Transformative Technologies & Jobs of the Future

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The Digital Transformation

Countries around the world are in transition towards a digital economy and society. This digital transformation is not new and has already contributed to significant structural changes and productivity gains. The main differences with earlier eras of digital transformation are three factors that have propelled this issue to the top of the policy agenda.

The first is the expansion of connectivity to almost every firm and household in the OECD. 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 Science, Technology and Industry Scoreboard 2017: The Digital Transformation*, OECD Publishing, Paris), every firm and 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 smartphone and with it the era of universal connectivity and ubiquitous computing. By December 2017, Japan led the G7 (and the OECD countries) with 163 mobile broadband subscriptions per 100 inhabitants *(Chart 1)*.

Third, these devices and many of the services that operate on the Internet generate vast amounts of data. In the 32 OECD countries for which data is available, mobile data usage doubled in the 12 months to the end of December 2017, amounting to over 15 GB per month in Finland. These flows are still somewhat lower in the G7 countries, but growing also there. They will grow further as connected devices such as automated vehicles become common.

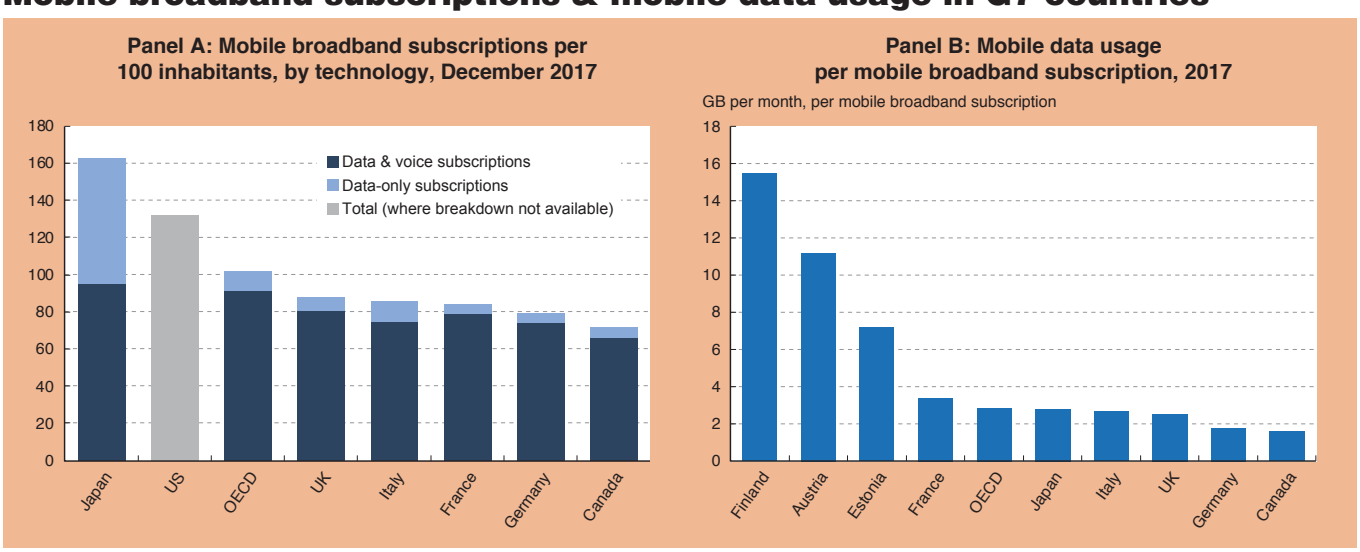
The growing amount of data, combined with steady advances in the power of computing, are enabling data-driven innovation. Online activity and networked things generate Big Data which enable machine learning and artificial intelligence (AI), which in turn lead to advances in intelligent machines (robotics, 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 data as a new factor of production, augmenting traditional capital and labor.

Addressing Digital Divides

Although digital transformation has already been underway for about half a century, digital technologies have only recently reached

CHART 1

Mobile broadband subscriptions & mobile data usage in G7 countries



Notes: In Panel A, data for the US are estimates. GB = gigabytes.
Source: OECD, Broadband Portal, www.oecd.org/sti/broadband/oecdbroadbandportal.htm, June 2018

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. However, despite the growth in connectivity, the uptake of digital technologies still differs by age, education and income levels, although these gaps have been closing with time. 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.

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 labor market ("Going Digital: The Future of Work for Women", *OECD Policy Briefs on the Future of Work*, 2017, Paris). More flexible ways of working can make it easier to combine paid work with caring responsibilities, which are 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 may benefit from increased flexibility in work but the growing 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. However, 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. And while jobs are likely to grow the most in business services, health, education and social services — many of which have been traditionally female-dominated — persistent gender differences in fields of study may mean that women will benefit less from the new job opportunities related to STEM (Science, Technology, Engineering, and Mathematics) occupations.

A second important dimension of the digital divide relates to the diffusion of digital technologies across firms, and notably to small and medium-sized enterprises (SMEs). For example, even though cloud computing can increase 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 Digital Economy Outlook 2017*, OECD Publishing, Paris). SMEs often face challenges in the use of information and communication technology (ICT), due to lack of access to finance, skills and management, amongst others. But while SMEs face challenges in the use of ICT, they also have important opportunities, such as the ability to engage in global e-commerce, improved 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.

Digital Transformation & Productivity

Whether the digital transformation is of the same magnitude as earlier industrial transformations linked to steam or electricity is an open question. Long-term trends 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 (*The Future of Productivity*, OECD Publishing, 2015, Paris). Today, despite the ongoing digital transformation and the range of technologies that are emerging, we once more "see […] computer[s] everywhere but in the productivity statistics" to paraphrase Robert Solow ("We'd better watch out", *New York Review of Books*, July 12, 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 advanced 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 Science, Technology and Industry Scoreboard 2017: The Digital Transformation*, OECD Publishing, Paris). 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.

Second, digital transformation is not only about the technology, but even more about the essential **complementary investments** that firms need to make into skills, organizational change, process innovation, new systems and new business models (*Capitalism Without Capital: The Rise of the Intangible Economy* by Jonathan Haskel and Stian Westlake, Princeton University Press, Princeton, New Jersey, 2017). These investments are often costly and take time to take effect. Moreover, the scale and complexity of these complementary investments may be growing, making digital transformation a challenge for many firms ("Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics", by Erik Brynjolfsson, Daniel Rock and Chad Syverson, *NBER Working Paper* No. 24001, November 2017, National Bureau of Economic Research, Cambridge, Massachusetts).

Third, the limited impacts of digital technologies on productivity thus far may also be 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 2007-2008 financial crisis, while the productivity of the latter group of firms has been falling rapidly relative to "viable" old firms. This has been accompanied by a slowdown in reform in product markets (*OECD Economic Outlook, Volume 2017, Issue 2*, OECD Publishing, Paris). By slowing down resource allocation and structural change, new business models have more difficulty gaining market share and the potential impacts of digital technologies on productivity will be slower to emerge.

This suggests that the impacts of digital transformation are likely to

emerge in the future, as more firms start to use advanced technologies, make the necessary complementary investments, and digitally-intensive firms gain market share. Policy can help in unlocking these potential productivity gains by fostering investment, including in skills, and strengthening structural reform.

Impacts on Jobs

Closely linked to the discussion on productivity is the question of jobs. 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 ("Automation, Skill Use and Training", by Ljubica Nedelkoska and Glenda Quintini, *OECD Social, Employment and Migration Working Papers*, No. 202, 2018, OECD Publishing, Paris). In short, about half of all workers will confront the need to significantly adapt to the new workplace.

The OECD estimates rely on the expert assessment carried out by Carl Frey and Michael Osborne ("The Future of Employment: How Susceptible Are Jobs to Computerisation?", *Working Paper of the Oxford Martin Programme on Technology and Employment*, Sept. 17, 2013) of the risk of automation for a subset of occupation titles, based on the tasks performed on the job within these occupations. This allows the identification of "bottlenecks to automation", i.e. the tasks that, given the current state of knowledge, are still difficult to automate. These include: social intelligence, such as the ability to effectively negotiate complex social relationships, including caring for others or recognizing cultural sensitivities; cognitive intelligence, such as creativity and complex reasoning; and perception and manipulation, such as the ability to carry out physical tasks in an unstructured work environment.

While these and other estimates of the possible redundancies triggered by automation have attracted the attention of policy makers worldwide, it is important to consider that the risks of automation need not necessarily translate into a decline in jobs at the economy-wide level. Technology adoption depends on a host of economic, legal, ethical and social factors, as well as on the availability of the requisite skills and organizational changes. Consequently, there is a gap between what can be automated from a technical point of view, and what is actually automated by firms. 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 adopted 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. In addition, while automation may displace some jobs or change the task content of others, technological change also creates new jobs. It can do so both directly, through the emergence of entirely new occupations, and indirectly, as a result of rising productivity growth and growing demand.

What is more certain is that the digital transformation will involve significant structural changes in the labor market. 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 work are also characterized by a higher share of non-routine jobs *(Chart 2)*.

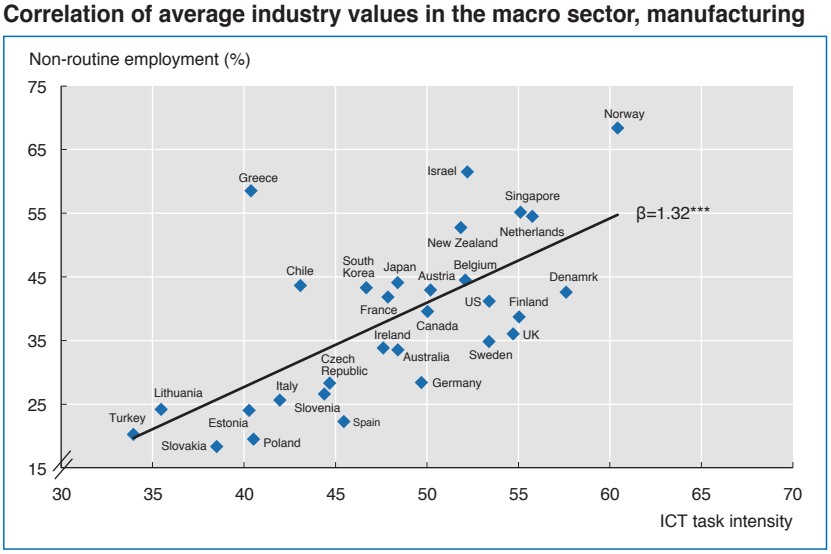
In particular, the labor market appears to be polarizing away from middle-skilled jobs and into low- and high-skilled jobs. Looking forward, however, low-skilled workers are most likely to bear the costs of the digital transformation. With the exception of some relatively low-skilled jobs — for instance, jobs that involve caring for and assisting others — the risk of automation declines as educational attainment and skill levels rise, as Nedelkoska and Quintini have shown. 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.

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 ("The Risk of Automation for

CHART 2

Share of non-routine employment & ICT task intensity, 2012 or 2015

Correlation of average industry values in the macro sector, manufacturing

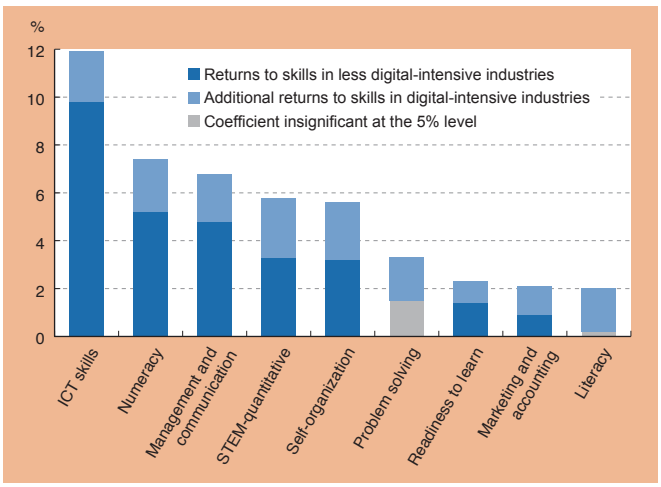


Note: Notes to this figure are available at http://dx.doi.org/10.1787/888933617586.
Source: OECD (2017a), OECD Science, Technology and Industry Scoreboard 2017: The Digital Transformation, http://dx.doi.org/10.1787/9789264268821-en.

CHART 3

Additional labor market returns to skills in digital-intensive industries, 2012 or 2015

Percentage change in hourly wages for a standard deviation increase in skills



Source: OECD, Science, Technology and Industry Scoreboard 2017, http://dx.doi.org/10.1787/888933617472

Jobs in OECD Countries: A Comparative Analysis", by Melanie Arntz, Terry Gregory and Ulrich Zierahn, *OECD Social, Employment and Migration Working Papers*, No. 189, 2016, OECD Publishing, Paris). 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-organization skills.

OECD analysis also finds that quantitative skills, ICT skills, numeracy and STEM skills as well as self-organization and management and communication skills seem to be especially important in digital-intensive industries *(Chart 3)*. This may be because workers in those industries operate in a more independent and decentralized fashion (e.g. through teleworking), perform relatively more non-routine tasks, or have to deal with continuously changing settings for which technical skills coupled with communication and organizational skills are increasingly important. Moreover, for workers in digital-intensive industries, bundles of skills appear to be particularly important: workers endowed with a high level of numeracy skills received an additional wage premium if they also showed high levels of self-organization or managing and communication skills ("Which Skills for the Digital Era?: Returns to Skills Analysis", by Robert Grundke, Luca Marcolin, The Linh Bao Nguyen and Mariagrazia Squicciarini, *OECD Science, Technology and Industry Working Papers*, 2018/09, OECD Publishing, Paris).

Policy Implications

The digital transformation requires workers, businesses and governments to prepare, now, for the emerging digital economy and society, 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 people's well-being at the center. By doing so, both people and firms will benefit. If business as usual prevails, a tech backlash may ensue that may prevent many of the positive outcomes made possible by the digital transformation.

With this transformation comes a rare opportunity to improve well-being 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 organizations and markets, and 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 an 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 labor market regulations and promote social dialogue. More precisely:

- **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 labor), the advent of the platform economy adds to these difficulties.
- **Future-proofing labor market regulation**: maintaining and improving labor market performance in the future world of work will also require a fresh look at existing labor market regulations to ensure that they are still 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 cooperation and mutual trust. JS

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