of the 20th century (e.g. electrification) are far more significant than anything that has taken place since then, or indeed, likely to transpire in the future. In his view, future economic growth will slow down further, owing to a number of headwinds related to demography, education, inequality, globalisation, environment and debt. By contrast, others, such as Brynjolfsson and McAfee (2011), take a more optimistic view and argue that the underlying rate of technological progress has not slowed and that the IT revolution will continue to dramatically transform frontier economies.

Long-term trends do point to a slowing down of productivity growth since the 1950s, a time of exceptional productivity growth, when there was significant scope for catch-up growth and the rebuilding of G7 countries following World War II (OECD, 2015a). From 1972 to 1995, productivity growth remained high in most G7 countries as the convergence process continued (Figure 2). From 1995 to 2004, the United States experienced an acceleration in productivity growth, largely reflecting gains associated with the diffusion of ICT technologies, that did not materialise to the same degree in other G7 countries where productivity growth slowed down considerably from previous periods. From the early to mid-2000s onwards, productivity growth has slowed down in all G7 countries, reflecting a mix of cyclical and structural factors. Two key factors are (OECD, 2015a): i) a slowdown in the contribution of capital deepening to gross domestic product (GDP) growth after 2000, which was accentuated during the post-2007 crisis period; and ii) a slowdown in multi-factor productivity growth pre-dating the crisis and continuing since.

**Figure 2. Labour productivity growth in the long run**

*GDP per hour worked, annual average growth*

<table>
<thead>
<tr>
<th>Year Period</th>
<th>Canada</th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Japan</th>
<th>United Kingdom</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-72</td>
<td>0.5</td>
<td>0.6</td>
<td>0.4</td>
<td>0.3</td>
<td>0.7</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>1972-95</td>
<td>0.7</td>
<td>0.8</td>
<td>0.6</td>
<td>0.5</td>
<td>0.9</td>
<td>0.7</td>
<td>0.9</td>
</tr>
<tr>
<td>1995-04</td>
<td>0.9</td>
<td>1.0</td>
<td>0.8</td>
<td>0.7</td>
<td>1.1</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>2004-17</td>
<td>0.8</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Notes: GDP = gross domestic product. The graph shows annual average growth rates for periods that may not correspond to the business cycle in individual G7 countries. Annual growth rates are available in the underlying source.


The potential impacts of the ongoing digital transformation on productivity also need to be considered in the context of this long-term slowdown. Once more, the world “see[s] […] computer[s] everywhere but in the productivity statistics”, to paraphrase Robert Solow (Solow, 1987). While the precise reasons for today’s productivity paradox remain difficult to disentangle, a number of factors are likely to contribute:
• The first factor that has thus far limited the impacts of digital transformation is the state of diffusion of digital technologies across the economy. While many firms now have access to broadband networks, the use of more advanced digital tools and applications within firms still differs greatly across countries, even among G7 countries. For example, only 16% to 17% of firms in France and Germany used cloud computing in 2016, compared to some 45% in Japan (OECD, 2017a). Moreover, there are important differences between firms within countries, with SMEs lagging. As with other periods of rapid technological change, advanced technologies are initially only adopted by some leading firms and then only later diffuse to all firms, as the technologies become more established, new business models grow, and costs fall. Consequently, there is a large gap between what can be automated from a technical point of view (and what may already be implemented by frontier firms) and what is actually being automated by the average firm. OECD research shows that global frontier firms have continued to have strong productivity performance even since the economic crisis, in both manufacturing and services, but also shows that most other firms have not experienced much productivity growth (OECD, 2015a). This divergence is particularly apparent in the ICT services sector (Figure 3).

• Second, digital transformation is not just about the technology, but even more about the essential complementary investments that firms need to make into skills, organisational change, process innovation, new systems and new business models (Haskel and Westlake, 2017). The scale and complexity of these complementary investments may be growing, making digital transformation a challenge for many firms (Brynjolfsson, Rock and Syverson, 2017).

• Third, the limited impacts of digital technologies on productivity are also related to a slow pace of structural change and resource re-allocation in OECD countries. For example, the share of non-viable old firms – firms older than 10 years that record negative profits over at least two consecutive years – has been increasing in many OECD countries, particularly since the 2007-08 financial crisis, while the productivity of the latter group of firms has been falling rapidly relative to “viable” old firms, as well as younger firms in general (Adalet McGowan, Andrews and Millot, 2017; Berlingieri, Blanchenay and Criscuolo, 2017). This has been accompanied by a slowdown in reform efforts to tackle regulations that impede product market competition (OECD, 2017b).

Figure 3. The divergence in multi-factor productivity growth
ICT vs. non-ICT services sector

Panel A: ICT services
- Frontier firms (top 2%)
- Laggards
- Frontier firms (top 10%)

Panel B: Non-ICT services
- Frontier firms (top 2%)
- Laggards
- Frontier firms (top 10%)

Notes: ICT = information and communication technology. This graph represents unweighted averages across two-digit industries normalised to 0 in the starting year. The vertical axes represent log differences from the starting year.

Although the available evidence suggests that the wide-spread benefits of digitalisation on productivity are likely to emerge in the future, policy can help ensure that they do indeed emerge. This will require a set of policy efforts, including policies that can help strengthen investment (in tangible and intangible assets); further structural reform to enable the necessary re-allocation of resources; efforts to foster the diffusion of digital technologies, organisational practices and business models across the economy, notably to SMEs; as well as policies that will ensure sound competition.

Technological change is obviously not the only important factor that is currently driving significant change in the G7. The ageing of populations is already having significant impacts in some G7 countries, notably Japan and Germany, and will have important repercussions on labour force growth, the growth of pension obligations, and a range of other key policies. At the same time, as the economies of G7 countries have strengthened, several are now starting to experience labour shortages, e.g. in certain technical occupations, such as data scientists. Moreover, while the recent financial crisis has now mostly been overcome, it has left the world economy with a range of long-run challenges that need to be addressed, including an overhang of high public and private debt. Shifts in the global economy, notably the growing weight of emerging economies, also affect G7 countries, e.g. in changing patterns of global competitiveness and affecting jobs. For example, OECD estimates show that in 2014, between 14% and 42% of jobs in the business sector in G7 countries were sustained by foreign demand (OECD, 2017a). Moreover, other mega-trends, such as climate change, and growing demand for water, energy and food all also affect the global economy and may contribute to ongoing structural change in the economy, including the growth of certain industries and the decline of others.
2. Transformative technologies

Technological change is also a significant megatrend in its own right, constantly reshaping economies and societies, often in radical ways. The scope of technology – in terms of its form, knowledge bases and application areas – is broad and varied, and the ways it interacts with economies and societies are complex and co-evolutionary. These characteristics create significant uncertainty about the future directions and impacts of technological change. Indeed, predictions about technological timelines – when key developments will arise – are typically inaccurate (Armstrong, Sotala and ÓhÉigeartaigh, 2014). In addition, overestimation of the short-run impacts of new technologies is common. Nanotechnology, for instance, considered revolutionary in the 1980s, has not yet met some of the early expectations (OECD, 2017c). But the digital basis and diversity of recent developments offer opportunities for firms, industries, governments and citizens to shape technology and its adoption.

Technological development can cause multiple forms of disruption, from shifts in the demand for workforce skills, to changes in market structure, the need for new business models, new patterns of trade and investment, novel threats to the (digital) security of business and broader challenges to societal and even political processes. Some potential disruptions could be entirely positive. For instance, recent breakthroughs in materials science – allowing nano-sieves from graphene – might help to address the global challenge of access to clean drinking water.

The list of transformative and potentially transformative technologies is long, from quantum computing and advanced energy storage, to new forms of 3D printing, big data analytics and neurotechnologies (OECD, 2016a). Three technologies are outlined here whose impacts have the potential to be particularly far-reaching: AI, the IoT and blockchain.

Artificial intelligence

AI is the ability of machines and systems to acquire and apply knowledge and carry out intelligent behaviour. Early efforts to develop AI centred on defining rules that software could use to perform a task. Such systems would work on narrowly-defined problems but failed when confronted with more complex tasks such as speech recognition (OECD, 2015b). Increases in computational power, new statistical methods, and advances in big data, have brought major breakthroughs to the field of AI, especially in “vertical” AI like automated vehicles as opposed to “general” AI. With machine learning algorithms that identify complex patterns in large data sets, software applications can perform tasks and simultaneously learn how to improve performance.

AI is not constrained to the digital world. Combined with advances in mechanical and electrical engineering, it has also enlarged the capacity for robots to perform cognitive tasks in the physical world. AI will enable robots to adapt to new working environments with no reprogramming. AI-enabled robots will become increasingly central to logistics and manufacturing, complementing and sometimes displacing human labour in many productive processes (OECD, 2015b). Sectors likely to experience AI-based transformations in production include agriculture, chemicals, oil and coal, rubber and plastics, shoe and textile, transport, construction, defence, and surveillance and security (ITF, 2015; ESPAS, 2015). Data on the world’s top 2 000 R&D firms show that the bulk of AI-related patenting occurs in the computers and electronics industry, but that there is also significant AI patenting activity in the transport equipment, machinery and IT services sectors (OECD, 2017a) (Figure 4).

AI will also be deployed in a wide range of services, including healthcare, entertainment, marketing and finance (OECD, 2017d). AI that recognises human facial expressions and emotions could help to deliver some public services, and possibly educational services (for instance, the New Zealand company Soul Machines has recently developed an AI-based assistant avatar for the Australian government to help the disabled understand and access government services, with facial expressions helping the avatar to identify what vexes or confuses people). And AI could become an important source of new scientific knowledge (for example, an AI-based
machine at Manchester University has independently discovered a compound effective against a major strain of the drug-resistant malaria parasite) and competitive advantage. For example, the McKinsey Global Institute estimates that AI has gained Netflix USD 1 billion in revenues by preventing customer churn (McKinsey Global Institute, 2017).

An essential factor for reaping the benefits of AI is the provision of reliable energy and communication networks, including for the IoT (OECD, 2015c). Therefore, laws and legal frameworks may need to be reconsidered before many of the benefits of AI can be had in fields such as transportation and health (ITF, 2015). Another legal dimension of AI concerns the intellectual property (IP) rights to inventions enabled by AI, and how IP rights and revenues should be shared.

Figure 4. Artificial intelligence patents by top 2 000 R&D companies, by sector, 2012-14

<table>
<thead>
<tr>
<th>Number of IP5 patent families, top 20 industries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top 5 industries</strong></td>
</tr>
<tr>
<td><strong>Number of patents</strong></td>
</tr>
<tr>
<td>Computers and electronic equipment</td>
</tr>
<tr>
<td>Transport equipment</td>
</tr>
<tr>
<td>Machinery</td>
</tr>
<tr>
<td>IT services</td>
</tr>
<tr>
<td>Electrical equipment</td>
</tr>
<tr>
<td>Publishing and broadcasting</td>
</tr>
<tr>
<td>Finance and insurance</td>
</tr>
<tr>
<td>Leisure and hospitality services</td>
</tr>
<tr>
<td>Automotive</td>
</tr>
<tr>
<td>Consumer electronics</td>
</tr>
<tr>
<td>Chemicals</td>
</tr>
<tr>
<td>Telecommunications</td>
</tr>
<tr>
<td>Other materials and minerals</td>
</tr>
<tr>
<td>Wholesale and retail</td>
</tr>
<tr>
<td>Other business services</td>
</tr>
<tr>
<td>Retail and repairs</td>
</tr>
<tr>
<td>Basic materials</td>
</tr>
<tr>
<td><strong>Other industries</strong></td>
</tr>
<tr>
<td><strong>Number of patents</strong></td>
</tr>
</tbody>
</table>

Notes: IT = information technology; IP5 = Five Intellectual Property Offices. Notes to this figure are available at http://dx.doi.org/10.1787/888933617301.

Demand for knowledge workers able to develop AI or to undertake tasks that complement AI will increase. Creative or tacit knowledge, which is less codifiable, and skills requiring social interaction or physical dexterity, which are less easily automatable, are likely to remain in human hands for the next few decades (Brynjolfsson and McAfee, 2015). But education systems will need to ensure that young people, and in-work adults, are equipped with the skills to perform in tomorrow’s AI-enhanced environment (see section 5 of this report).

The international debate on AI has gained significant momentum in recent years. In the Takamatsu Ministerial Declaration of April 2016 (G7, 2016), G7 ICT Ministers agreed on the need to facilitate R&D and the adoption of emerging technologies including AI, and to ensure policy frameworks that take into account the broader societal and economic implications of such technologies as they are developed. In September 2017, G7 ICT and Industry Ministers in Turin committed to a multi-stakeholder exchange on human centric AI for societies, reiterating the need for further information sharing and discussion to deepen the understanding of the broader potential effects of these technologies on society and economies, ranging from issues of privacy, transparency, accountability, to ethics, job creation, cybersecurity, and to explore multi-stakeholder approaches to AI-related policy and regulatory issues. G7 countries agreed to continue to lead the effort towards a socially beneficial AI, with the support of the OECD.
Stakeholders from the private sector, research communities, civil society and trade unions are also actively examining AI-related issues. For example, some of the most active AI companies have engaged in a Partnership on Artificial Intelligence to Benefit People and Society; the IEEE Standards Association has created the Global Initiative for Ethical Considerations in the Design of Autonomous Systems; and AI-focused foundations and institutions are developing. Broad multi-stakeholder consensus is emerging on the need for policy and values to guide AI design and use.

The Internet of Things

The IoT comprises devices and objects whose state can be altered via the Internet (or in local networks), with or without the active involvement of individuals (OECD, 2015c). The networked sensors and actuators in the IoT can serve to monitor the health, location and activities of people and animals and the state of production processes and the natural environment, among many other applications (OECD, 2016b). Development of the IoT is closely related to big data analysis and cloud computing. While the IoT collects and distributes data, cloud computing allows the data to be stored and big data analysis amplifies the power of data processing and data-based decision-making.

The number of connected devices in and around people’s homes in OECD countries could increase from 1 billion in 2016 to around 14 billion by 2022 (OECD, 2015c). While the IoT has many implications for all aspects and sectors of the economy, the largest impacts are expected in healthcare, manufacturing, network industries and government. The IoT is already playing a major role in manufacturing by improving factory operations and managing risk in the supply chain (OECD, 2015c).

How fast and how effectively the IoT will evolve over the next 15 years depends to a large extent on the roll-out of fixed and mobile broadband and the decreasing cost of devices. Some of the most innovative developments will require low-latency 5G networks while the expected increase in volumes from automatic vehicles using such wireless networks, will also require substantial fixed line support to ensure efficient backhaul. Intel, for example, one of the leaders in conducting trials with automobile manufacturers such as BMW, predict that the average “driverless car” will generate 4 000 GB of data per day. That is the equivalent of nearly 50 000 people at the current OECD average for mobile data usage.

In addition, business and government will have to build capacity to process the large volumes and variety of data produced. Skills for data analysis are key in this context, for both growth and social equity (Policy Horizons Canada, 2013). But with the large number of devices being connected, security and privacy issues are also important issues relating to the IoT (see, for instance, Simon [2017] on the issue of critical infrastructure).

Blockchain

Blockchain is a distributed database that acts as an open, shared and trusted public ledger that nobody can tamper with and everyone can inspect. Protocols built on blockchain (e.g. Bitcoin, a digital currency) specify how participants in a network can maintain and update the ledger. Blockchain technology was originally conceived for Bitcoin, but the expected impacts of blockchain technology go beyond digital money and may significantly affect any activity based on authenticating a transaction. Potential applications can be clustered into three categories:

- **Financial transactions**: a blockchain may be “unpermissioned” as in Bitcoin, i.e. open to everyone to contribute data and collectively own the ledger. It may also be “permissioned”, so that only some users in the network can add records and verify the contents of the ledger. Permissioned ledgers offer many applications in the private sector. Clearing houses (e.g. Nasdaq), banks (e.g. Goldman Sachs), credit card companies (e.g. Master Card) and insurance companies have invested more than USD 1 billion in start-ups using blockchain technologies (Pagliery, 2015).
- **Record and verification systems**: blockchain technology can also be used for creating and maintaining trustworthy registries. Possible uses include the registration and proof of ownership of land titles and pensions, and verification of the authenticity and origin of items ranging from works of art to drugs (The Economist, 2015). Blockchain ledgers could also improve resource allocation in the public sector by consolidating accounting, increasing transparency and facilitating auditing.

- **Smart contracts**: blockchain technology offers the opportunity to append additional data to value transactions. These data could specify that certain rules must be met before the transfer can take place. In this way, a transaction works as an invoice that would be cleared automatically upon fulfilment of certain conditions. Such contracts are also referred to as “programmable money” (Bheemaiah, 2015).

The pseudo-anonymity of blockchain-based transactions raises several concerns. While blockchain-mediated transfers are permanently recorded and immutable, they contain information only relative to an agent’s Internet identity, which may not be authentic. More effective methods of identification could eventually lead to more effective law enforcement in digital currencies, compared with cash (OECD, 2015d). However, smart contract applications could also allow the creation and operation of illegal markets that function beyond regulatory oversight.

**Some implications**

The transformative technologies considered here are wide-ranging in their origins and potential applications. However, they exhibit some common features relevant to policy. One is their dependence on large data sets and ICT. Technology convergence – with a growing role played by digital technologies in all the sciences – can be aided by cross-disciplinary institutional spaces (for example, for interdisciplinary R&D and training). While G7 governments increasingly support such efforts, more needs to be done to overcome long-established mono-disciplinary institutional and organisational arrangements for funding and performing R&D.

Public sector research is often critical in providing new knowledge of phenomena underpinning emerging technologies and often contributes to prototype and demonstrator development. Just as importantly, public sector research nurtures many of the needed skills. The emerging technologies carry several risks and uncertainties, and many also raise ethical issues. This calls for inclusive, anticipatory governance of technological change that includes assessment of benefits and costs and an active shaping of future development and uses. Such governance arrangements remain under-developed in G7 countries.

Policies related to transformative technologies are also influenced by the engagement of stakeholders in the development of policies and strategies. It is important for governments to find effective ways of consensus building, especially for difficult science and technology issues, involving the relevant parties, including citizens and scientists, but also media, as well as fostering public engagement in science. Gauging the public perception regarding these processes and actual degree of participation will inform the design of policies. Another important issue is how scientists view and engage with the public. Policy makers are increasingly interested in encouraging scientists to demonstrate or at least articulate the beneficial impact of their activities on the economy and society.
3. Economic transformation and society

Addressing the divides

Although digital transformation has already been underway for about half a century, digital technologies have only now reached almost all individuals in G7 countries. In 2016, between 73% and 98% of adults in G7 countries accessed the Internet, with access almost universal in Japan and the United Kingdom. But despite the rapid uptake of digital technologies, the uptake of digital technologies still differs by age, education and income levels, although these gaps have been closing with time (OECD, 2017a). For example, while in some G7 countries, the gap between those with higher and lower levels of education has almost disappeared, it remains sizeable in other G7 countries (Figure 5).

Figure 5. Gap in Internet use by educational attainment, 2016
As a percentage of the population in each country

Notes: Data is not available for some G7 countries. Notes to this figure are available at http://dx.doi.org/10.1787/888933620056.

Apart from affecting access, age and education also affect how the technology is used. For example, young people are dominating digital communication, content creation, social networking, online purchases, cloud computing, and software downloads, whereas older people are more frequent users of e-government and e-banking. Higher education levels are associated with the uptake of more sophisticated activities such as online purchases, cloud computing and job search. Other digital divides are also important in several countries, notably urban versus rural, high versus low income levels, as well as gender gaps (OECD, 2017a; 2017e). Addressing and closing these gaps is important to ensure an inclusive digital transformation.

Gender is particularly important in ensuring an inclusive transformation and many believe that the ongoing digital transformation provides new opportunities to empower women and strengthen their position in the labour market. More flexible ways of working may make it easier to combine paid work with caring responsibilities which are still more often taken on by women; automation is also more likely to replace less skilled jobs, giving women an advantage since they now outperform men on most measures of educational attainment.

However, a closer look at the evidence suggests a mixed picture. Women and men have just as much to gain and fear from new digital technologies. Women may benefit from increased flexibility in work but the unscrupulous use of new atypical work arrangements may also reduce job quality. Automation has so far been most common in sectors like agriculture and manufacturing, where men dominate. But in the future, automation is expected to spread, albeit to different degrees, across all sectors and most occupations, including those traditionally dominated by women, such as retail trade, food and beverage services. In addition, jobs are likely to grow the most in business services, health, education and social services – many of which have been traditionally female-dominated (Figure 6). At the same time, persistent gender differences in field of study may mean that women will benefit less from the new job opportunities in STEM-related occupations.
Skills provide an important safeguard against the risk of automation. Fewer than 5% of workers with a tertiary degree are at a high risk of losing their job due to automation, on average, compared to 40% of workers with a lower secondary degree (Arntz, Gregory and Zierahn, 2016; OECD, 2016e). To thrive in the digital era, all workers will need to be equipped with a wide set of skills, encompassing cognitive as well as non-cognitive and social skills, and notably ICT skills, STEM-quantitative and self-organisation skills. At the same time, measures targeted to underrepresented groups will be needed. This includes not only women, but also indigenous people, early school leavers, NEETs, long-term unemployed and unemployed youth, as well as ethnic minorities, many of whom today display a lower level of skill endowments.

Whether the digital transformation will close or widen participation gaps in the labour market will, to a large extent, depend on policy. Governments therefore have a crucial role to play. Key policy actions that could be considered include (OECD, 2017e):

- **Promoting female participation in STEM**: while women now outperform men in overall educational attainment, they remain less likely to pursue studies in the most specialised STEM fields.
- **Removing barriers to lifelong learning and equity in learning opportunities**: adapting and upgrading the skills and competences of those already in the labour market also calls for policy action. Evidence for G7 countries shows that those who are most likely to get trained are those that already have high proficiency in numeracy and literacy, with workers performing routine-type jobs have a lower probability of being trained (OECD, 2017g). Re-thinking and better targeting the beneficiaries of current training programmes will provide the most vulnerable with the opportunities to adapt to changing skills need in the digital era.
- **Closing gaps in access to, and in the use of, new technologies**: even in G7 countries, some gaps remain in underrepresented groups’ access and use to the Internet. Alongside boosting framework conditions to
enhance access to technologies, policies aiming at enhancing public acceptance and trust in the digital economy will be crucial to ensure a more inclusive uptake and use of technologies.

- **Promoting flexible ways of working using new technologies**: employees and employers can use new technologies to reorganise work schedules and introduce job sharing and home offices. This will benefit all workers, but in particular women who in all countries still bear the brunt of family responsibilities and usually work fewer paid hours than men.

- **Adapting social protection systems to the new forms of work**: the rise of non-standard employment is challenging traditional forms of social protection, which are still largely predicated on the assumption of a full-time, regular, open-ended contract with a single employer. The so-called “flexi-security” model of several Nordic countries provides a possible approach. Extending social protection schemes to non-standard forms of employment will only be effective if it does not incentivise misclassification of workers (regulatory arbitrage); reaches high coverage among the target groups; does not lead to adverse selection; is affordable for contributors; and has reasonable administration costs.

**Impacts on society**

Beyond its economic impacts, the digital transformation also has important impacts on society and broader well-being. For example, digital technologies can promote social inclusion by creating better access to quality education, offer new opportunities for skills development, enhance access to health care, or improve access to free and low-cost information, knowledge and data. For example, the Danish OnlineTele is a web-based portal that offers a range of services to vulnerable elderly people, including video communications (one-on-one, one-to-many, many-to-many) that can be used to deliver remote care. Mobile telephony in particular has been used intensively in a number of inclusive innovation initiatives that aim at improving the welfare of lower-income and excluded groups in developing countries (OECD, 2015e).

More broadly, new digital platforms allow consumers to negotiate better prices for products (as well as identify better quality products). They also facilitate access to key goods and services, e.g. mobility and accommodation, sometimes avoiding consumers from making costly purchases. Digital technologies can also be a significant driver of improved services to vulnerable groups in society (Mickoleit, 2014). For example, opportunities to file taxes and apply for public support online have made application procedures more convenient; benefitting in particular individuals located in remote areas and lower-income and excluded groups who rely on public support. Social media also allows governments to reach specific groups with information most relevant to their needs, offering the potential for better citizen-government communication. Moreover, it helps underrepresented groups connect and collaborate.

But while digital technologies can provide important benefits for broader well-being, they cannot fully overcome some of the inherent barriers that prevent certain disadvantaged group from benefitting from these technologies. For example, even though it enhances access to education, there is little evidence that more open education lowers existing inequalities in education opportunities. And older people – that could benefit most from applications in the health area – are less likely to use digital tools than younger ones.

The digital transformation also raises some broader challenges. For example, digital technologies like block chain could greatly enhance the ability of a government to manage its payments while reducing the potential for fraud. But they could also enhance the ability to undertake illegal financial transactions. For example, Bitcoin, while it has legal use, can also be used to avoid government oversight (e.g. in illegal arms and drug trade). These risks are compounded by the speed and pervasiveness of these technologies that may sometimes stretch beyond the capacities of society to adapt. The digital transformation can be highly beneficial for well-being but the risks of adverse outcomes are real and should not be ignored by policy makers. The challenge is how to maximise the advantages while minimising the negative impacts.
4. Inclusive innovation

In the context of transformative technological change, an important challenge is how to ensure that wide-spread innovation creates opportunities for all and benefits all. Enhancing access to technology to all groups in society, as discussed above, is one important dimension to ensuring inclusive innovation, as is the application of new technologies for the benefit of society and enhanced well-being. Well-designed industry and innovation policies can also help, as can the inclusion of SMEs, and sub-national regions in the development of innovation policies.

The contribution of industry and innovation policies

Interest in industry and innovation policies has grown over the past decade. Following the recent economic crisis, policy makers in many countries are exploring new sources of growth. Concerns about a loss of manufacturing capacities, and growing competition from emerging economies, have also contributed to a surge in interest, as has the prospect of a science and technology-driven “new industrial revolution”. Most G7 countries have therefore been looking for new ways to strengthen value creation from industry and innovation. For example:

- **In Canada**, the recent Innovation and Skills Plan includes the Innovation Superclusters Initiative, which will invest up to CAD 950 million between 2017 and 2022 to support business-led innovation superclusters with the greatest potential to energise the economy and become engines of growth. The initiative includes a small number of high-value, strategic investments, co-investing with industry to strengthen Canada’s most promising clusters and build superclusters at scale. Five superclusters will receive funding in 2018, covering digital technology, protein industries, advanced manufacturing, AI-powered supply chains, and oceans.

- **The European Union**’s innovation policy debate has been guided by a “3 Os” strategy – Open Innovation, Open Science and Open to the World – which resulted in initiatives such as the European Open Science Cloud, the European Fund of Funds, the Seal of Excellence or the Innovation Deals. Preparations for the European Union's next Framework Programme for research and innovation, to be launched in 2018, are now underway and discussions are focusing on: i) building on the Horizon 2020 programme, provide better direction to EU research and innovation (R&I) funding by introducing the concept of “missions”; and ii) fostering innovation in firms by supporting markets that are creating innovation. A pilot European Innovation Council could be put in place to help top-class innovators, entrepreneurs, small companies and scientists to scale up their efforts internationally.

- **In Japan**, the 5th Science and Technology Basic Plan set a vision towards “Society 5.0” where intelligence becomes ambient and systematic integration of cyberspace and real world would lead economic growth and provide solutions to societal challenges. To realise the vision, the plan provides measures to reinforce the fundamentals for science, technology and innovation as well as to incorporate advanced technologies into all industries and social lives. In concert with the plan, the Growth Strategy 2017 identified five strategic fields where the efforts towards Society 5.0 should be focused. Those are: i) (preventive) health care, and medical and nursing services; ii) mobility; iii) supply chain; iv) smart cities (and infrastructure); and v) financial services (fintech).

- **In the United States**, the 2017 National Security Strategy (NSS) (The White House, 2017), released in December 2017, identifies specific actions for the United States to “lead in research, technology, invention, and innovation”. To maintain a competitive advantage, the NSS identifies emerging technologies – such as data science, encryption, autonomous technologies, gene editing, AI – as critical elements to fostering economic growth and security.

- **In France**, the 34 Plans for Industrial Recovery presented in September 2013 have been reduced to 10 “industrial solutions” under the overarching programme titled New Industrial France (Nouvelle France industrielle [NFI]). The NFI aims to assist all businesses to further their modernisation and transform themselves using digital technologies.
• In Germany, *Industrie 4.0* (Industry 4.0 or I40) is a national strategic initiative that aims to drive digital manufacturing forward by increasing digitisation and the interconnection of products, value chains and business models. It also aims to support research, the networking of industry partners and standardisation.

• Beginning in 2012, Italy launched the Fabbrica Intelligente (Smart Factory – National Technological Cluster). The mission of the Smart Factory Cluster is to propose, develop and implement an R&D-based strategy to help transform Italy's manufacturing sector. Implementation of the strategy developed by the Smart Factory Cluster includes activities ranging from networking and sharing of research infrastructures to technological foresight.

• The United Kingdom launched its new Industrial Strategy in November 2017. The strategy sets out how to build a Britain fit for the future, helping businesses create better, higher-paying jobs with investment in the skills, industries and infrastructure of the future. It seeks to boost productivity and earning power across the country by focusing on five foundations: ideas, people, infrastructure, business environment and places.

The contribution of such initiatives – and many others like it – is to foster new sources of growth that can create new opportunities for workers and regions affected by digital transformation and other structural changes. The focus on clusters and regions in several strategies in G7 countries recognises that places are important and that some regions might require additional action to ensure they do not fall behind.

**Digital technologies and the inclusion of SMEs**

While great wealth can come from creating technology, most companies will mainly be technology users. And even in the most advanced economies, diffusion of new technologies can be slow or partial. For example, even though cloud computing has increased the availability and affordability of computing resources, only 22% of enterprises with 10 to 49 employees used cloud computing services in 2016, compared with almost 47% of firms with over 250 employees (OECD, 2017d).

The diffusion issue is twofold. First, it is about increasing new-firm entry and the growth of firms which become carriers of new technology. Governments must attend to a number of conditions which affect this dynamism, such as timely bankruptcy procedures and strong contract enforcement (Calvino, Criscuolo and Menon, 2016). Second, diffusion is about established firms implementing productivity-raising technologies. In this second case, an important issue is that small firms tend to use key technologies less frequently than larger firms. In Europe, for example, 36% of surveyed companies with 50 to 249 employees use industrial robots, compared to 74% of companies with 1 000 or more employees (Fraunhofer, 2015).

Several factors, at national and international levels, shape the diffusion process. These include: i) global connections via trade – which is a vehicle for technology diffusion and an incentive for technology adoption – and foreign direct investment; ii) the international mobility of skilled labour; iii) connections and knowledge exchange within national economies, such as the interaction between scientific institutions and businesses; iv) the development of standards (the semiconductor industry, for example, uses over 1 000 standards); v) the extent of businesses’ complementary intangible investments in R&D, skills, managerial capabilities and other forms of knowledge-based capital; and vi) the efficiency of the processes by which firms can attract the resources they need to grow.

In addition, institutions for technology diffusion can be effective. Innovation systems contain multiple sources of technology diffusion, such as universities and professional societies. But some of the institutions involved, such as technical extension services, tend to receive low priority in innovation policy overall. However, such institutions can be effective, if properly designed, incentivised and resourced (OECD 2017c).
While SMEs face challenges in the use of ICT, they also have important opportunities, such as the development of small firms that are “born global” (for instance, with owners located in several countries), 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. Moreover, Internet platforms can increase the supply 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.

Inclusion and sub-national regions

The digital economy may exacerbate geographic disparities in income, as it amplifies the economic and social effects of initial skills endowments (Moretti, 2012). Evidence across all OECD countries shows that income convergence across sub-national regions has either halted, or reversed, over recent decades (Ganong and Shoag, 2015). A number of remedial policies can be considered. Investments in skills and technology are particularly important (because investments in infrastructure and transport, to facilitate greater geographic spread of skills and economic benefits, while often beneficial, also have diminishing returns (Filippetti and Peyrache, 2013). With each new high-tech job that a sub-national region can create, many other jobs are created, possibly as many as five (Moretti, 2012).

Regional and local development policies can also help address spatial differences in incomes and well-being outcomes. Regional and local development policy approaches typically aim to make targeted public investments in ways that support the place’s promising economic opportunities and the quality of life for its residents. Such policies often address local obstacles to entrepreneurship, innovation and skills development in order to increase local growth (OECD, 2016c). With respect to urban policies, more can be done in many countries to improve the functioning of individual cities, such as through better metropolitan governance, as well as to improve the network of cities to promote greater growth spillovers throughout the country. Rural development policy approaches sometimes remain too much focused on agriculture, and could further consider improving productivity in nonfarm economic activity, recognising the diversity of rural regions (OECD, 2016d).

Fostering inclusion in a time of rapid technological change

The scope and pace of coming technological changes that could affect and possibly challenge inclusion remains uncertain. For instance, as has happened in the past in the field of AI, technical challenges and inadequate scientific understanding could slow progress in AI. Alternatively, a key discovery might propel the field faster than currently foreseen and deepen the possibilities of automation. Policymakers need to act to respond to the already existing challenges of exclusion and prepare for future developments. Strengthening education and training systems, facilitating labour markets adjustments, and ensuring framework conditions that help translate technological possibilities into growth, are all essential – and will be beneficial irrespective of the precise pace of future change. Wider developments in welfare systems may also be needed to accommodate the impacts of future technologies. But it is important that innovation and technological progress not be stymied for they are essential for raising labour productivity and maintaining and enhancing our standard of living. This is especially important in a context where labour productivity has been stagnating, ageing populations imply that the dependency ratio in most OECD countries is set to double in the next 35 years, and as some research suggests, new ideas are becoming harder to find (Bloom et al., 2017). Innovation and technology will be central to generating economic resources that can ultimately help to strengthen inclusion. They may also help to develop a more diverse and inclusive workforce that can help unlock the potential of all workers.
5. Policy levers and labour force demand/supply issues

The impacts of the digital transformation on jobs are being widely discussed. Recent OECD estimates suggest that digital technologies will put about 14% of workers at a high risk that their tasks will be automated over the next 15 years, and another 30% will face major changes in the tasks required in their job and, consequently, the skills they would need to do their job. In short about half of all workers will confront the need to significantly adapt to the new workplace.

These estimates of the risk of automation need to be put into perspective, however. For example, there is a difference between what can be automated from a technical point of view (which is what these estimates aim to assess) and what will actually be automated in the real world. As discussed above, data on the diffusion of specific ICT technologies shows that while most firms have access to broadband networks, most have not yet adapted more advanced digital technologies, such as big data, which implies that diffusion is only occurring slowly. Moreover, large differences remain in the ICT intensity of different sectors of the economy (OECD, 2017a).

What is more certain is that the digital transformation will involve significant structural changes particularly among business models as they adopt data-driven innovation strategies as well as a large re-allocation of labour. Most jobs will be transformed in some way, others will be displaced – as elevator and phone operators have been displaced in the past – and new ones will be created. The types of jobs that are being created are not the same as those that are disappearing and the workers affected by job loss in declining activities may not be those benefitting from the new job opportunities emerging in expanding areas. Many of the new jobs that will be created will use (and complement) digital technologies, as this will lead to more complex tasks that cannot be easily codified in turn. OECD countries where workers use ICT more intensively at the work are also characterised by a higher share of non-routine jobs (Figure 7).

**Figure 7.** Share of non-routine employment and ICT task intensity, 2012 or 2015

Correlation of average industry values in the macro sector, manufacturing

![Graph showing the correlation between non-routine employment and ICT task intensity from 2012 to 2015](http://dx.doi.org/10.1787/888933617586).

Note: Notes to this figure are available at [http://dx.doi.org/10.1787/888933617586](http://dx.doi.org/10.1787/888933617586).


In particular, the labour market appears to be polarising away from middle-skilled jobs and into low- and high-skilled jobs (OECD, 2017f). Looking forward, however, low-skilled workers are most likely to bear the costs of the digital transformation. With the exception of some relatively low-skilled jobs – for instance, jobs that involve caring for and assisting others – the risk of automation declines as educational attainment and skill levels rise.
Low-skilled workers look most likely to lose their jobs, face increased competition for jobs from middle-skilled workers, are least likely to be able to adapt to new technologies and working practices, and are also least likely to benefit from the new opportunities that arise as a result of the digital transformation.

These structural shifts require workers, businesses and governments to prepare, now, for this new world of work, rather than to look for ways to stop or reverse these trends. Despite all the uncertainty about the depth and speed of change, clinging to the status-quo is not an option; rather a people-centred “adaptation agenda” needs to be formulated so that all individuals may benefit from a positive, forward-looking plan that does not leave anybody behind and puts welfare at the forefront. By doing so, both people and firms will benefit. If business as usual prevails, a tech backlash may ensue that prevents us from achieving many of the positive outcomes made possible by the digital transformation.

With this transformation comes a rare opportunity to improve welfare and address pressing social issues from health care to education to the environment. Yet potential benefits come with serious challenges as digital transformation changes the nature and structure of organisations and markets, raises concerns around jobs and skills, privacy, security, how we interact, the formation and composition of communities and notions of equity and inclusion. Adjustments are inevitable, but there is a window of opportunity to shape them with sensitivity and foresight so they can support more inclusive growth and improve well-being.

In particular, policy will need to facilitate worker redeployment, invest in skills, strengthen social protection, future-proof labour market regulations and promote social dialogue:

- **Facilitating worker redeployment**: adapting to technological progress will require policies facilitating the redeployment of workers across businesses, industries and regions.

- **Investing in skills**: people, especially youth, need to prepare for the jobs of the future by being equipped with the right mix of skills required to successfully navigate through ever-changing, technology-rich work environments. This mix includes general cognitive skills, complementarity skills such as problem solving, creative thinking, communication, ICT generic skills and technical skills, and a strong ability to continue learning.

- **Strengthening social protection**: adequate social protection is crucial to help workers transit smoothly between jobs, especially when they have been displaced. In a context where many countries already struggle to provide adequate social protection for workers on non-standard work contracts (e.g. temporary contracts, self-employed, on-call labour), the advent of the platform economy adds to these difficulties.

- **Future-proofing labour market regulation**: maintaining and improving labour market performance in the future world of work will also require a fresh look at existing labour market regulations to ensure that they still are fit for purpose.

- **Fostering social dialogue**: anticipating future challenges and opportunities, finding solutions, managing change proactively, and shaping the future world of work can be achieved more easily and effectively if employers, workers and their representatives work closely together with governments in a spirit of co-operation and mutual trust.
References


TRANSFORMATIVE TECHNOLOGIES AND JOBS OF THE FUTURE


