BRIDGING THE DIGITAL GENDER DIVIDE

INCLUDE, UPSKILL, INNOVATE

OECD
BETTER POLICIES FOR BETTER LIVES

This report of the Organisation for Economic Co-operation and Development has been prepared at the request of the Australian government. It aims to further strengthen the evidence base in support of G20 Digital Economy Task Force discussions on the equitable participation of women in the digital economy.

The figure on the cover displays the core part of the co-authorship network emerging among the top 1 000 most downloaded package authors of the "R" open-source software. Each point represents a male author. Female authors are denoted by a stylised woman icon. The network clearly shows that female authors are relatively few, and are poorly represented within the core network of package co-authorship.

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Foreword

Gender equality is not only a fundamental human right. It is also a keystone of a prosperous, modern economy that provides sustainable inclusive growth. Recognising that gender equality is essential for ensuring that men and women can contribute fully for the betterment of societies and economies at large, G20 Leaders first committed to “women’s full economic and social participation” in Los Cabos in 2012. They then set the ambitious goal to reduce the gender gap in labour market participation by 25% by 2025 (the 25x25 target) at the 2014 Brisbane Summit, and committed to implementing a set of policies to improve the quality of women’s employment and the provision of support services. Since then, as documented by the OECD, most G20 countries have made progress, but much remains to be done. In 2016, the gap in labour market participation rates between men and women aged 15-64 was around 26% for G20 economies.

Today the digital transformation provides new avenues for the economic empowerment of women and can contribute to greater gender equality. The Internet, digital platforms, mobile phones and digital financial services offer “leapfrog” opportunities for all and can help bridge the divide by giving women the possibility to earn additional income, increase their employment opportunities, and access knowledge and general information. We need to seize this opportunity to foster greater gender equality in the labour market, boost economic growth and build a more inclusive, digital world.

The road ahead is uphill: today worldwide some 327 million fewer women than men have a smartphone and can access the mobile Internet. Women are under-represented in ICT jobs, top management and academic careers and, as shown in this report, men are four times more likely than women to be ICT specialists. At 15 years of age, on average, only 0.5% of girls wish to become ICT professionals, compared to 5% of boys. Women-owned start-ups receive 23% less funding and are 30% less likely to have a positive exit compared to male-owned businesses.

This report explores a range of factors that underpin the digital gender divide, bolsters the evidence base for policy making and provides policy directions for consideration by all G20 governments. It has been prepared by the OECD at the request of the Australian Government to support advancement of the 2017 G20 *Roadmap for Digitalisation: Policies for a Digital Future*, in particular its aim to support the equitable participation of women in the digital economy. It complements the initiative of the 2018 Argentinian G20 Presidency to share policies, actions and national practices that have had a significant and measurable impact in bridging the digital gender divide, while supporting Argentina’s mainstreaming of gender across the G20 agenda.

The report finds that hurdles to access, affordability, lack of education as well as inherent biases and socio-cultural norms curtail women and girls’ ability to benefit from the opportunities offered by the digital transformation. In addition, girls’ relatively lower educational enrolment in disciplines that would allow them to perform well in a digital world – such as science, technology, engineering and mathematics, as well as information and communication technologies – coupled with women’s and girls’ more limited use of digital tools could lead to widening gaps and greater inequality.

Acting now to reverse these trends can pay off: the reports finds that greater inclusion of women in the digital economy and increased diversity bring value, both social and economic. For instance, inventions arising out of mixed teams are more economically valuable and have higher impact than those in which only men are involved.

Co-ordinated policy action can help narrow the digital gender gap. This requires raising awareness and tackling gender stereotypes; enabling enhanced, safer and more affordable access to digital tools; and stronger co-operation across stakeholders to remove barriers to girls and women’s full participation in the digital world. Digital technologies provide new opportunities to make progress, but technological fixes cannot address the underlying structural problems that drive the digital gender divide. Concrete policy actions are needed to foster women's and girls' full participation and inclusion in the digital economy, while at the same time addressing stereotypes and social norms that lead to discrimination against women.

The digital gender divide needs to be resolved. There is no reason for women to trail behind in the digital transformation. The cost of inaction is high and in the face of sluggish growth, ageing societies and increasing educational attainment of young women, the economic case for digital gender equality is clear. Bridging the gender divide, also in the digital world, can provide new sources of global economic growth, support the implementation of the 2030 Agenda for Sustainable Development and help achieve the G20 goal of strong, sustainable and inclusive growth.

Together, we must and can advance in making digital gender equality a reality.

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Acronyms and abbreviations

APC	Association for Progressive Communications
CEO	Chief executive officer
CPS	Current Population Survey (United States)
EPO	European Patent Office
EQUALS	Global Partnership for Gender Equality in the Digital Age
GBA	Gender-based analysis
GDP	Gross domestic product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (Germany)
GSMA	Global System Mobile Association
ICT	Information and communication technology
ILO	International Labour Organisation
IP	Intellectual property
IP5	Five largest intellectual property offices
IPC	International Patent Classification
ISCED	International Standard Classification of Education
ISIC	International Standard Industrial Classification
ITC	Information and communication technology
ISCO08	International Standard Classification of Occupations 2008
ITU	International Telecommunication Union
LDCs	Least developed countries
MOOC	Massive open online course
MSMEs	Micro, small and medium enterprises
NBN	National Broadband Network (Australia)
NOC	National Occupation Classification (Canada)
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCT	Patent Cooperation Treaty

PIAAC	Programme for the Assessment of Adult Competencies
PISA	Programme for International Student Assessment
SDG	Sustainable Development Goal
SMEs	Small and medium-sized enterprises
STEM	Science, technology, engineering and mathematics
TEGA	Technology Enabled Girl Ambassadors
TiVA	Trade in Value Added
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNU	United Nations University
USPTO	United States Patent and Trademark Office
USPTO	United States Patent and Trademark Office
VC	Venture capital
VET	Vocational education and training
WWB	Women's World Banking

Executive summary

This report has been produced at the request of the Australian Government to support advancement of the 2017 G20 *Roadmap for Digitalisation: Policies for a Digital Future*, in particular its dimension on supporting the equitable participation of women in the digital economy. It aims to provide policy directions for consideration by all governments, including G20 economies' governments through identifying, discussing and analysing a range of drivers at the root of the digital gender divide. In bolstering the evidence base and drawing attention to critical policy areas, the analysis complements the important initiative of the 2018 Argentinian G20 Presidency to share those policies, actions and national practices that have had a significant and measurable impact in bridging the digital gender divide, and supports Argentina's approach of mainstreaming gender across the G20 agenda.

While G20 economies have already put in place a number of important actions aimed at narrowing the gender gap, more needs to be done in light of the many worrying signs of a widening digital gender divide and the compounded effect that its different components may have in the future. Hurdles to access, affordability, lack of education as well as inherent biases and socio-cultural norms curtail women and girls' ability to benefit from the opportunities offered by the digital transformation. In addition, girls' relatively lower educational enrolment in those disciplines that would allow them to perform well in a digital world (e.g. science, technology, engineering and mathematics [STEM] and information and communication technologies [ICTs]), coupled with women's and girls' limited use of digital tools and relatively scarcer presence or activity on platforms – e.g. for business purposes – suggest a potential scenario of widening gaps and greater inequality, especially in disadvantaged areas. If one adds to this the fact that women receive comparatively less financing for their innovative endeavours and are often confronted with "glass ceilings" curbing their professional ambitions (especially so in tech industries), the picture that emerges is far from positive and points to a vicious circle that could lead to widening of digital gender divides.

Policy, especially in the form of co-ordinated and complementary actions, may reverse these trends and trigger a more inclusive path, based on narrowing digital and gender gaps. Addressing the digital gender divide requires raising awareness and tackling gender stereotypes, while at the same time enabling enhanced, safer and more affordable access to digital tools and fostering strong co-operation across stakeholders to remove barriers to girls and women's full participation in the digital world. Digital technologies may provide new opportunities for making progress, underscoring the importance of broadening access. But "tech fixes" can do little to address the underlying structural problems driving the digital gender divide and gender biases. While the report discusses some of the ways in which women can be empowered, gaps narrowed and hurdles leapfrogged, narrowing the (digital) gender divide is not about "fixing women", or perpetuating existing roles with the aid of technology. Rather, the focus needs to be on putting in place concrete policy actions fostering women's and girls' full participation and inclusion in the digital economy, while at the same time addressing ingrained stereotypes and social norms that lead to discrimination and even violence against women.

The **key messages and findings** of the report are:

- **Gender-based digital exclusion has many causes**. Hurdles to access, affordability, (lack of) education and skills and technological literacy, and inherent gender biases and socio-cultural norms, are at the root of gender-based digital exclusion. Enhanced, safer and more affordable access to digital tools is critical, as are policy interventions addressing long-term structural biases.
- **Women in developing parts of the world need to be connected**. Worldwide roughly 327 million fewer women than men have a smartphone and can access mobile Internet. Women are on average 26% less likely than men to have a smartphone. In South Asia and Africa these proportions stand at 70% and 34%, respectively.
- **The gender divide in Internet use is widening**. While the global digital gender divide in Internet usage remained almost unchanged between 2013 and 2017, at about 11%, the gap between developed and

developing countries increased, driven by an increase in the gender Internet usage gap of by 3 percentage points in least developed countries (LDCs) and 4 percentage points in Africa.

- **Digital technologies offer leapfrog opportunities and help empower women**. The Internet, digital platforms, mobile phones, and digital financial services, offer "leapfrog" opportunities for all and can help bridge the divide by giving women the possibility to earn (additional) income, increase employment opportunities, and access knowledge and general information. This benefits women and their families, thus enhancing the lives and well-being of people and of society as a whole.
- **Women have much to gain from boosting their use of digital tools**. While going digital can be enabling for all, the digital gender divide means there is important scope for women to extract more value from their use of digital tools. Female users currently tend to use fewer services than men and are less confident in using the Internet. For instance, while mobile money accounts offer an effective way to boost financial inclusion, it remains the case that fewer women are likely to own and use such an account. Online or video-based upskilling and tutorials may especially help women make better use of digital tools and extract more value from them.
- **Compulsory education helps to eliminate the digital gender divide**. Compulsory schooling is crucial to ensure that individuals gain the basic skills and competences needed for full participation in labour markets and society. At the age of 15, the gender gap in terms of skills for the digital area is not clear-cut: girls underperform boys in specific digital-related skills, but they outperform boys in collaborative problem solving skills, which are increasingly valued by employers. Although women display greater literacy and collaborative problem solving skills than men at the age of 15, this gap in literacy is bridged by the age 27 for the average man, while men's advantage in numeracy skills increases with age.
- **Gender-specific expectations about the future need to change**. At 15 years of age, on average across OECD countries, only 0.5% of girls wish to become ICT professionals, compared to 5% of boys. Twice as many boys as girls expect to become engineers, scientists or architects. Changing gender-specific expectations about professions is key, including by fostering female role models in STEM.
- **Lower proportions of women graduate in engineering, manufacturing and construction, or ICTs**. While more women than men completed tertiary education in 2015, only 24% of graduates in engineering, manufacturing and construction were women; the share in ICTs was just 25%. Also, when women graduate in these fields and go on to the labour market, they display on average lower numeracy skills than male graduates.
- **Raising awareness about education opportunities is key for women and girls**. Women are less likely than men to participate in massive open online courses (MOOCs), which can often be accessed for free and cover a range of topics. Informing workers, and working women especially, about training opportunities can encourage participation.
- **Removing obstacles to adult education is important** for all workers, and for women in particular. This calls for more flexible opportunities for adults to upgrade their skills and for co-ordination across institutions and actors, including education and training institutions, employers, but also social policy institutions.
- **Increased participation in labour markets, including via digital platforms, needs to go hand in hand with job quality**. For women, and men, to benefit from the work opportunities offered by digital technologies, including platforms, efforts need to be made to ensure that flexibility does not occur at the cost of reduced job quality, in terms of e.g. pay, job security and social protection.
- **A better redistribution of unpaid childcare and housework would help foster women's participation in (digital) labour markets**. Women spend 2.6 times more time than men on unpaid care and domestic work and this restricts the time they can spend in paid work or to upskill themselves. Actions aimed to raise awareness, challenge gender stereotypes and norms, coupled with measures fostering gender-neutral parental leave-taking and childcare services provision would help address norms, attitudes and behaviours around childcare and housework ingrained in society, and enable greater female participation in (digital) labour markets and training.

- **Skills in high demand in digital intensive sectors are more frequently displayed by men**. Narrowing the gender wage gap requires policies aimed to equip female workers with more self-organisation, management and communication, and advanced numerical skills; encouraging greater female enrolment in STEM-related studies and apprenticeships; and targeting existing gender biases in curricula and parental preferences.
- **ICT skills can help narrow the gender wage gap**. Men and women differ in their endowment of the skills needed in the digital era. Women in fact display a relative advantage in ICT task-based skills which can garner relatively higher rewards on labour markets, contributing to the reduction of the gender wage gap.
- **Women's participation in inventive activities has been increasing, but the pace is slow**. Lack of diversity in the composition of innovation teams across the world reflects widespread socio-cultural biases. To counter this, a greater diversity of inventors is needed. Female participation in patenting activities increased at a faster pace than the average rate at which all patent applications grew over the period 2004-15 – and in ICTs increased relatively more than in all other technological domains. But the low starting point coupled with the relatively slow progress means that, at the current pace, it will be 2080 before women are involved in half of all patented inventions within the five largest IP offices (IP5).
- **Diversity brings value, both social and economic**. Greater inclusion of women in inventive activities is good not only for women themselves, but also for stronger economic growth and enhanced societal well-being. Inventions arising out of mixed teams, or women-only groups, appear to have wider technological breadth (and may therefore be more economically valuable) and higher impact from a technological viewpoint than those in which only men are involved.
- **Software is a male-dominated world, especially in companies**. Analysis focusing on one well-known open-source software (R), shows that women are few and far between in the software world and play a relatively less important role, with many of them less connected to the network of software developers than their male colleagues. Especially in companies, very few (15%) female (R) software authors can be found.
- **The gap in entrepreneurship and in start-ups and venture capital (VC) investment point to socio-cultural gender bias**. The gender gap in entrepreneurship is striking and persistent. Men are nearly twice as likely as women to be self-employed; they are three times more likely than women to own a business with employees across OECD countries; and 90% of innovative start-ups seeking VC investments have been founded by men. Women-owned start-ups receive 23% less funding and are 30% less likely to have a positive exit – i.e. be acquired or to issue an initial public offering – compared to men-owned businesses. Nevertheless, progress is possible: VC firms with at least one female partner are more than twice as likely to invest in a company with a woman in the management team, and three times as likely to invest in female chief executive officers (CEOs).
- **Many gender equality initiatives are under way in G20 economies, but more needs to be done**. Co-ordination among different initiatives, scaling up, learning from successful and unsuccessful programmes and building on lessons learned may go a long way in improving the equitable sharing of the benefits of digitalisation. Narrowing the gender gap, also the digital one, calls for actions addressing the structural root causes of the divide. Success at increasing the number of girls and women studying STEM will do little to bridge gaps if these people confront unchanged biases in the workplace.
- **Action requires measurement**. Evidence-based policy making requires the systematic collection of data, aimed at identifying priorities, and defining and monitoring key lines of actions. Fostering the addition of gender-related dimensions in official statistics is important in this respect.

A G20 agenda for action on the digital gender divide

The analysis suggests there is strong potential for positive **policy action** in at least six core areas. Taken together, these could provide the basis for a shared G20 ambition to bridge the digital gender divide and build a more inclusive digital future. A possible agenda could include:

- The **design and implementation of national digital strategies** that actively aim to close the gender digital access, adoption and usage gaps, and improve the affordability of digital technologies while enhancing online safety.

  National digital strategies should include targets (both numbers and dates) for closing the digital gender divide across at least four dimensions, namely:

  – extend networks and digital access (e.g. through satellite) to rural areas

  – promote access to and affordability and use of connected digital devices (e.g. smart phones, tablets, laptops), especially for low-income individuals

  – boost availability and promotion of e-banking and mobile money, especially to women and other disadvantaged categories

  – increase online safety.

- **Adapt national and G20 Skills Strategies to increase awareness of the digital gender divide**, help address stereotypes, target existing gender biases in education curricula, encourage greater female enrolment in STEM studies and more generally, bridge the skills gender divide in the digital era.

  Addressing the digital gender divide requires sufficient awareness and strong co-operation across stakeholders and tackling gender stereotypes is critical. In many G20 economies, the digital gender divide is particularly large in STEM education and in high-technology sectors that require STEM degrees.

  G20 economies could consider making the following commitments:

  – agree to establish (time bound) targets for women in STEM

  – create fund and grant schemes aimed at enhancing the enrolment of women in STEM education

  – establish awards and prizes enhancing the visibility of women in STEM and in high-technology sectors

  – implement awareness campaigns tackling socio-cultural norms and biases and stereotypes.

- **Facilitate the labour market participation of women**, at the same time as monitoring and ensuring job quality and the provision of support services aimed at allowing women to work and pursue a career while being mothers or having a family. It would also be important to pair labour market participation-related actions with actions fostering a better redistribution of unpaid childcare and housework and shaping investment for better targeted life-long training.

  In 2016, the gap in labour market participation rate between men and women aged 15-64 was estimated to be around 26% for the G20 economies. OECD analysis has found that those countries with the highest shares of women working from home are also the ones that exhibit the highest employment rates and that greater work flexibility goes hand in hand with higher employment rates among mothers.

- **Foster women's entrepreneurship and engagement in innovation**, through the promotion of diversity in entrepreneurship and within teams of researchers and inventors.

  G20 economies could take action across a number of dimensions, including:

  – promote a more gender balanced composition of financing institutions especially those receiving public funds, including VC

  - design prizes and incentive schemes for companies and organisations actively implementing gender-neutral policies linked to measurable targets
  - foster networking and gender inclusion in entrepreneurial and innovative activities.

- **Foster evidence-based gender-related actions** by collecting gender-disaggregated data. To this end, it would be important to add a gender dimensions to data already collected by National Statistical Offices which at present are not declined by gender (e.g. related to entrepreneurship, innovation, etc.) and to design and implement the collection and publication in periodical reports (e.g. education and employment-related reports) of gender-related statistics, also linked to the targets mentioned above. Initiatives such as the OECD Gender Portal could further help collecting the evidence available in support of policy assessment and or monitoring and benchmarking of progresses made.
- The **publication of an annual Digital Gender Equality Report** that is based on a common methodology and indicators and the periodical collection. The *Measurement Toolkit for the Digital Economy* being prepared for the G20 Digital Economy Task Force by the OECD in conjunction with the International Telecommunication Union (ITU) and other international organisations represents a solid starting point. Monitoring progress, benchmarking initiatives and identifying best practices and high-impact measures is critical for keeping the momentum behind efforts to close the digital gender divide.

Introduction

Digital transformation – the effects on economies and societies of digitisation and the use of interconnected digital technologies and data – is offering new opportunities across the world, and holds promises for enhanced productivity growth and improved well-being of all citizens. However, a significant gender gap in the access, use and ownership of digital technologies is still present in many G20 economies and beyond, limiting the equitable realisation of the benefits of digital transformation. Furthermore, the transformation is profoundly changing the content and nature of jobs and the skills needed to perform them. This uncertainty clouds the potential impact of digitalisation on the labour market for women: new and more flexible jobs can foster greater labour market participation and better, more formal jobs, but new challenges appear as automation and ICTs spread across sectors and occupations and potentially erode existing labour policies and standards. Fresh insights and evidence are needed, to enable governments to accurately diagnose issues and take steps to empower all individuals in our increasingly digital world.

Recognising both the opportunities that digitalisation is providing for the economic empowerment of all, including women, and the challenges of ensuring that the benefits of the digital transformation are being equitably shared, G20 Ministers responsible for the Digital Economy in their 2017 *Roadmap for Digitalisation: Polices for a Digital Future* ("the Roadmap"), committed to share national practices on bridging the digital gender divide, and to consider taking action across a range of key policy areas.

This important commitment by G20 Ministers responsible for the Digital Economy is part of the broad effort that G20 economies are making to promote gender equality globally, including through the debates on skills in the digital era taking place in the G20 Employment Working Group and the G20 Education Working Group. G20 Leaders first committed to "women's full economic and social participation" as part of their agenda in Los Cabos (2012), with an important follow-up commitment to reduce the gender gap in labour market participation by 25% by 2025 at the 2014 Brisbane Summit. These important aims serve to support a new source of inclusive global economic growth, as well as working to achieve gender equality (Sustainable Development Goal [SDG] 5) and implement the 2030 Agenda for Sustainable Development Agenda.

In support of this broad effort and particularly to take forward the gender dimension of the 2017 Roadmap, the Australian Government asked the OECD to carry out work aimed at strengthening evidence and analysis related to bridging the digital gender divide. The work provides a valuable complement to the initiative of the Argentinian 2018 G20 Presidency to share those policies, actions and national practices that have had a significant and measurable impact in bridging the digital gender divide.

This report presents the outcomes and findings of a multifaceted approach integrating complementary work, articulated around the following key areas of analysis:

1. **The gender divide and digital technologies**, providing an overview of the gender divide in access, uptake and usage of technological tools and the extent of digital financial inclusion worldwide, in particular regarding the use of ICT and digital platforms, mobile phones and digital payments by women.
2. **Leapfrogging opportunities for reducing the gender gap**, discussing some of the many opportunities that digital technologies offer for narrowing the digital gender divide.
3. **Skills for the digital era**, discussing how the pervasiveness of digital technologies changes the way individuals access and elaborate knowledge, understand and interact with the reality around them, and whether women and girls possess the (set of) skills allowing for a deeper understanding and meaningful use of digital technologies. The objective should be to equip women and girls with the skills needed to thrive in the digital era.

4. **Jobs and skills in the digital transformation**, shedding light on whether women are equipped with the skills needed to navigate the world of work in the digital economy; analysing the returns to skills, in terms of wages, for men and women in digital and less digital intensive sectors; and discussing how digital platforms can be leveraged to boost women's labour force participation and help achieve the G20 "25 by 25" goal.

5. **Women and innovation**, proposing a first-time analysis of the participation of women in innovation activities and output at the core of the digital transformation, i.e. both technological developments and open-source software. This section also includes an analysis of tech entrepreneurial activity as reflected in VC activity.

6. **Learning from experience**, presenting existing national practices for economic empowerment of women, drawing on a stocktaking exercise of national initiatives.

7. **Bridging the digital gender divide: the role of policy**, synthesising the main policy implications of the overall analysis and identifying possible policy directions for consideration by G20 governments.

In each of its components, the report will seek to identify and discuss the broad range of drivers at the root of the digital gender divide, ranging from barriers to access and affordability, to education and technical literacy, to socio-cultural attitudes and biases.

This work was led by the OECD Directorate for Science, Technology and Innovation (STI) in co-operation with the OECD Directorate for Employment, Labour and Social Affairs (ELS) and the OECD Directorate for Education and Skills (EDU), and with the involvement of the ITU and the United Nations University) (UNU (the research lead of the Global Partnership for Gender Equality in the Digital Age [EQUALS]). It builds on discussions under the 2017 German G20 Presidency on skills and gender, for which an issues paper was discussed by the Digital Economy Task Force in Hamburg on 23-24 October 2017, and neatly complements the approach of the Argentinian 2018 G20 Presidency to place gender as a critical cross-cutting priority of its agenda. Taken together, these focused efforts on analysing and providing policy insights into women's empowerment in the digital age aim to provide G20 governments with evidence and good practices to further leverage national and international efforts (such as the G20 #eSkills4Girls) to achieve their gender goals, particularly the "25 by 25" goal, and identify the most promising avenues for further policy action.

Chapter 1

THE GENDER DIVIDE, DIGITAL TECHNOLOGIES AND LEAPFROG OPPORTUNITIES

Digital technologies hold immense potential to improve people's economic and social outcomes, yet challenges remain regarding women's access to and use of these technologies.

This chapter presents a broad overview of the existing gender gap and its root causes, related to the access, uptake and usage of technological tools and the extent of digital financial inclusion worldwide. The focus is on three key technologies and applications, namely ICT and digital platforms, mobile phones and digital payments.

The chapter then discusses the possible "leapfrog" opportunities that digital technologies may offer to all, with particular attention devoted to access and usage of digital technologies as a means to empower women, give them access to information and life-enhancing opportunities, and foster women's engagement in labour markets.

The digital gender divide and its root causes

The digital transformation offers immense opportunities for economies and societies. However, the benefits of the digital transformation are currently not equally balanced between societal groups and genders and access, use and ownership of digital tools are not gender-neutral. The term “digital gender divide” is frequently used to refer to these types of gender differences in resources and capabilities to access and effectively utilise ICTs within and between countries, regions, sectors and socio-economic groups (see UN Women, 2005).

There are a number of root causes of the digital gender divide, including hurdles to access, affordability, education (or lack thereof) and lack of technological literacy, as well as inherent biases and socio-cultural norms that lead to gender-based digital exclusion (OECD, 2018d; OECD, 2015a; Hilbert, 2011; Cooper, 2006; Korupp and Szydlik, 2005[1]). Women were found to do 2.6 times the amount of unpaid care and domestic work that men do, which leaves them less times to grow their careers (UN Women, 2018a). There is a recognition that action is needed across diverse areas to ensure all women and girls can fully participate in the online world, with a recent Broadband Commission Working Group on Digital Gender Divide proposing several recommendations, including around digital literacy and confidence, and the availability of relevant content, applications and services (Broadband Commission, 2017a). Skills, skill endowment and skill demand also play a fundamental role in determining, and limiting, the digital gender divide and are discussed in Chapters 2 and 3 of this report.

Affordability is a challenge for all but affects disproportionally more women and girls, and remains one of the key hurdles in accessing ICTs. Also, the digital gender divide is found to increase as technological sophistication and functionality grows and with the cost of ownership (BMZ, 2017). A study by Intel and Dalberg (2012) finds that affordability not only represents a barrier for those who are not yet Internet users, but further prevents Internet users from using the World Wide Web to its full extent, if e.g. Internet data allowances increase importantly with the quantity of megabits included in the contract. When it comes to affordability, the cost of accessing the Internet varies across countries and regions and partly depends on the level of development of the country.

Another reason why fewer women than men use digital tools is the lack of awareness of the potential benefits that the Internet may bring. Women are significantly more likely than men to not use the Internet because they think they “do not need it” or they “do not want it” (Fallows, 2005). Intel and Dalberg (2012) find that 25% of the women who do not engage online are generally not interested in using the Internet, and almost all of them believe that accessing the Internet would not bring them any benefit. Evidently, lack of trust in digital devices or the Internet may also play a role, despite women mainly reporting lack of interest or having low expectations about its usefulness and relevance to their local context (i.e. lack of use of local languages).

Illiteracy further hinders women’s and girls’ ability to access online services. About 83% of women worldwide are literate, compared to 90% of men (UNESCO, 2017), and illiterate women only appear to be using online platform services, such as Skype and YouTube, that are more familiar to them or are easier to access and use. To try and address this hurdle, some search engines, such as Google, have installed voice navigation systems in local languages to make Internet search queries more accessible and inclusive.

The digital gender divide is also fuelled by digital illiteracy, which often translates in lack of comfort in using technology and accessing the Internet. Such “technophobia” is often a result of concurrent factors including education, employment status and income level. For instance, Intel and Dalberg’s (2012) survey shows that more than half of the women having no formal education said they were not familiar or comfortable with the technology. However, this percentage fell to 15% in the case of women with at least high school education.

Even girls in formal education appear to be less confident in ICTs, maths or science. The OECD *ABC of Gender Equality in Education* (2015a) report shows that differences in performance in scientific and ICT-related fields do not stem from innate differences in aptitudes, but rather from students' attitudes and confidence in their own capabilities. Girls are less confident in their maths, science and IT abilities, often due to or fuelled by societal and parental biases, and parents' expectations about the future of their 15-year-old boys and girls – independently of performance in mathematics. This ultimately leads to girls' self-censorship and lower engagement in science and ICTs.

Additionally, socio-cultural reasons play an important role in explaining the digital gender divide. In India and Egypt, around one-fifth of women were found to believe that the Internet was not appropriate for them, for a number of cultural reasons. In India, around 12 % of women report not to use the Internet because of the negative social perception associated to its use, and 8% due to the lack of acceptance by family members (Intel and Dalberg, 2012). In the case of women, in fact, family support emerges as a key enabler when it comes to using the Internet. Active female Internet users are three times more likely to have families who are "very supportive" of their Internet use, whereas female non-users are six times more likely to be exposed to family opposition (Intel and Dalberg, 2012). Such family hurdles can range from lack of support to outright discouragement or even prohibition.

Safety-related issues are often a key reason for families' opposition to the use of the Internet or the ownership of a mobile phone for both women and girls in developing and emerging economies. For example, for women in the People's Republic of China (hereafter "China") and Mexico, harassment is among the top barriers in owning and using a mobile phone (GSMA, 2015a). Women and girls using the Internet can be exposed to additional risks, including cyberstalking, online harassment or even sexual trafficking, and it thus become crucial to develop measures to protect and prevent gender-based violence online. The European Institute for Gender Equality (EIGE, 2017) estimates that one in ten women have already experienced a form of cyber violence since the age of 15. It further reports the results of a German survey of Internet users aged 10 to 50, which finds that women are significantly more likely than men to have been victims of online sexual harassment and cyber stalking. A 2014 Pew Research Center survey found that women, especially aged 18 to 24, disproportionately experience severe types of cyber harassment, including cyber stalking and online sexual harassment (Pew Research Center, 2014). The paucity of data that exist calls for the need to collect harmonised data, on a recurrent basis, related to cyber violence against women and girls, for effective actions to be designed and implemented and progress monitored.

OECD work (OECD, 2017j) finds that students spend a considerable amount of time online, making it crucial to understand whether and how Internet use influences students' well-being. On the one hand, Internet tools, including online networks, social media and interactive technologies, are giving rise to new learning styles where young people see themselves as agents of their own learning, where they can produce multimedia content, update and redefine their interests, and learn more about the world, others and themselves. On the other hand though, online activities pose several risks to well-being, ranging from peer pressure (cyber bullying) and stigmatisation to sexting to being groomed by strangers. OECD (2017j) finds that social networks can have an impact on girl's health as they are the object of more personal attacks and cyber bulling. When it happens to 15 year-old teenage girls, this can create risky situations and may impact their health and well-being.

If in the developing parts of the world access, literacy and safety are among the greatest barriers to being online and using digital devices, in developed economies women face other types of barriers. Among them, socio-cultural perceptions and biases may prevent women from obtaining senior roles in (digital) companies to the same extent as men (Farrell and Greig, 2017; The New York Times, 2017; Seetharaman, 2017; WEF, 2017). For example, in the mobile industry, women worldwide are 20% less likely to hold a senior leadership position than men. In Africa, the percentage of women holding senior positions in the mobile industry falls to a mere 10% (GSMA and ATKearny, 2015).

Finally, the ability of women to access and use digital technologies is directly and indirectly affected by market-related factors including investment dynamics, regulations, and competition, especially in rural areas. In rural areas, which are often scarcely populated, the investment and installation of infrastructures, such as broadband infrastructures and cell phone towers, is less economically profitable. This can affect disproportionally more women in developing countries as they seem to be more often located in rural areas, whereas working age men tend to be mainly in urban areas (UN Statistics, 2016). Women and girls in rural areas of developing countries further face persistent structural constraints, including their higher probability to be out of school than boys – their likelihood is twice as high as girls in urban areas. Furthermore, women and girls in rural areas generally work in agriculture, and their work is often unpaid or considered as a contribution to the family. When employed, women in rural areas tend to have shorter term and more precarious jobs and are generally less protected than men in rural areas or people living in urban areas (UN Women Watch, 2018). This ultimately translates in being confined in technology-poor environments where it is difficult if not impossible to use digital technologies, and into having scarce (if any) resources, also financial ones, to be used to go online.

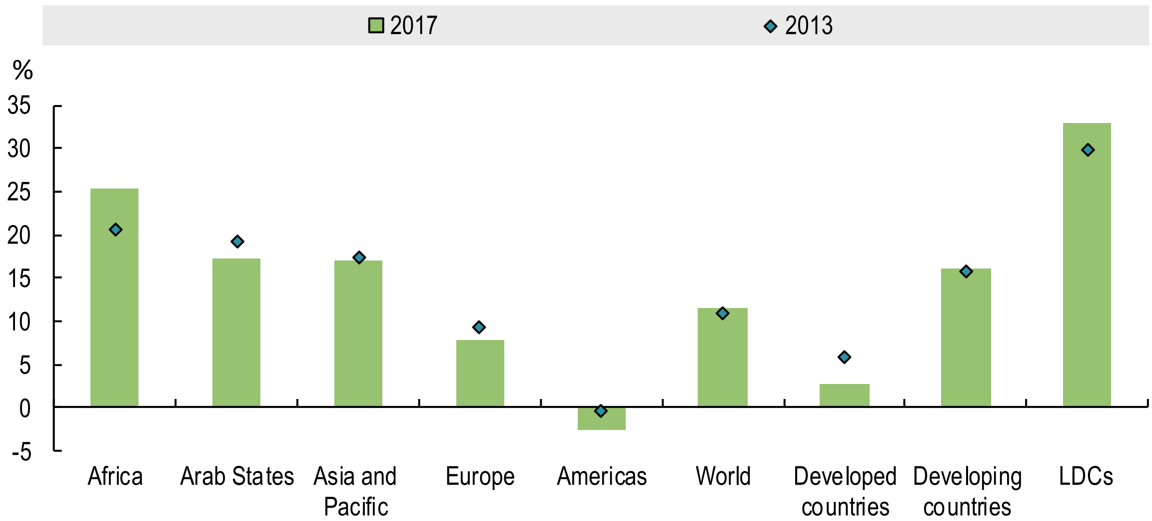
The Internet, digital platforms and the digital gender divide

The digital gender divide may take many forms, which also vary depending on the specific technology considered.

The Internet

Internet use has experienced unprecedented growth since the development of the World Wide Web in 1990. Broadband infrastructures are now installed in more than 104 countries worldwide, and more than 80% of the youth population is an active Internet user (ITU, 2017). However, Internet growth has been uneven and has resulted in a digital gender divide in two-thirds of countries worldwide and in regional and intergenerational digital gender divides.

Figure 1. Digital gender divide in Internet usage, 2013 and 2017



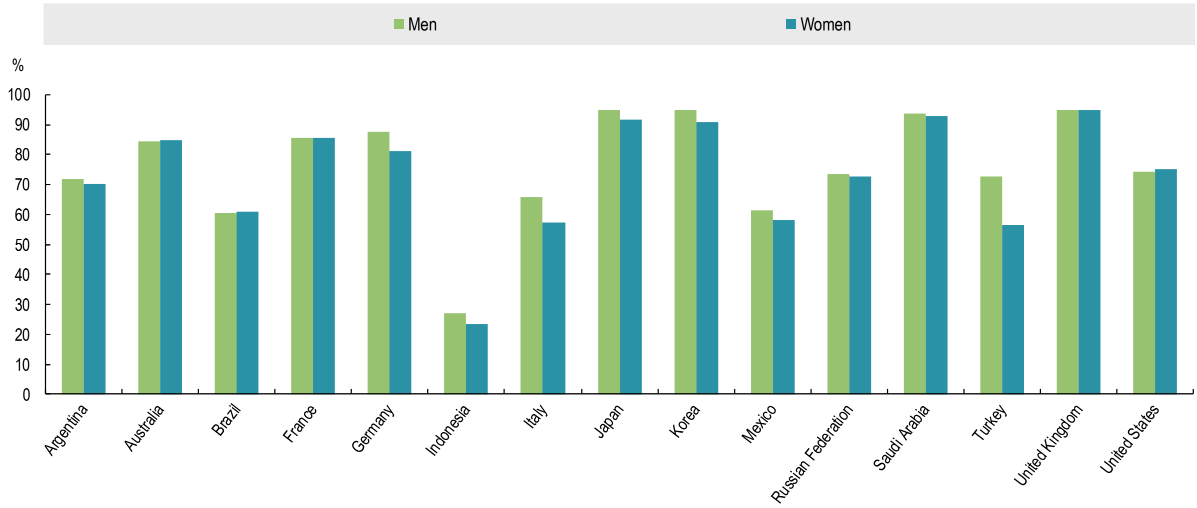
Notes: LDCs = least developed countries. The digital gender divide in Internet usage refers to the difference in the proportion of men and women who used the Internet from any location in the last three months. Positive numbers denote relatively higher Internet usage by men. Negative numbers reflect higher Internet usage by women as compared to men. See ITU (2014) for more details. See the ITU Country Classifications at https://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx based on the M49 standard for area codes used by the United Nations.

Source: ITU (2017), *Facts and Figures 2017*, https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2017.pdf.

In the case of women, the global Internet penetration rate[2] is about 45%, as compared to about 51% for men – this corresponds to having 250 million fewer women than men online (ITU, 2017). On a regional basis, the gap in Internet usage has been decreasing in some regions but increasing in others (ITU, 2017). Notably, between 2013 and 2017 the gap has generally narrowed in developed economies including Europe, as well as in Arab States (by about 3%, 1.5% and 2%, respectively), whereas it widened in LDCs and in Africa (by 3% and 4% respectively). Conversely, in the Americas, over the period considered, the balance even tilted towards women, passing from a situation in 2013 where men and women used the Internet to the same extent, to having women ahead by about 2 percentage points in 2017. While the global digital gender divide in Internet usage remained essentially unchanged (passing from about 11% in 2013 to roughly 12% in 2017), the patterns observed are worrisome as they point to increased inequality in Internet use between developed and developing countries (Figure 1).

In the case of G20 economies, Turkey, Italy and Germany exhibited relatively wider gender gaps in Internet usage (about 6.5% and 8.5% in the case of Germany and Italy, respectively, and 16% in the case of Turkey) than the other G20 economies for which data are available. Relatively more women than men seem to be using the Internet from any location in Australia, Brazil and the United States (by 0.7%, 0.5%, and 0.7%, respectively) (Figure 2).

Figure 2. Individuals using the Internet (from any location) in selected G20 economies, 2016



Note: Data for Australia and the United States refer to 2015; data for Germany and Turkey refer to 2017.

Source: ITU (2018e), *World Telecommunication/ICT Indicators*, https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx.

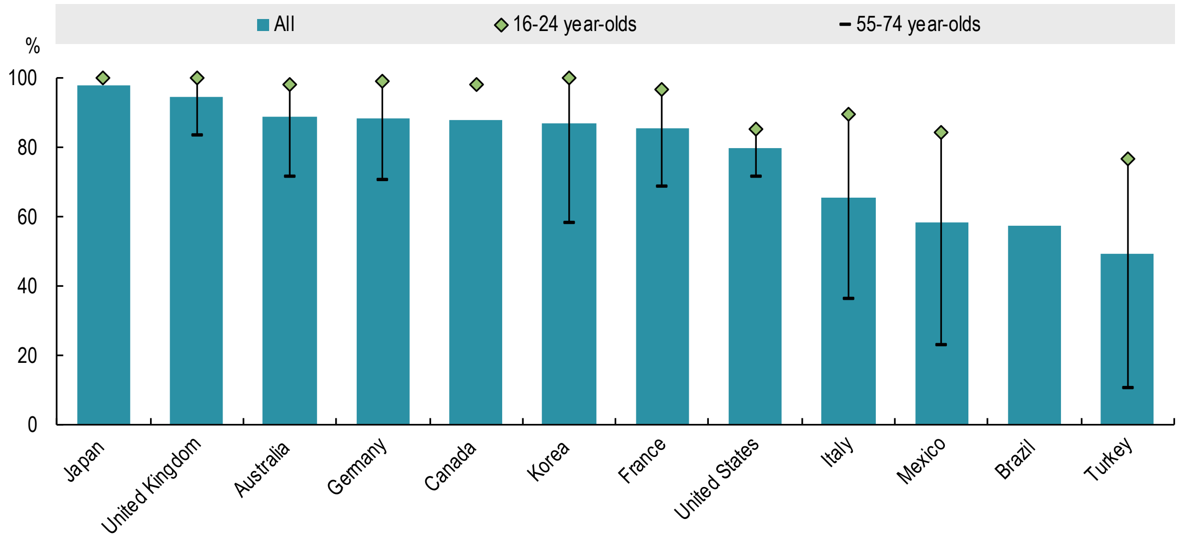
Within countries, evidence points also to regional and intergenerational digital divides, highlighting the importance of policies at subnational level, involving relevant regional and local stakeholders and communities.

The gender gap in Internet use in rural areas is more pronounced in industrialised economies, (at 9.4%), than in developing and emerging economies (at 7.5%) (ITU [2016b] and the World Wide Web Foundation [2016]). In urban areas on the contrary, the digital gender divide for Internet usage is conversely higher in emerging and developing economies (6.6%) than in industrialised economies (6.3%). In other words, women in rural areas in developing and emerging economies are relatively more included when it comes to Internet usage than women in urban areas, although all women worldwide remain generally less likely to use the Internet than men.

When it comes to the age of Internet users, a more important gap in the extent to which older women access the Internet is observed in developing and emerging economies: among 15-24 year-old people the digital gender gap is about 3%, whereas the 55-74 age group display a digital gender divide in Internet usage of about 8 percentage points. In developed economies, differences in Internet usage between women and men among the 25-74 age group on average amount to 3.5 percentage points (ITU, 2016; World Wide Web Foundation, 2016).

Figure 3. Women Internet users, by age, 2016

As a percentage of the population in each age group



Note: Data for Brazil are not available for the different age groups; data for Canada are not available for the younger age group.

Source: OECD (2017a), *OECD Science, Technology and Industry Scoreboard 2017*, http://dx.doi.org/10.1787/9789264268821-en, based on OECD (2017l), *Education Database*, http://dx.doi.org/10.1787/888933620075.

Digital platforms

While the "gig economy" (Box 1) currently accounts for a relatively small share of workers, platform-based or enabled jobs may be particularly interesting and empowering for women. They may create new options for women to participate in labour markets, both local and global, and give them the chance to emerge from the shadow economy in which they might have been working, thus earning or supplementing much needed income from other paid work. Platforms further make it possible to have more flexible work schedules which in turn may support women to both work and care for their families. Platforms may further help empower women and make them more independent by facilitating access to finance and to financial means, and by easing establishment of businesses reaching out to international markets. Also, platforms are important for knowledge flows and for networking, and may help women access relevant or useful information and contacts.

BOX 1 THE GIG ECONOMY AND GIG WORKERS

Digital technologies may enable more efficient matching between labour supply and demand and may allow subdividing jobs into tasks to be performed in a more flexible way or by different individuals located in different parts of the world. Such digitally enabled possibilities create opportunities for workers to enjoy the flexibility and benefits of freelancing, and to top-up their income with additional work in other jobs, thus leading to the flourishing of the "gig", "on-demand" or, more generally, the "platform economy" (e.g. AirBnB, Uber, Lyft, Blabla Car, Nubelo, Amazon Mechanical Turk, Task Rabbit, YoupiJob or Frizbiz) (OECD, 2016b).

While no official definition of gig workers exists, these types of jobs get their name from the music industry, where musicians usually move from job to job (i.e. from one gig to another), are generally employed for a particular performance or over a defined time period, and do not have or cannot expect any established or long-term connection with the employer or the venue seeking their services them for the specific gig.

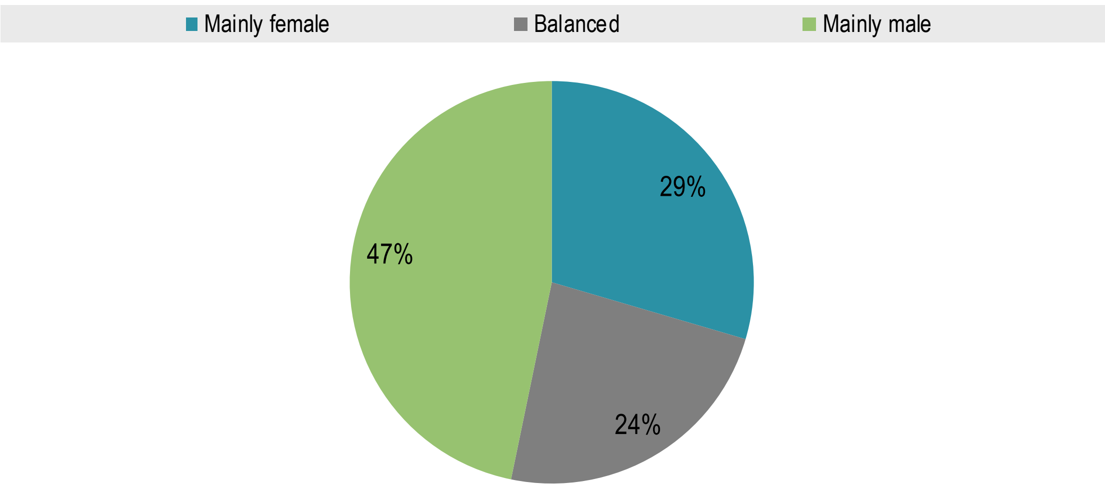
Platform-enabled digital opportunities may be especially important for women in developing countries, and help them leapfrog and contribute to the welfare and well-being of their families and communities. However, for digital platforms to become the empowerment tool that they may represent for women, it is important that policy helps remove the many conscious and unconscious biases and stereotypes which too often constrain women's participation in online platforms. Also, action is needed to remove the hurdles that women may encounter, also in digitally enabled working environment. Policies must ensure that online platforms do provide real opportunity, rather than substituting a traditional sweat shop for a digital one (OECD, 2017b).

Professional social networks

Data from the United States indicate that most of the participants in the online platform economy are men (Farrell and Greig, 2017). Similarly, in the United Kingdom, approximately 69% of gig workers are male (RSA, 2017). Moreover, data from LinkedIn (LinkedIn, 2015), and Xing, a business social network headquartered in Hamburg focusing on professional relationships (Statista, 2016), show that fewer female accounts exist relative to total memberships overall. For example, on LinkedIn, an international professional social network platform with the highest number of users in the United States, India, Brazil, United Kingdom and Canada (Aslam, 2018), roughly 56% of overall membership accounts belong to male members. If one considers only the accounts of members in leadership positions, gender imbalances appear even starker, with the most pronounced gaps emerging in healthcare, retail, and financial services. Looking at healthcare, about 60% of all LinkedIn members in the industry are women. However, only about 45% of members in leadership positions are women. Retail and financial services show a similar gap; with the latter displaying the lowest absolute representation of women in leadership positions (approximately 29%). Government, education, and non-profit industries conversely display the narrowest gaps (6.4%) (LinkedIn, 2015).

Similarly, data from the OECD Business Survey of small and medium-sized enterprises (SMEs) registered on Facebook (April 2018) shows that 65% of management positions in SMEs are held by men. Only one in three SMEs features a mainly female management, according to the Survey, and only one in four SMEs has a gender balanced management team (Figure 4).

Figure 4. Management of SMEs registered on Facebook, by gender, April 2018



Note: The Future of Business Survey is a collaboration between Facebook, the OECD and the World Bank to provide monthly data on the perceptions, challenges, and outlook of online SMEs. The target population consists of SMEs that have an active Facebook business page and include both newer and longer-standing businesses, spanning across a variety of sectors. Until now more than 60 million SMEs have created a Page, and more than 140 000 of these Facebook Page owners have taken the survey.

Source: Future of Business Survey (2018), *Explore the Future of Business*, https://eu.futureofbusinesssurvey.org/manager/Storyboard/RHViewStoryBoard.aspx.

Labour platforms, service platforms and online market platforms

At present, women may at times be able to only partially benefit from the opportunities offered by labour platforms, service platforms and online market platforms, because of gender discrimination and (at times unconscious) biases towards female sellers and freelancers. These impinge upon women's subsequent evaluations and customer protection and, coupled with the paucity of female role models in technology-based endeavours, risk triggering vicious circles of gender biases and may widen the divide, instead of narrowing it.

Studies looking at labour platforms such as Fiverr (an online marketplace for freelance services founded in 2010 and based in Tel Aviv), Upwork (a freelancing platform fostering businesses and independent professionals to connect and collaborate remotely) and Design99 (the world's largest online graphic design marketplace) show that workers' evaluations are correlated with gender. Women often receive less positive evaluations than men, and this may affect their further employment opportunities (Hannak et al., 2017) and reinforce existing gender biases. Also, gender-biased buying behaviours on online market platforms tend to result in lower auction prices for women selling their products on eBay. Kricheli-Katz and Regev (2016) find that women earn 20% less when selling identical new products on eBay. Differences in selling prices also emerge for used items, with auction prices that are 3% lower in the case of female sellers. To try and avoid being discriminated against and to be able to tap into the repository of opportunities that platforms represent, women may at times have to hide their gender. A survey by Hyperwallet (2017) showed that 33% of women work online under a pseudonym, or have a user name that does not reveal their gender, in an attempt to avoid being discriminated against. Among them, 72% choose to work under a gender-neutral name to maintain anonymity; 14% do so to increase bids on online selling platforms and the remaining 14% explicitly do so to avoid sexism or hostility.

Platforms may also allow women to enter or to better participate in typically male-dominated professions. Hall and Krueger (2015) find that in the United States women make up 14% of Uber's driver-partners, a share exceeding that of taxi drivers and chauffeurs who are women in those markets (8%). For women to participate to an even higher extent in this type of platform-enabled labour market, it is nevertheless important that they feel secure and supported: there have been cases when women did not feel appropriately protected from sexual harassment by customers on service platforms as TaskRabbit and Uber (Forbes, 2015). Further, there is evidence of a pay gap of 7% among male and female drivers (Cook et al., 2018). This entails that, even in the gig economy, pay disparity still exists, although it may be easier to identify its root causes. The existence of such pay gap even in a technology platform that removes gender bias, as the algorithm can be confirmed to not have any predisposed bias, is worthy of greater attention, and leaders may want to take such evidence into account going forward, when considering positive steps in algorithmic policy. Finally, to foster virtuous platform-enabled circles and to allow women to thrive in the platform economy, it is important have more female role models. A survey by Elance (2013) finds that almost half of all responding women who do not engage in gig work do so as they lack female role models in technology.

Full-time employment and digital platforms

For women to thrive in platform-based or enabled jobs, it is important not only that they do not feel discriminated against when working as freelancers but that they succeed in being formally employed by platform companies and tech companies. Only a small percentage of women do so at present and leading regions like Silicon Valley, but also elsewhere, still suffer from little gender diversity (The New York Times, 2017; Farrell and Greig, 2017).

Globally, women make up just 27% of employment in the software and IT services industry and account for fewer than 20% of leadership roles, according to recent analysis based on LinkedIn data (WEF, 2017). A study from a recruiting start-up called Apli, finds that only 9 of the 100 main tech start-ups in Mexico have a woman as a CEO and only 20% of them have a woman among their founders. Within Fintech companies, only 11% had women founders (El Universal, 2017).

In addition to representing a relatively low share of the workforce of IT companies, women also face higher hurdles. In May 2017, the Wall Street Journal reported that women software engineers at Facebook were 35% more likely to have their code rejected by the company's internal peer review system (Seetharaman, 2017).

Several recent monographies on the history of computing contradict a belief that men are somehow more suited to computing work than women. Miltner (2018),[3] among others, argues that computer programming was originally the purview of women and that, during the first two decades of modern computing, programming was associated with and predominantly done by women. However, when programming shifted from a low-status, female-type of task to work seen as central to the control of corporations and state resources, women were edged out.

To address these shortcomings, a number of companies are trying to collect evidence about different aspects leading to this gender gap, to take necessary action and many are revising their diversity strategies (Amazon, 2018; Facebook, 2017; Financial Times, 2014). Some top-listed American companies show progress in recent years with respect to women obtaining leadership roles in Silicon Valley companies (Fenwick, 2015).

Enhancing women's job satisfaction in the gig economy

As Denham (2018) underlines, the gig economy is no longer a buzz-word but a reality that has empowered and opened up a wealth of opportunity to workers while simultaneously enabling businesses to cut costs by hiring independent, short-term contractors. The UK Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA, 2017) estimates that there are 1.1 million gig workers in Britain and that female part-time self-employment increased from 439 000 to 812 000 between 2001 and 2016. Also, two million women are expected to become their own boss by the start of 2019, driven by job characteristics like freedom over working hours and greater control over earnings (Denham, 2018).

Opportunities may nevertheless come with threats and it is important not only to remove the barriers hindering female participation in the gig economy, but also to enhance the quality of gig jobs. Flexibility is one of the major advantages of digital platforms for women since they can flexibility chose where, how and when to work. However, if more flexibility comes at the cost of increased working hours and problems in separating work and personal life, the bottom line can mean greater stress. Women engaged in platform-related or based work may risk seeing the opportunity to work anytime anywhere transformed into having to work every time everywhere (see e.g. Eurofound and ILO, 2017). Also, for all workers, including women, to maximise the benefits of the gig economy it would be important to address possible shortcomings such as irregular income, lack of benefits, lack of retirement benefits and of social security coverage. The consequent lowered job quality may make working in the gig economy less attractive: 88% of women participating in a survey by Hyperwallet (2017), said as much and 57% of women working in the gig economy would not recommend this type of work to their children (Hyperwallet, 2017).

Farrell and Greig (2017) find that lower-income individuals are more likely to participate in labour platforms than higher-income individuals, and that they are also more reliant on their labour platform income. In the case of the most economically vulnerable workers (i.e. those with the lowest incomes and who experienced at least one month of non-employment) online platforms provide a substantial fraction of their income and for an extended period of time. Conversely, as outside employment options improve, platform workers appear increasingly difficult to recruit and retain. The fact that women are more likely to drop out than men within 12 months (62% and 54%, respectively) may thus be a sign that platforms help women gain much needed income during difficult times. That said, turnover of platform workers may be the result of low job quality (OECD, 2017d). This being the case, it would be important to address such shortcomings.

More generally, the technological advances and the introduction of new business models which have led to the emergence of new forms of on-demand labour, represent a possible source of income and flexibility for workers, including on working time, while at the same time contributing to enhanced innovation and productivity. They may also facilitate the labour market integration of under-represented groups including women (and therefore promote inclusiveness) by e.g. helping individuals overcome barriers to participation. However, labour market outcomes vary greatly across non-standard workers, in particular in terms of pay, job security and social protection. In addition, workers may not be covered by collective bargaining arrangements and/or some labour regulations, and may receive less training and suffer more job strain. Given that certain population groups are over-represented in "non-standard" (OECD, 2018b) forms of work (typically women, youth, the least-skilled, workers with disabilities, and workers in small firms as well as migrants), on-demand labour risks being a source of inequality in access to good jobs (with some groups confined to less attractive types of work), thus resulting in increased labour market segmentation.

With the advent of the platform economy, having an adequate social protection becomes a must, despite the difficulties that countries may face in pursuing this objective. Already at present many countries struggle to provide adequate social protection for workers on non-standard work contracts (e.g. temporary contracts, self-employed, on-call labour). An increasing number of people only work occasionally and/or have multiple jobs and income sources, with frequent transitions between dependent employment, self-employment and work-free periods. Many people do not even have all of the formal permits allowing them to formally work and as such be protected under existing rules. All this is adding to the challenges faced by existing social security systems, which are still largely predicated on the assumption of a full-time, regular, open-ended contract with a single employer. As a result of these challenges, more workers risk falling through the cracks – although the scale of the problem that lies ahead is difficult to predict at this stage. In some cases, employment regulation will need to be clarified or adapted to take into account new forms of employment. Tax and benefit systems would also need to be extended and or adapted to the new forms of work so that all workers are both provided with some minimum protection and their various sources of income are brought into the tax system. Portability of social security entitlements should be promoted to prevent the loss of benefit entitlements when workers move between jobs. And governments may also need to expand the role of non-contributory schemes so that no one is left without social protection as a result of their contract status (OECD, 2018c). This is especially true for women, given the higher likelihood of unemployment or of off-work spells that women face because of family duties or maternity.

Mobile phones

While the diffusion of satellite technologies, among others, has enabled the spread of mobile phones and of (almost) worldwide coverage, women remain disproportionally disadvantaged because of their relatively scarcer ownership and usage of mobile phones and smartphones.

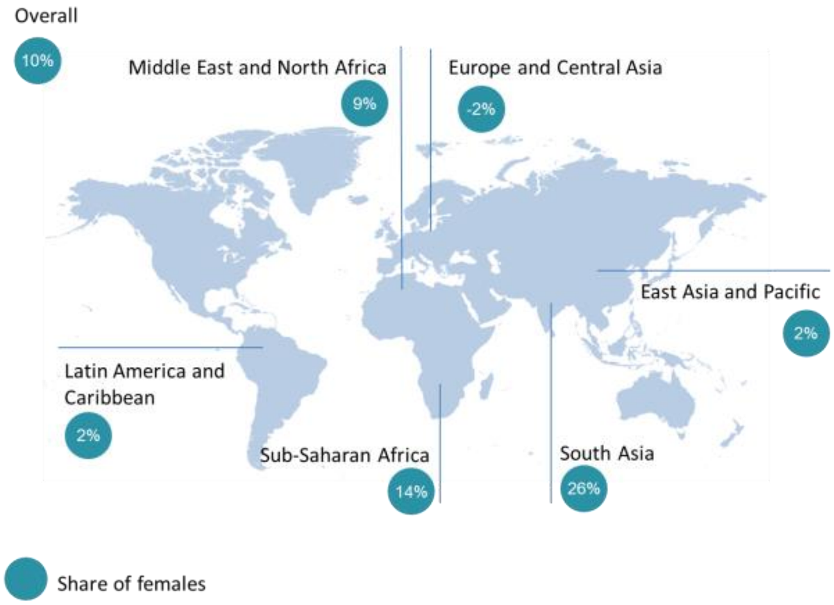
Figure 5 shows the gender gap in basic and smart mobile phone ownership in low- and middle-income countries. On average, women are 10% less likely to own a basic mobile phone and 26% less likely to own a smartphone, although the gap differs between regions and appears most pronounced in South Asia and Sub-Saharan Africa. In South Asia women are 26% less likely to own a basic mobile phone and 70% less likely to own a smart phone that can connect to mobile Internet; in Sub-Saharan Africa this gender gap is 14% and 34%, respectively. The gender gap in smartphone ownership results in roughly 327 million fewer women than men with a smartphone and, consequently, mobile Internet access (GSMA, 2018a).

Interestingly, even when access is granted, the digital gender divide persists in usage: among smartphone owners, women are 18% less likely to use mobile Internet (GSMA, 2018a; see also Alliance for Affordable Internet, 2014; Web Foundation, Women's Rights Online, 2015). In Indonesia and India, the gender gap in using mobile Internet is 20% and 10%, respectively. Only 40% of Indonesian women access the Internet through their mobiles, as compared to 60% of Indonesian men. In India, 20% of women do so compared to 30% of men (GSMA, 2015a).

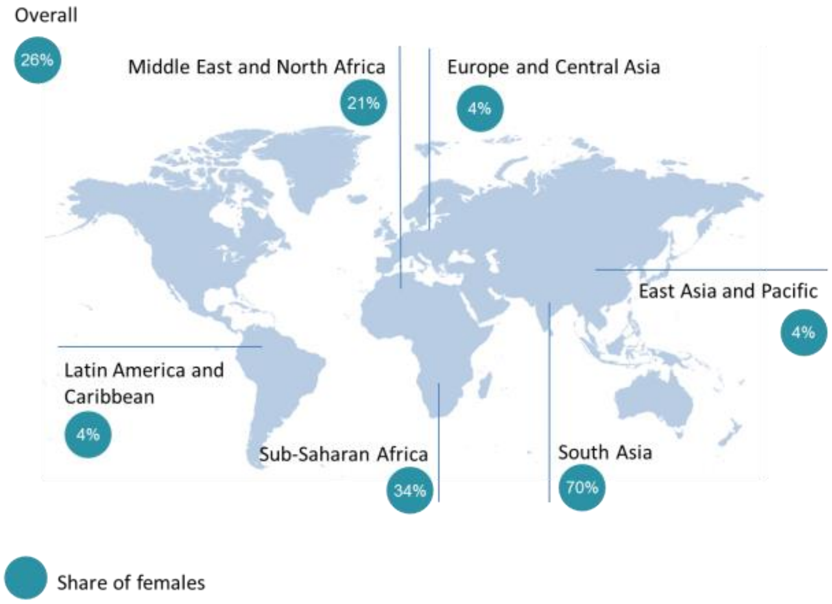
Divides are wider in rural areas: in rural India, women are 27% less likely to own a basic mobile phone, as compared to a 14% gap in urban areas. In the case of smartphones, the digital gender divide is even more pronounced: women in rural India are 72% less likely to own a smart phone, as compared to a 63% difference in urban Indian areas (GSMA, 2018a).While the fixed and variable costs of mobile phone ownership and usage represent a barrier for women and men alike, women face higher hurdles gaining access and meaningful use due to the higher proportion of women and girls who have low educational attainment and no or little income, especially in some Asian and Sub-Saharan African countries. For example, 40% of Nigerian women who do not own a mobile phone reported that literacy presents a key barrier to ownership, compared to 22% in the case of men (GSMA, 2018a). Safety-related reasons were further mentioned by most respondents in Latin America, with 40% of women in Mexico who do not own a mobile phone indicating they are concerned about sexual harassment (vs. 24% of men) (GSMA, 2018a).

Figure 5. Gender gap in basic and smart mobile phone ownership in low- and middle-income countries

A. Basic mobile phone ownership, by region



B. Smartphone ownership, by region



Note: Unconnected females include those who do not own a mobile phone, but may borrow one.

Source: OECD, adapted from GSMA (2018a).

Barriers to using smartphones do not differ from the ones hindering women to own a basic mobile phone. The high prices of mobile phones, which are even higher for smartphones, make the purchase and ownership of such devices simply not easy or possible for many. However, the cost of smartphones for consumers has been decreasing (Meeker, 2018). Further, mobile phone initiatives such as providing 4G capable smartphones for free are thought to have the potential to provide coverage for 99% of India's population (Firstpost, 2017). Nevertheless, in the case of smartphones, awareness seems to play an important role too, with women in Africa and Asia tending to show little awareness about the possible benefits that having a smartphone may bring them (GSMA, 2018a). For instance, while 62% of men in Nigeria and 41% of men in India know about mobile Internet, this is the case for only 45% of women in Nigeria, and 19% of women in India.

Women and men further differ in the way they use mobile phones. Female users tend to use fewer services than men and prefer to make and receive video calls. Video calling offers not only lower hurdles for women who are less confident in using the Internet, but is socially also more accepted in order to remain in touch with family members overseas. Men are conversely more likely to browse the Internet and to download and use apps (GSMA, 2017).

Digital financial inclusion

Despite the key role of women in managing the household's money, in contributing to their family's income, in being responsible for undertaking transactions related to family expenditures – including sending and receiving transactions or remittances – and managing the government support that may be available for their household, women tend to be less financially included and economically empowered than men. Increasing access to and use of financial products and services is particularly important for women, as it would help make them more independent and able to take better care of themselves and their families. Many women still depend upon their partners; they disproportionately experience poverty, inequality and discrimination, and suffer from the unequal divisions of labour and lack of control over economic resources. About one in three married women in developing countries have no control over household spending on major purchases, and about one in ten is not even consulted about how her earnings are spent (UN, 2015). Also, women often have limited education and (to some extent relatedly) employment opportunities, and little if no control over tangible assets and land ownership, including the assets they may have inherited (Holloway, Niazi and Rouse, 2017). Fostering women's financial inclusion is thus extremely important as it would empower women and make them (better) able to manage risk, to start or invest in businesses, or to fund expenditures related to e.g. education, health or home improvements.

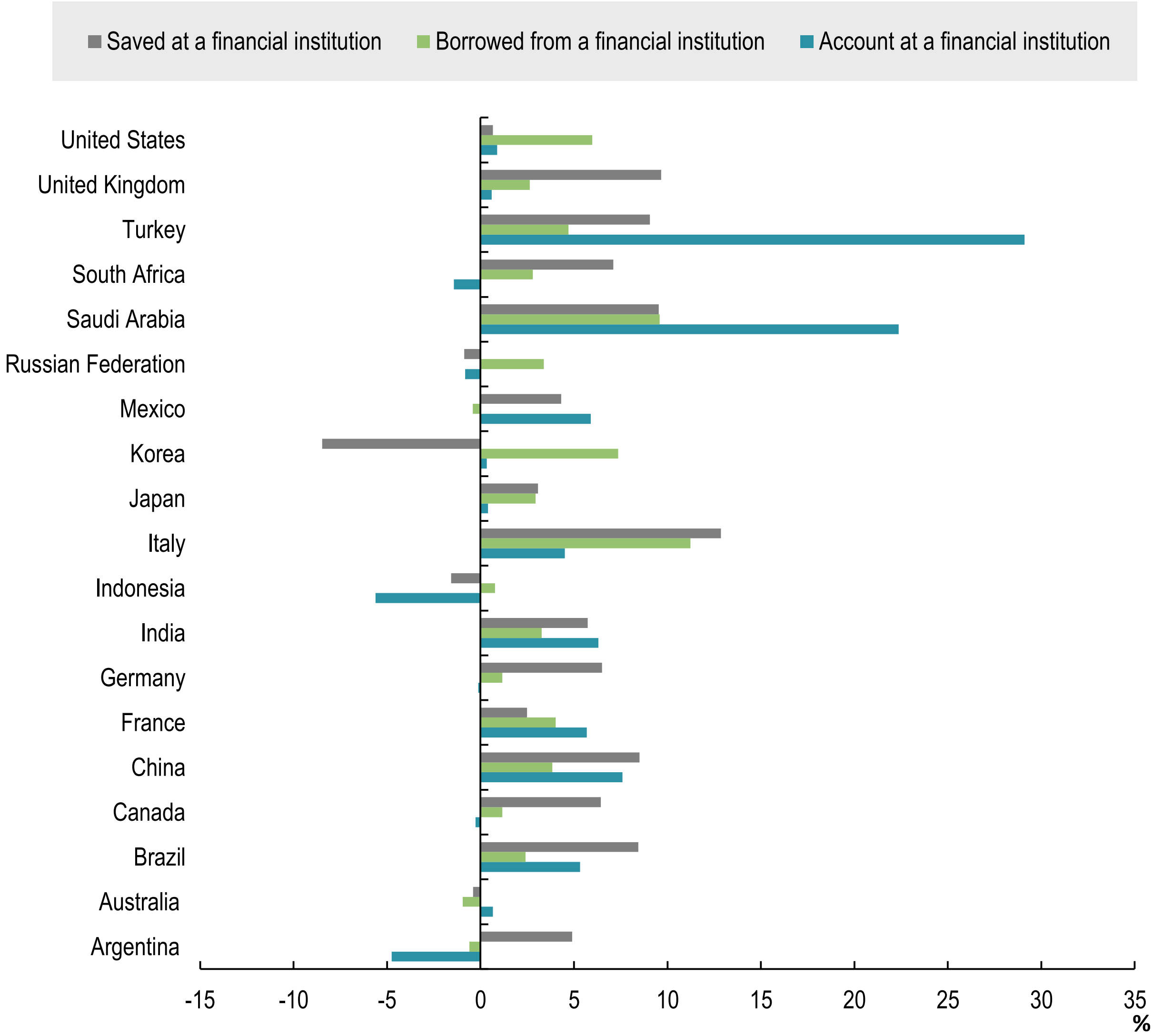
Formal financial systems

Women are often less likely to own a financial account, albeit this gap differs among regions. Based on data from the Global Financial Inclusion Database 2014 (Demirguc-Kunt et al., 2015), in the period 2011-14, women worldwide were about 8% less likely than men to own a formal bank account. In 2014, only about 25% of African women aged 15 and above had access to a formal financial account, as compared to almost 33% of men (Demirguc-Kunt et al., 2015).

Figure 6 illustrates the gender gap related to formal financial activities, such as having a bank account and borrowing and saving activities at formal financial institutions for several G20 economies. Although some countries such as Korea and Indonesia stand out in terms of the high female involvement in saving activities, financial integration is generally far from being achieved.

Figure 6 shows comparatively bigger gender gaps in formal financial inclusion in Turkey, Saudi Arabia, China, India, Brazil, and Italy, where women are between 29 and 45 percentage points less likely to have a formal bank account. Women in China are about 8 percentage points less likely to have an account at a financial institution. In India, 83% of men have an account at a financial institution, compared to only 77% of women. In Saudi Arabia, 58% of women have a financial bank account compared to about 81% of men. In Turkey, women are 29 percentage points less likely than men to own a bank account at a financial institution. Although bank account holders in G20 economies are primarily male (with slight exceptions in Indonesia and Argentina), some countries exhibit proportionally higher female involvement in formal saving activities. For example, more women in Korea and Indonesia use a financial institution for formal savings (by about 8% and 2%, respectively). Furthermore, Australia and Argentina emerge as countries where slightly more women than men borrow from formal financial institutions (by about 1 % in each country).

Figure 6. Difference in men's and women's formal financial activities, 2017



Note: The figure shows the difference of male and female formal financial activities. If the difference is negative, more women than men are involved in the financial activity considered.

Source: World Bank (2018), *World Bank Global Financial Inclusion*, http://datatopics.worldbank.org/financialinclusion/indv-characteristics/gender.

The more women are involved in financial transfers, the more they are likely to use bank accounts. Research shows that women receiving social grants are more likely to use bank accounts for several payments. For example, every fourth women in South Africa receives a social grant and this leads to greater use of bank accounts for financial payments (FinMark Trust, 2016a).

BOX 2. FINANCIAL INCLUSION AT THE G20

Financial inclusion has emerged as one of the priorities of the G20 agenda over recent years, in acknowledgement of the difficulties many individuals and micro, small and medium-sized businesses (MSMEs) face in accessing finance. In 2016, the G20 adopted the *G20 High Level Principles for Digital Financial Inclusion* (GFPI and G20, 2016), providing a basis for country action plans to leverage the potential offered by digital technologies. The eight Principles reflect that digital financial services, together with effective supervision (which may be digitally enabled), are essential to close the remaining gaps in financial inclusion.

Principle 6 recognises the importance and relevance of financial literacy competencies to allow consumers and small businesses (and especially groups at risk or vulnerable) to take full advantage of the increasingly digitalised financial landscape. The 2017 *G20/OECD INFE Report on Adult Financial Literacy in G20 Countries* highlighted the lack of basic financial knowledge held by people in many G20 economies, and particularly underscored a gender gap (OECD, 2017i). The difference between the percentage of men and women achieving the minimum target score for financial knowledge in G20 economies stood at 11 percentage points, with men significantly more likely to achieve this score than women in all but three of the countries with comparable data. Clearly, financial education must be designed to take into account the significant differences in knowledge across men and women, as recommended in the *OECD/INFE Policy Guidance on Addressing Women's and Girls' Needs for Financial Awareness and Education* (OECD, 2013) endorsed by G20 Leaders in 2013.

Sources: OECD (2017i), *G20/OECD INFE Report on Adult Financial Literacy in G20 Countries*, www.oecd.org/finance/G20-OECD-INFE-report-adult-financial-literacy-in-G20-countries.pdf; GFPI and G20 (2016), "G20 high level principles for financial inclusion", https://www.gpfi.org/sites/default/files/documents/G20-HLP-Summary_0.pdf.

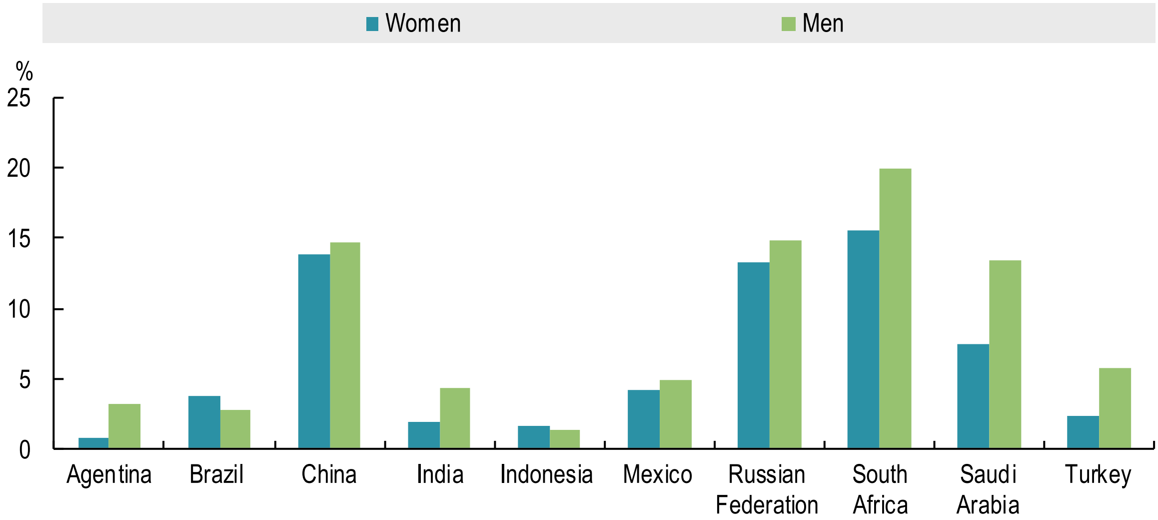
Women tend to not only have less access to formal bank accounts, which generally happens by means of visiting the local bank branches. They also have less access to mobile banking, i.e. accessing formal bank accounts through smart phones or tablets.

Mobile banking has a number of advantages over traditional banking. These include: time saving, convenience and ubiquity, as users do not need to physically present themselves during a narrow set of daily hours; security, privacy and ease of access; increased efficiency and flexibility in the type of operations that can be performed (that is, there is no physical queue to endure when performing Internet or mobile banking) and no need to talk with different bank clerks for different types of operations. In addition, mobile banking reduces the possibility of fraud, as customers can check and follow operations in real time.[4] All these characteristics of mobile banking may facilitate the financial inclusion of women as they contribute to lower barriers to access, use and management of financial products and services and, more generally, their financial means and resources.

Data from the World Bank Global Financial Inclusion (Global Findex) database shows that women use mobile banking to a lesser extent than men to make financial transactions. Figure 7 shows in the majority of G20 economies, women generally are less likely than men to make mobile phone-enabled transactions, despite having formal financial accounts. Such differences are especially large in the case of Saudi Arabia (6%), South Africa (4.4%) and Turkey (3.5%), followed by Argentina and India (2.5% each).

Social and cultural perceptions contribute to explain these gaps, albeit to a different extent. A number of studies argue that women are more likely to reject mobile banking since they are affected by social norms (peer influence) to a greater extent than men (see Riquelme and Rios, 2010; Garbarino and Strahilevitz, 2004; Laukkanen and Pasanen, 2008). A study further finds that in Finland women trust electronic services less than men, whereas the opposite is true in Portugal (Kivijärvi, Laukkanen and Cruz, 2007). Additionally, women in the United States are found to access mobile banking services especially through mobile phones and tablets, whereas men use personal computers to a greater extent for this purpose (Ernst & Young, 2017).

Figure 7. Transactions made through a mobile phone by individuals having formal financial accounts, 2014

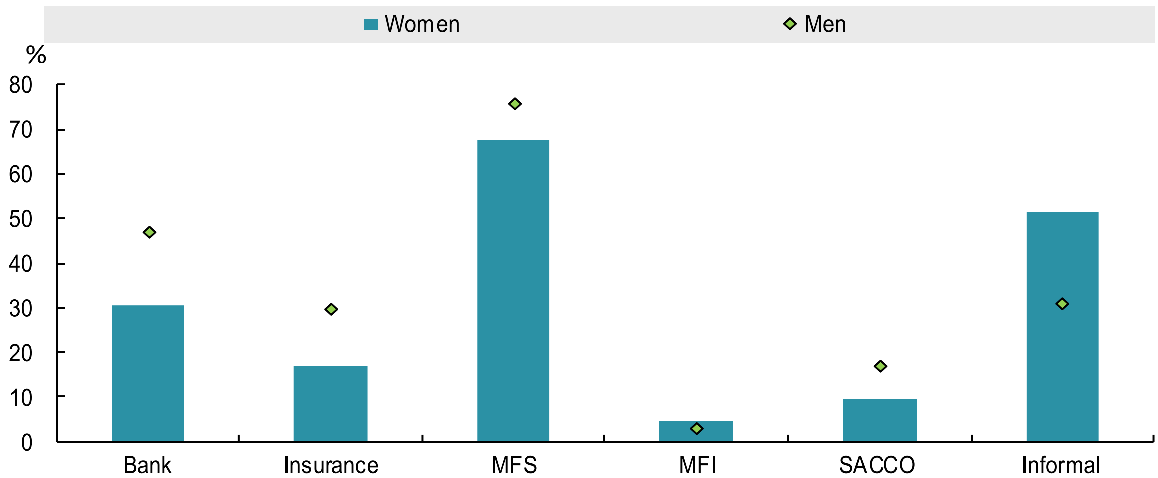


Notes: This figure denotes the percentage of respondents (age 15 and above) who report making a transaction with money from their account at a bank or another type of financial institution using a mobile phone in the past 12 months. This can include using a mobile phone to make payments, to make purchases or to send or receive money.

Source: World Bank (2018), *World Bank Global Financial Inclusion*, http://datatopics.worldbank.org/financialinclusion/indv-characteristics/gender.

The 2016 FinAccess Household Survey Report on Kenya's gender gap in financial inclusion, showed that the usage of financial service providers differed by gender (Figure 8). While the report shows that formal financial inclusion generally increased among women between 2009 and 2013, especially driven by the spread of mobile financial services such as the M-Pesa[5] – an initiative using simple text messaging to transfer money which can be used even on the most basic mobile handset – women still display lower access to formal services than men (35% for women vs. 50% for men).

Figure 8. Usage of financial service providers, by gender, in Kenya, 2016



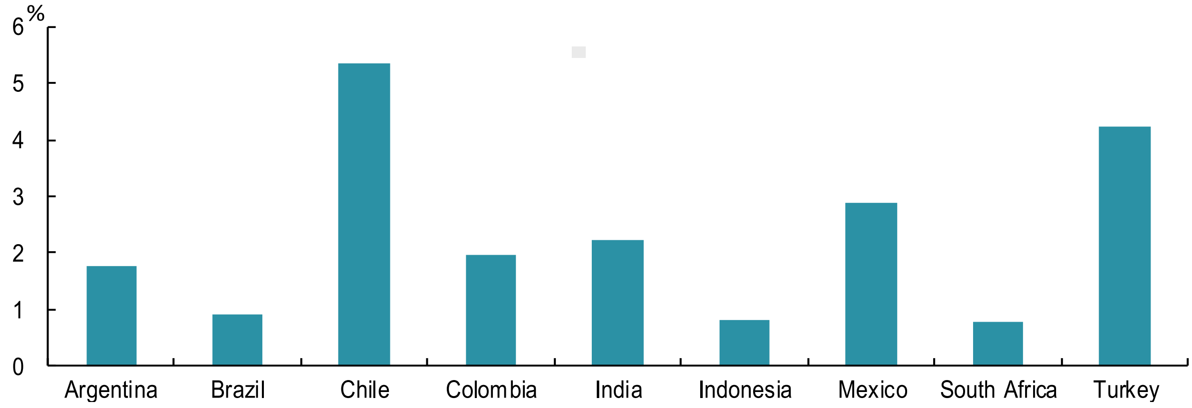
Note: MFS = mobile financial service provider (that include Airtel Money, M-Pesa, MobiKash, Orange Money and Tangaza Pesa); MFI = credit-only microfinance institutions; SACCO = savings and credit co-operative.

Source: FinAccess (2016), "2016 FinAccess Household", https://www.centralbank.go.ke/uploads/financial_inclusion/736331048_FinAccess%20%20Household%202016%20Key%20Results%20Report.pdf.

Informal financial systems

"Mobile money" presents a useful way to make financial transactions from SIM card to SIM card. For many people with no bank account "mobile money accounts" can be a way to bring more women into the global economy through digital financial services (Better Than Cash Alliance, 2015). However, data from Global Findex (Demirguc-Kunt et al., 2015) and the World Bank Global Financial Inclusion database suggest that fewer women are likely to own and use a mobile money account.

Figure 9. Gender gap in mobile money accounts in selected G20 economies and OECD countries, 2017



Note: Data for mobile money accounts is not available for other G20 economies or other OECD countries.

Source: World Bank (2018), *World Bank Global Financial Inclusion*, http://datatopics.worldbank.org/financialinclusion/indv-characteristics/gender.

Figure 9 shows that among the G20 economies and OECD countries for which data are available (namely: Argentina, Brazil, Chile, Colombia, India, Indonesia, Mexico, South Africa and Turkey) mobile money accountholders are unequal between women and men. This is an important sign of women being not only less integrated in the formal (Figure 6) but also informal financial economy (Figure 9).

"Leapfrog" and other digital opportunities for economic empowerment and reducing the gender gap

The gender gap in access to and usage of digital technologies remains a challenge for individuals and society. Policy makers need to act to unleash the potential of digital technologies to empower all individuals, including women and girls. The focus here is on three selected technologies, namely the Internet and digital platforms, mobile phones, and electronic payments, as they offer "leapfrog" opportunities for all, and have the potential to improve the lives of women and girls in particular.

Leapfrog opportunities – bypassing traditional technologies and taking up digital alternatives – can offer additional income, additional employment opportunities and improved access to knowledge and general information that benefit women and girls in particular by providing a path to narrow other gender gaps, such as those related to education, labour market participation, wages and entrepreneurship. For instance, by lowering entry barriers, improving labour matching, and bringing transaction costs down, platforms may help many disadvantaged individuals, and especially women who may otherwise face hurdles to working in the formal economy. However, for the benefits of digital platforms to accrue to people, it is important to address the possible adverse effects that the use of non-standard employment may have, including workers' lack of bargaining power, higher job insecurity and risk of occupational accidents, poorer work-life balance and less training.

Internet and digital platforms

The Internet and digital platforms may help foster economic growth and social well-being by means of connecting people and ideas, thus helping to spur innovation and the sharing of relevant knowledge, including about relevant technologies and business methods. Unlocking the benefits of the digital transformation can therefore transform the lives of many, and offer leapfrog opportunities to women and girls in particular.

The Internet

Internet access provides various opportunities, including increased access to knowledge and education and to new customers and markets, and allows for more flexibility with respect to the time and locus of work.

On average around the world, girls often attend fewer years of school than boys – which ultimately results in worldwide higher illiteracy rates for women than men; they also face higher hurdles than men when it comes to starting or owning an entrepreneurial endeavour, and they struggle to combine family duties with earning much needed household income. These disadvantages mean that women and girls may benefit disproportionally from digital technologies.

The Internet improves information flows and lowers hurdles to accessing both general and specific knowledge, including about education and training possibilities. While this is beneficial to all people, it may prove particularly helpful for girls with little education (if any), as they may be able to access online courses and acquire general information, also delivered in the form of podcasts, videos, tutorial and "how to" types of instructions that reduce the reliance on written text books. This may in turn increase women's awareness about possible education programmes for their children, and lead to improved education for children, paving the way for enhanced participation in secondary or even tertiary education. In the case of women depending on agriculture for their income, access to the Internet may allow them to benefit from weather forecasts and thus help optimise the harvesting time and the quality and quantity of output. It may also help women access health care-related information, including about specific medical treatments or prophylaxis, and reduce the risks and costs of early pregnancy (Billari, Gintella and Stella, 2017).

The possible benefits of the Internet are not limited to specific regional areas. Women in industrialised economies, who are often the primary caregiver at home and try to supplement household income, can benefit from more flexible work and employment types (e.g. part-time, telework, freelancing or other types of more flexible work arrangements). For instance, a recent study shows that the roll-out of Australia's National Broadband Network (NBN) has led to an increase in female entrepreneurship in Australia (NBN, 2018). Fast broadband connection at home has encouraged more people to work from home, access education, have smart devices in their homes, and to start their own business. The effects were found to be particularly strong in rural areas and for women. Upon the broadband roll-out, the number of self-employed women grew at an average 2.3% every year, compared to only 0.1% on average in non-NBN areas (NBN, 2018). Such findings are confirmed in analysis focusing on the Indo-Pacific region that shows that, on average, growth in Internet use was associated with four-fifths of the increase in female workforce participation between 2000 and 2016 (Watson, Corliss and Le, 2017). Also Dettling (2016) shows that high-speed broadband was estimated to increase married women's workforce participation by 4.1 percentage points.

Moreover, increased flows of cross-border knowledge and technology transfer, combined with less restrictive social perceptions towards female employment, may translate into an increased supply of female workers into the labour force. This may be particularly relevant for countries exhibiting low fertility growth and unbalanced demographical change (Billari, Giuntella and Stella, 2017). However, general privacy concerns and identity information disclosure concerns can be more important in the case of women than men, and risks such as those related to possible stalking, online abuse or harassment need to be addressed for women to be able to benefit from being online.

Digital platforms

The platform economy or gig economy has grown recently with ever increasing demand for online services. Platforms are important for women because they may help reduce barriers to participation in the labour market and enhance the opportunity to work for different clients and/or projects. Particularly for less-developed countries, platforms can help all, and women in particular, to transit from the informal, "shadow" economy to standard work, but policy needs to ensure that online platforms do provide real opportunity, rather than substituting a traditional sweat shop for a digital one (OECD, 2017b). Increased flexibility through platform work can be desirable for women as long as women have control over it and work-life balance does not end in "work-life blurring". There is evidence that women face many conscious and unconscious biases and stereotypes which can also constrain their participation in online platforms.

Most women in the digital economy work as professional freelancers for digital labour platforms (e.g. Upwork, Freelancer and 99designs[6]). Upwork and Freelancer are sites that match demand and supply of a large range of (mainly) professional services, from data entry and administrative support to translation and design, to coding, legal advice, and business consulting. Combined, both platforms had an estimated 49 million registered users in 2016 (OECD, 2017g). Only 6 years after its start in 2000, the job platform Freelancer had a total of registered 10.2 million jobs with a value of USD 3 billion (Freelancer, 2017). Other platforms range from direct selling platforms (e.g. Mary Kay, Rodan and Fields), to service platforms (e.g. TaskRabbit and Care.com), to ride services (e.g. Uber and Lyft), holiday accommodation (e.g. Airbnb or HomeAway), home-decoration services (e.g. Etsy) and food delivery platforms (e.g. Grubhub or Postmates).

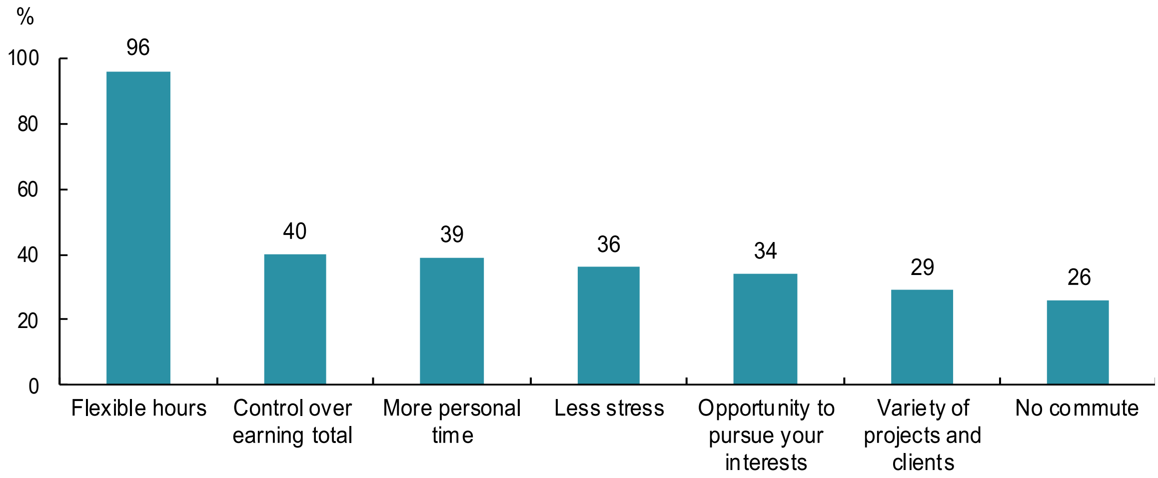
Digital platforms offer a range of benefits for women

Digital platforms may help women in many ways, in both emerging and industrialised economies. They can facilitate more efficient labour market searches and skills matches and increase the range of customers reached worldwide, without investing in traditional marketing. Also, by means of enabling access to and participation in wider ranges of customers and projects, platforms may allow women to improve their skill sets. This, in addition to their potential role in integrating women in the labour force, complementing household income, and allowing women to combine motherhood while pursuing a career, thus indirectly supporting fertility growth, especially in ageing societies.

In developing and emerging economies, digital platforms provide leapfrog opportunities. They can help entrepreneurs of MSMEs reach a wider range of customers without incurring expensive marketing and sales expenditures. Reaching out to distant customers and markets can be particularly valuable for women with constrained mobility, e.g. those in rural areas. Linking platforms with other digital technologies, such as cloud computing, can enable entrepreneurs, including female entrepreneurs, to expand their business capacity and services more quickly (Asia Foundation, 2018). Also, thanks to big data and artificial intelligence, platforms may be able to match job seekers worldwide more efficiently, effectively, and in a gender-neutral fashion (see for example the Talent Intelligence Platform Eightfold.ai (Shieber, 2018). Nevertheless, the potential for inherent bias in algorithms remains a general concern for policy makers and evidence of gender disparities in the field of artificial intelligence (e.g. low female presence in leadership teams of start-ups: see CBInsights [2018]; The New York Times [2016]) further underlines the need to be attentive to this issue.

Many women join the gig economy because it allows for more time flexibility, more job variety and more time with their family, while at the same time helping with the family income. A survey of 2 000 women working as freelancers from home for digital platforms by Hyperwallet (2017) finds that for almost all women (i.e. 96%) in the gig economy, flexible working hours are the key perceived benefit (this was the conclusion found in other studies as well, e.g. MGI, 2016b; JPMorgan Chase, 2016). In addition, supplementing income and increased control over earnings motivate 40% of the survey respondents to pursue a job in the gig economy. Additional perceived benefits include having more personal time (39%), also linked to avoiding commuting (26%), which results in less stress (36%) and greater opportunities to pursue personal interests (34%). Further, almost a third of all respondents (29%) appreciated the variety of projects and clients they had, and the related possibility to increase their skill sets and move on in their careers (Figure 10).

Figure 10. Benefits of working in the gig economy



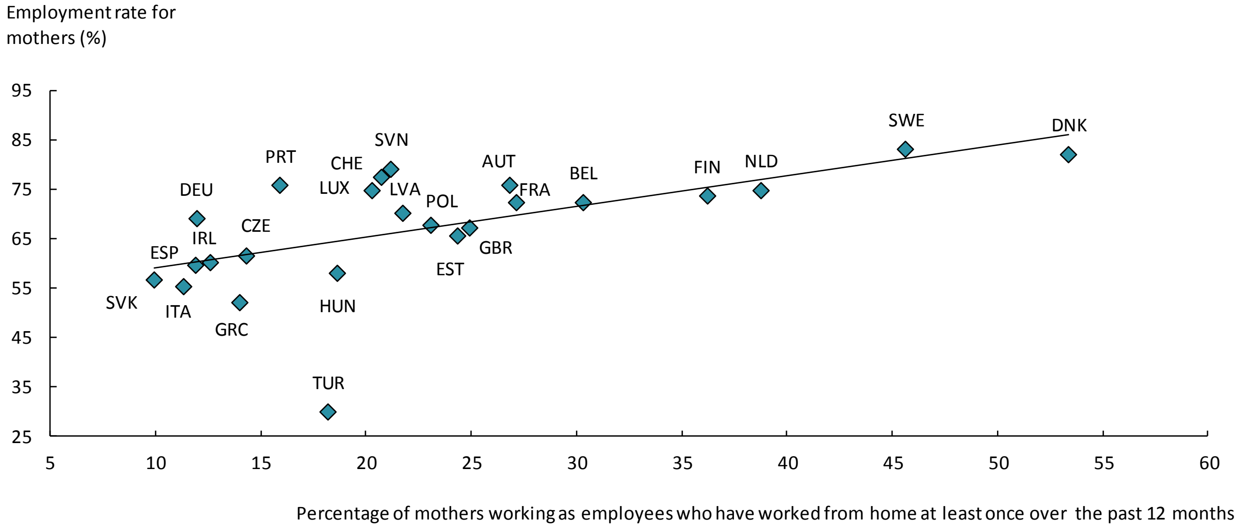
Source: Hyperwallet (2017), *The Future of Gig Work is Female – A Study on the Behaviours and Career Aspirations of Women in the Gig Economy*, https://www.hyperwallet.com/resources/ecommerce-marketplaces/the-future-of-gig-work-is-female/.

Flexible working times of platforms are fostering female labour participation

One of the major advantages of digital platforms is that people can flexibly chose where, how and when to work. While at times raising concerns about job quality, more work flexibility can increase employment, and can help parents combine work and family responsibilities. It offers women the possibility to better combine motherhood and the pursuit of a career – most women in the gig economy are in fact the primary caregiver at home (Elance, 2013). Of the women who left their "traditional" jobs to start working as freelancers for digital platforms, 32% wanted to change for a more flexible job, and 28% said that they needed more time as a caregiver for a family member at home (Elance, 2013). OECD analysis finds that those countries with the highest shares of women working from home are also the ones that exhibit the highest employment rates (Figure 11).

Figure 11. Correlation between work flexibility and employment rates among mothers

Percentage of mothers (all ages) working as employees who have worked from home at least once over the past 12 months, and employment rates (%) for mothers (16-64 year-olds), 2014-15



Notes: Data on home working refer to 2015. Data on maternal employment refer to 2014, except for Denmark and Finland (2012) and Germany and Turkey (2013). "Mothers" are defined as women with at least one child aged 0-14. For Sweden, for the data on maternal employment, data refer to women aged 15-74 with at least one child aged 0-14.

Source: OECD (2017e), *The Pursuit of Gender Equality: An Uphill Battle*, http://dx.doi.org/10.1787/9789264281318-en.

With flexibility being one of its key advantages, the gig economy has seen increased participation of women in gig work, also in platforms related to home-decoration, home-sharing services and ride-sharing. For example, more women are working for Etsy, a digital home-decoration platform, than there are female sellers in the "home-decoration" sector in traditional shops in the United States. While 86% of sellers on Etsy are women, there are proportionally fewer female sellers in traditional shops for home furnishing and household appliances (BLS, 2016). Furthermore, with 67% female hosts on Airbnb, there are more female hosts on home-sharing services as Airbnb, than there are women employed in the tourism industry (Etsy, 2015; OECD, 2017b).

Higher female employment rates can be also found in the ride-sharing economy. The ride-sharing economy has more female chauffeurs than there are female taxi drivers: transport services as Uber show a higher female employment rate for freelancer/individual worker than comparable transport services. In the United States, the proportion of female drivers is higher for Uber (14%) than for traditional taxis (8%). "Working part time or flexible schedules" because of a "family, education, or health reason" is the main reason for female drivers (42%) (as compared to 26% in the case of men; see Hall and Krueger, 2015). Also, three-quarters of female drivers for ride-sharing platforms rank flexibility among the top three benefits of ride-sharing platforms as it helps working out additional family responsibilities (IFC and Accenture, 2018).

Furthermore, service platforms related to health, such as the telemedicine platform DoctHERs (DoctHERs, 2018) in Pakistan, enable women to get back into the labour market, and in some cases even make them the primary breadwinner of the household. The platform connects unemployed or underemployed female doctors to patients in remote areas. Women in Pakistan are often pressured to prioritise families over careers, and this leads to around half of female medical school graduates never entering the workforce. Some even argue that, although gig economy jobs may lack insurance plans, regular sick days or vacation time, the absence of these safety nets may be considered relatively less important in view of the upsides of the gig economy (Toppa, 2018). In any case, while enhanced flexibility may be the primary quality that attracts women to gig jobs, it should not come at the expense of being subjected to unscrupulous use of new atypical work arrangements that may reduce job quality. If more flexibility results in increased working hours and problems in separating work and personal life, the bottom line may be a worsening of women's employment situations. Whether such flexibility ends up being good or bad for workers will depend on whether it is: 1) voluntary or not; 2) associated with more or less work autonomy; and 3) paired with more or less job security (OECD, 2017b).

More diversity and reduced barriers to entry than competing for a full-time job

Platforms may reduce barriers to entry in the labour market for women. Data suggest that more than the majority of women working for labour platforms find it easier to be hired for a job online while working for multiple clients than to compete for a full-time job in a traditional fashion (Elance, 2013). Women in the ride-sharing economy confirm that low barriers to entry via the app make it relatively easy for women to enter this traditionally male-dominated industry, albeit the proportion of female drivers remains lower (IFC and Accenture, 2018).

Women may find in platforms a way to make it through the "glass-ceiling". Based on a survey of 7 000 global independent female professionals, many women indicate that working for the gig economy enables them to "escape" from traditional work barriers. As such, platforms provide an opportunity to avoid "glass-ceiling" issues. A survey by Facebook, OECD and the World Bank shows that digital businesses may help decrease access barriers since cultural norms can be avoided and customers reached worldwide (OECD, 2017b).

In terms of permanent and full-time positions, the Chinese online seller Alibaba employs more women in managerial positions than traditional companies. While one-third of the successful Chinese e-commerce group's 18 founding partners are female, and women account for nine of the 30 partners who control management decisions, in Asia on average only 6% of corporate board positions are occupied by women (Financial Times, 2014).

In developing and emerging economies, online job platforms can offer leapfrog opportunities to women, as their international reach may allow them to find a paid job, also in a distant location, thus helping them exit from the shadow or grey economy. This could be especially beneficial when cultural barriers or rules make it difficult to work in the formal economy (OECD, 2017b).

Supplementing household income

Another reason for women to offer their work and services on digital platforms is that platforms facilitate supplementing household income, and help address gender wage gaps. A survey of 2 000 women working as freelancers for digital platforms showed that for the majority of women (86%) working for platforms offered the possibility to get equal pay. Only 41% believed that traditional work would offer that opportunity (Hyperwallet, 2017). This goes in line with evidence from the United States showing that the gender wage gap tends to be lower in industries where working arrangements are more flexible (Goldin, 2014).

Almost two-thirds of women working on platforms have spouses with full-time careers who are the main household contributor. However, the work for digital platforms allows them to supplement household income while often being the primary caregiver. Around 42% of US women and 48% of European women who participate in the gig economy are also caregivers (MGI, 2016b). More than half of the women working in the gig economy in the United States can contribute to the annual net family salary through "gig work" by up to USD 10 000 (Hyperwallet, 2017). Etsy finds that 17% of Etsy sellers can contribute to household income by up to USD 25 000 annually (Etsy, 2015). Further, women based in the United States were found to be more likely to participate in online capital platforms that connect customers with individuals who rent assets or sell goods peer-to-peer, as Airbnb and Ebay, than in online labour platforms (where individuals perform discrete tasks, as Uber or TaskRabbit) (JPMorgan Chase, 2016), albeit differences exist between different platforms and types of activities. JPMorgan Chase (2016) found that this might be related to differences in the importance of earnings from capital platforms and labour platforms. While capital platforms, as Airbnb and Etsy, are more likely to supplement non-platform income, earnings from labour platforms are more likely to offset salary decline from traditional jobs or in transition periods between two different jobs (JPMorgan Chase, 2016).

Employment in the gig economy also permits to support other entrepreneurial activities or studies. Fifteen percent of female drivers in the ride-sharing economy run separate business activities in addition. Some of them use their ride-hailing income to smooth the cash flow of their operations and to improve credit profiles; others use the contacts they make on the ride-sharing platform as potential advisors, investors and customers (IFC and Accenture, 2018).

Location and profiles of women offering their work on digital labour platforms

Most women working as independent freelancers are young and are parents with dependents at home – either children or other family members, or both. Elance's survey (2013) finds more than half (58%) of the gig women to be less than 35 years old, around one-third to be between 35-50 years old, and only 12% to be between 51 and 70 years of age. Two-thirds of the women surveyed by Hyperwallet (2017) are found to have been working independently for digital platforms for less than two years. Moreover, as shown in Figure 12, most workers offering their services on digital labour platforms (such as Upwork) are located in low-income countries while employers are mainly based in high-income countries (OECD, 2017b).

Figure 12. Location of digital service workers on online platforms

Top ten employer and provider countries on Upwork, 2014

Notes: Upwork is one of the leading global freelancing platforms. Top 10 (provider) countries are denoted by their flags and to-digit international codes. Circular flows denote flows where employer and provider countries coincide.

Source: OECD (2017e), *The Pursuit of Gender Equality: An Uphill Battle*, http://dx.doi.org/10.1787/9789264281318-en.

Elance's (2013) survey finds that most women were based in the United States (44%), while the remaining female gig workforce was based in India (7%), followed by the Philippines (6%), Canada (5%), and the United Kingdom (4%). Most of the clients were based in the United States (76%), Australia (5%), United Kingdom (5%), Canada (3%) and India (2%).

Mobile phones

Access to mobile phones is likely to increase in the future. The Global System Mobile Association (GSMA) expects that by 2025, mobile Internet penetration will reach 61% globally (GSMA, 2018b). This could help women worldwide to improve their economic and social condition, by providing access to information, and reducing existing information asymmetries.

Mobile phones allow women to access markets and improve saving behaviours (Karlan, Morten and Zinman, 2012). Reduced communication costs and improved access to mobile phones have enabled women to gain and exchange information, for their own benefit and for the benefit of their families and the wider society. Smart phones in particular offer women more privacy and confidentiality in accessing the Internet. For a woman trying to be an entrepreneur in a patriarchal society, this may represent an important source of independence. These effects can be particular strong in rural areas, where mobile phones have proved to be crucial to connecting individuals to markets, services and information (Aker et al. 2016; Aker, Ksoll and Lybbert, 2012; Aker and Mbiti, 2010). Moreover, mobile phones allow women to access relevant information, including on governmental support and pension rights. There is also evidence that access to mobile phones has increased female participation in governmental elections (Gakuru, Winters and Stepman, 2009; GSMA, 2013, 2016).

The use of mobile phones has further been found to allow women to access information which can improve access to medical treatments and maternal health care (Lester et al., 2010). Further, research has shown that increased access to information ultimately makes women feel safer, more autonomous and self-confident (Aker et al., 2016). Also, mobile phones can help women by allowing the collection of relevant data that may complement socio-economic statistics, in case of limited availability of official statistics (Blumenstock, Cadamuro and On, 2015). In Tanzania, for example, mobile phones have helped to facilitate birth registrations by mothers as part of a plan to improve health, education and other public services.

BOX 3. MOBILE PHONES AND THEIR IMPACT ON WOMEN IN INDIA

The growth of digital markets in India, and their impact on women is expected to be important. By 2020, India's online user base is estimated to increase from around 120 million in 2015 to more than 300 million. That growth will not only be driven by the expansion of broadband Internet in rural areas and by the growing importance of young users,[1] but also by the greater use of digital technologies by women.

Decreasing prices of mobile phones and voice commands are contributing to overcome the gender gap in mobile ownership in India. An Indian company will soon launch the worldwide cheapest phone with support for voice input, including the support of 22 Indian languages. Among others, voice commands can be used to respond to queries, send messages, and place calls – surmounting illiteracy barriers. The phone will be offered for free, against a refundable deposit, which will be returned once the phone is returned after three years. The aim is to cover 99% of India's population. It is expected that women will be the ones benefitting the most from such innovation (Firstpost, 2017).

Additional governmental and business programmes are complementing existing endeavours aimed at overcoming barriers for women with respect to the lack of technology literacy. For examples, the provision of information in video format instead of text formats as well as initiatives as Internet Saathi ("Internet Friend") (which was developed by Google and the Tata Trust), and Google's voice recognition function have contributed to decrease illiteracy and improve technical literacy for women in rural India.

- The Internet Saathi initiative trains young female digital instructors to show women in rural villages basic digital skills of Google-provided smartphones, including different Internet or chat applications as Google Chrome and WhatsApp (Google, 2018). Internet Saathi has reached more than 2.6 million women in over 60 000 villages. Empowered with basic digital literacy and Internet access, those women were able to access government programmes, including welfare programmes and subsidised meals, and this has increased access to education, and female entrepreneurship. In regions that are less well-connected and have a variable electricity network, women are able to use special "feature-phones" that have more basic functions but extended battery life.
- The "Fightback" app is a mobile application that is contributing to address issues related to sexual harassment, and to improve security for women in India. The app allows sending global positioning system co-ordinates to pre-selected contacts by pushing an SOS button on the mobile phone. Since its development, it has been downloaded more than a million times.
- The Pradhan Mantri Jan Dhan Yojana programme is recent governmental initiatives that aims at improving the financial inclusion of women at the national level, including the promotion of mobile wallets, based on mobile transactions through telecom operators, and the development of Cash Out Point centres (PMJDY, 2018).

1. A strong growth of young smart phones users (aged 18 to 30), who already make more than 50% of the total user base, is expected to accelerate the growth of digital markets in India. This result may lead to a growth in the mobile payment market to around USD 6.6 billion by 2020 (Choudhury and Sharma, 2017).

Digital financial services

Both mobile banking and mobile money facilitate extension of banking services and security to the unbanked. However, while mobile banking is a product of the formal banking system, mobile money offers particular leapfrog opportunities for the poorest and unbanked parts of society, including women in developing economies. Mobile money is provided by telecom companies, and operates via software installed on SIM cards. This form of banking has often been referred to as "shadow banking"[7] as it does not take place within the formal banking system.

Using digital channels and agents for financial transactions can lower costs by as much as 90% compared to transactions conducted in physical branches of financial service providers. As a result, digital financial service providers can offer financial services in areas where bank branches and automated teller machines are not viable to consumers who have historically been unprofitable to serve (ITU-T DFS, 2017). Digital financial services present convenient, cost-effective financial services to manage irregular income streams to smooth consumption, save small lump sums to cover larger periodic expenses (e.g. education, health, housing), address income shocks (such as the loss of a job or death of a breadwinner), and borrow for consumption or business purposes. It is therefore important to foster innovation, promote competitive markets, and enable efficient and sustainable provision of high-quality digital financial services for financial inclusion. At the same time, it is important to ensure that consumers – particularly those who are poor and economically vulnerable – are protected from unfair or deceptive practices or the loss of their funds, and financial sector stability is maintained. (ITU-T DFS, 2017).

Women account for the (vast) majority of the millions of "unbanked" people worldwide. In emerging economies as a whole today, 45 % of adults – two billion individuals – do not have a financial account at a bank or another financial institution (WEF, 2016). While the share of the "unbanked" is higher in Africa, the Middle East, Southeast Asia, and South Asia, in all economies it is particularly high among poor people, women, and people living in rural areas. Even those who do have basic financial accounts may lack access to a broad range of financial services including savings accounts, loans and insurance products.

Mobile money can help rescue millions of people from financial exclusion. Mobile money has seen a rapid uptake in developing and emerging economies in the past years: between 2016 and 2017, globally registered mobile money accounts grew by almost 25%, from 553.7 million to about 690 million. Likewise, the volume of transactions increased by about 25%, from USD 1.5 billion to USD 1.8 billion (GSMA, 2017). The expected future growth of mobile money can allow around 1.6 billion unbanked people to access financial services for the first time, about half of them being women in developing and emerging economies, and 45% coming from the poorest two quintiles of the world income distribution (MGI, 2016a).

There are a range of successfully implemented mobile money initiatives worldwide. Examples include bKash in Bangladesh, WING in Cambodia, PayTM in India, M-Pesa and Tigo Pesa in Kenya, Easy Paisa in Pakistan and Smart Money in the Philippines. The GSMA Mobile Money Trackers lists installed or planned mobile money initiatives worldwide. Figure 13 shows an overview of the countries where mobile money initiatives have been already successfully implemented. For example, in Bangladesh, the number of mobile money accounts increased to about 40 million since its implementation in 2011 (IMF, 2017). To overcome issues around interoperability between different digital financial services and payment platforms, the Bill & Melinda Gates Foundation has released a new open-source software, called Mojaloop.[8] This extends the interoperability from mobile money providers to any bank, merchant or government institution in a way that specifically meets the need of the poor. The software enables an individual's digital wallet to connect with the employer's bank account and children's school account to complete monthly transactions (Gates Foundation, 2017).

Mobile money has grown to a significant size and reached market coverage in two-thirds of middle- and low-income countries within the past years (GSMA, 2017). Within one decade of the existence of mobile money accounts, registered accounts have surpassed more than half a million worldwide.

Figure 13. Countries with mobile money services for the unbanked

Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

In December 2016, the transaction volume was more than USD 22 billion, with more than 43 million transactions per day (GSMA, 2016c). If this rate of growth continues, McKinsey Global Institute estimates that mobile money services may add about USD 3.7 trillion to global gross domestic product (GDP) within the next decade (MGI, 2016a). If mobile operators in low-and middle-income countries were to close the gender gap in mobile ownership and mobile Internet use today, this would generate estimated incremental revenue of USD 15 billion over the coming year (GSMA, 2018a). Mobile money can be the gateway to huge and yet untouched markets: digital finance has the potential to reach over 1.6 billion new retail customers (half of them women) in emerging economies, and to increase loans to individuals and businesses by around USD 2.1 trillion (McKinsey Insights on Financial Services, 2018).

Benefits of mobile money

Mobile money offers a number of prospective benefits, including financial integration, improved financial resilience and privacy. One of the key features is that everyone can deposit, transfer, and withdraw money without owning a formal bank account (Suri, 2017). In addition, mobile money is easing international remittances due to lower transaction costs, which can be around 50% cheaper than transaction costs through formal channels (GSMA, 2016b). At the same time, mobile money's transactions are private which is particularly important for women who may suffer from cultural and social barriers that prevent their financial integration (GSMA, 2015b; Better Than Cash Alliance, 2015). Further, mobile banking represents a way for women to increase their revenues and savings, thus ultimately making them more resilient against financial risks (MGI, 2016a).

BOX 4. REMITTANCES AND MOBILE MONEY

Remittances represent a major source of income for millions of families and businesses around the world. In 2011, the G20 leaders committed to reducing the global average cost of sending remittances to 5% (from 9.30% in mid-2011). The Leaders recommitted to this target in 2014, and in 2016, the G20 aligned its work with the 2030 Agenda, by including the target (i.e. to reduce to less than 3% the cost of remittances and to eliminate remittance corridors with costs higher than 5% by 2030) under SDG 10. Harnessing emerging technologies is one of the important paths being followed by G20 economies as they implement their national plans.

Source: GFPI (2017), "2017 update to leaders on progress towards the G20 remittance target", https://www.gpfi.org/sites/default/files/documents/CORRECT%20VERSION%20Final%202017%20Progress%20Reporting%20-%20National%20Remittance%20Plans%20endorsed%281%29.pdf.

Mobile money has been found to reduce long-run poverty and to change the financial behaviour of women. Mobile money has also been found to be a factor that facilitates women to start a business and to reduce their agricultural activities. Mobile money may further shape migration and employment perspectives, and reduce the dependence of women on multiple part-time occupations (Suri and Jack, 2016). For example, GSMA (2015a) finds that 64% of working women across 11 low- and middle-income countries have greater access to business and employment opportunities because of mobile phone technologies. A survey of Kenyan women finds that almost all had an M-pesa mobile banking account and that over three-quarters of them transacted at least twice a week, with 95% saying that they sent money to their relatives. Of the 37% of women owning a business, 96% said that M-Pesa helped them scale their venture (Kombo, 2017). As a result, an estimated 194 000 households have saved money more effectively and moved out of extreme poverty (Gates Foundation, 2017).

BOX 5. DIGITAL PAYMENTS AND WOMEN: THE CASES OF CHINA AND INDIA

China

The gender gap in the use of digital technologies in China appears relatively small. This is related to its past efforts in achieving a comparatively high mobile Internet connectivity and strong growth in digital payment services. In 2018, China reached more than 1 billion 4G users, which makes of China the biggest online population worldwide (Xinhua, 2018). The increase in 4G users in China has triggered a significant growth of China's two most important digital payment services WeChat[1] and Alipay.[2] The value of combined payment transactions from Alipay and WeChat grew 20 times within four years, reaching USD 2.9 trillion in 2016. In total, digital payments as a share of all transactions in China grew from about 3.5% in 2011 to about 17% in 2015 (Better Than Cash, 2017).

Together with other related applications, they are impacting the lives of millions of families in China and have contributed to increase transparency, security, cost savings and financial inclusion, especially for women. For example, Ant Financial is a lender for many small enterprises and entrepreneurs, supporting the option to borrow money for low-income earners (Crowdfundinsider, 12.6.2017). This has proportionally supported many women, who are less integrated in formal financial systems (UN, 2017; Demirguc-Kunt et al., 2015). In addition, Alipay and Tianhong Asset Management started co-operating on offering a low-risk money market account, similar to a bank account, where small individual amounts can be invested. Today, more than 152 million customers use the application, making it to one of the biggest market funds worldwide (Financial Times, 2016). Further innovations related to mobile money as new creditworthiness systems ("Sesam Credit") have supported millions of individuals and small businesses.

India

Electronic banking through modern forms as payments, as payments on WhatsApp, a ubiquitous messaging service in India, has helped to transfer rupees more easily than paying with bank notes. The application allows transferring money without setting up a digital wallet or downloading another new application. At least outside China, there seems no easier way to transfer money today (Economist, 2018). This has made it easier for women to transfer money without having a formal financial account, and has helped Indian tax authorities since digital transactions, unlike using hard currency, make it harder to hide economic activities in the shadow economy, and to hide from obligatory taxation.

1. WeChat was founded by Tencent in 1998. Together with the second major social communication application QQ, both applications combined had in 2016 an active monthly user base of 846 million people (Tencent, 2017). WeChat has experienced a rapid growth; active daily users have grown from 195 million to about 806 million in 2016. WeChat had approximately 697 million users in 2015; who spent USD 568 on average. One year later, this figure grew by 168%, reaching USD 1 526 spending per user (Better Than Cash, 2017 [based on Millward, S., 2016a; 2016b]).

2. Alipay was launched in 2004 as an Internet-based payment service for the e-commerce Alibaba. By 2016, Alipay was processing 175 million transactions per day; the majority (around 60%) was conducted through a mobile phone. Alipay had around 450 million monthly active users in 2015 (Better Than Cash Alliance, 2017 [based on Russel, 2016]).

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 working 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 (Better Than Cash Alliance, 2017).

The economic effects of mobile money on the life of individuals are even more powerful than aid work through microcredits. Comparing the effects of mobile money and microcredits on the well-being and economic development of women, research shows that the benefits of mobile money are often more significant (Banerjee, Karlan and Zinman, 2015a; Attanasio et al., 2015; Augsburg et al., 2015). Other studies find that microcredits for women can have less impact than mobile money, as the effects may be gender-neutral, or even negative with respect to female business activity (Karlan and Zinman, 2011).

Finally, mobile money also provides opportunities for governments and companies. Digitising payments increases transparency, and reduces transaction costs, as payments can be more easily and faster processed (GSMA, 2013), thus ultimately reducing spending tax revenues (GSMA, 2016c). In Mexico, a shift to the electronic distribution of many government payrolls, pensions and social benefits has contributed to approximately USD 1.27 billion annual savings (Better Than Cash Alliance, 2013). Worldwide, a widespread adoption and digital finance could lead to savings around USD 11 billion annually (MGI, 2016a). Mobile money may also have indirect positive effects, and help close the gender mobile phone ownership gap. Evidence suggests that mobile money, such as the M-Pesa in Kenya, can help overcoming the gender gap in mobile phone ownership, thus facilitating access to new services, like health insurance (Women's World Banking, 2018).

Conclusions

Digital technologies have immense potential and can improve people's economic and social outcomes in multiple ways. But while about half of the world's population is now connected to networks, up from 4% in 1995, and businesses seem almost unable to run without the use of some ICTs, this growth in connectivity has not been enjoyed by everyone equally. A digital gender divide emerges, which has a number of root causes. Among them, hurdles to access, affordability, education (or lack thereof) and lack of technological literacy, as well as inherent biases and socio-cultural norms leading to gender-based digital exclusion, rank among the most important.

The first part of this chapter provides a broad overview of evidence on the existing gender gap regarding the access, uptake and usage of technological tools and the extent of digital financial inclusion worldwide, in particular regarding the use of ICT and digital platforms, mobile phones and digital payments by women. Among other stylised facts, it emerges that while the global digital gender divide in Internet usage remained essentially unchanged (passing from about 11% in 2013 to roughly 12% in 2016), the patterns observed are worrisome as they point to increased gaps in Internet use between developed and developing countries. The gender gap in smartphone ownership results in roughly 327 million fewer women with a smartphone and, consequently, mobile Internet access (GSMA, 2018a). Also, female users tend to use fewer services than men and prefer to make and receive video calls. Video calling offers not only lower hurdles for women who are less confident in using the Internet, but is socially also more accepted in order to remain in touch with family members oversees. Men are conversely more likely to browse the Internet and to download and use apps (GSMA, 2017).

At the same time, digital technologies can provide "leapfrog" opportunities for everyone, and can be particularly valuable levers for the economic empowerment of women and girls. By means of connecting people and ideas, the Internet as well as basic and smart phones help women to share and access knowledge, online education, and connect to new markets – and this regardless of time and location. A major advantage of digital platforms is that women can flexibly chose where, how and when to work, which may help women to overcome constraints of mobility, supplement household income and ultimately may help women to combine being a mother and developing a business or pursuing a career. This is important since women in G20 economies are still less likely to engage in paid work than men. Platforms can be an important means to not only starting a business but also to extending it to new markets and customers; likewise online job platforms may facilitate better skill matching for job profiles worldwide. Electronic payments provide further "leapfrog" opportunities for women and girls. The emerging electronic payment technology "mobile money" can be a powerful tool for the financial integration of millions of unbanked and the poorest in society, who often are women and girls. Mobile money offers ways to increase revenues and savings, improve financial resilience, and reduce transaction costs through faster and more transparent payment systems. E-payments can be another factor that spurs female entrepreneurship.

Given the existing digital gender divide, not every woman is able to benefit from these "leapfrog" opportunities. Future trajectories will very much depend on the support of policy in ensuring the access, uptake and usage of technological tools, especially by women and girls, to narrow – and eventually close- the digital gender divide.

All the above calls for policies that help address the many root causes of the digital gender divide, especially access to and affordability of digital tools and means. Access and affordability-related policies further need to be coupled with education-related initiatives aimed at enhancing digital literacy, and at addressing the many conscious and unconscious biases and stereotypes which too often constrain women's participation in digital environments. Such policies should be further paralleled by initiatives aimed at guaranteeing security in the cyber space, which will in turn contribute to increase women's and girls' trust in digital means, and make them able to maximally benefit from the opportunities that the digital era may offer to them. Furthermore, for platforms to represent the empowerment tool they may be, it is important to ensure that platform jobs are also quality jobs. This entails ensuring that platform workers, including women, have bargaining power, control over their flexibility, and that social insurance mechanisms apply to them as well.

Notes

1. For more literature, see also BMZ (2017); Accenture (2016); WEF (2016); Nikpur (2015); Alliance for Affordable Internet (2014); Broadband Commission (2013) and UN Women (2005).
2. The global Internet penetration rate refers to the number of women/men using the Internet, as a percentage of the respective total female/male population.
3. Miltner (2018) builds on the work of Plant (1997) and Light (1999), Abbate's "Recoding Gender" (2012), Ensmenger's (2010) "The Computer Boys Take Over", and Hicks's (2017) "Programmed Inequality".
4. See, for instance, Chandran (2014) for a discussion about the pros and cons of mobile banking, with particular attention to the Indian case.
5. See e.g. https://www.safaricom.co.ke/personal/m-pesa for more info.
6. 99design is a labour platform dedicated to graphic, logo and web design.
7. Shadow banking refers to the intermediation of credit through a collection of institutions, instruments, and markets that lie at least partly outside of the traditional banking system.
8. The software was developed together with Fintech developers and is based on cutting-edge ledger technology. The software can be downloaded through the open-software development platform GitHub and it will not be owned or implemented by the Gates foundation. The project also brought together some of the biggest mobile systems companies to develop an open application programming interface (API) for mobile money interoperability. These APIs will allow mobile money providers to integrate seamlessly with the software.

Chapter 2

SKILLS FOR THE DIGITAL ERA: IS THERE A GENDER GAP?

The analysis in this chapter focuses on skills for the digital era, in everyday life. It illustrates gender differences in digital literacy among 15 year-old students, based on the OECD's Programme for International Student Assessment survey, and compares these differences to gender differences observed when text comprehension is measured through standard paper-based testing instruments. It further analyses gender differences in previously unexplored dimensions of individuals' skill sets. Going beyond mapping achievement in mathematics, science and text comprehension, it explores gender differences in creative problem solving and collaborative problem solving, which are emerging as essential skills to thrive in the digital era. The chapter also identifies gender differences in attitudinal and behavioural dimensions of learning among 15 year-olds, since these have been shown to be crucial if boys and girls are to be able to exploit the opportunities that the digital transformation brings.

A second section, drawing on evidence from the OECD's Survey of Adult Skills (Programme for the Assessment of Adult Competencies), discusses ICT use at work and the emerging need for workers to be endowed with a diverse set of skills, rather than having high level competencies along one single dimension. It analyses differences between men and women in the exposure of their jobs to digitalisation, in the skills endowment needed to face these changes and in the barriers that they may face to continue learning and to participate in adult education.

The gender skill gap in the digital era

The pervasiveness of digital technologies is fundamentally changing the way people access and elaborate knowledge, understand and interact with the reality around them, and the way they relate to each other.

Seizing the opportunities that digital technologies are opening in many areas and coping with the challenges that they may pose requires individuals to have or develop (a set of) skills that enable a deeper understanding and meaningful use of these technologies, and of the consequences that they may have on all aspects of life. Also, people will more and more need to screen huge amounts of content made available through digital means, be able to select and understand relevant information, and continue to learn and acquire relevant knowledge as the digital transformation evolves.

Evidence shows (OECD, 2016a) that the increasing use of digital technologies at work is raising the demand for sound foundation skills, digital literacy, and higher order thinking competencies as well as social and emotional skills. To shed light on the existence of a digital gender divide and support the implementation of policies aimed at narrowing it thus calls for a better understanding of whether and to what extent girls and women are equipped with the skills needed to adapt and excel in the digital economy and, as a result, can contribute to making digital societies more inclusive.

In what follows, a first section uses new indicators, broken-down by gender, that explore results from the Programme for International Student Assessment (PISA). These focus on the skills and knowledge of 15 year-old students, which are essential to succeed in a digitalised world. While individuals have the opportunity to accumulate skills as adults, there is evidence that compulsory schooling is crucial in ensuring that individuals gain basic skills and competences. Such skills are important for full participation in the labour market and society and equip people to gain new skills in the future (OECD, 2016a). A second section looks at ICT use at work, drawing on evidence from the OECD's Survey of Adult Skills (Programme for the Assessment of Adult Competencies [PIAAC]).

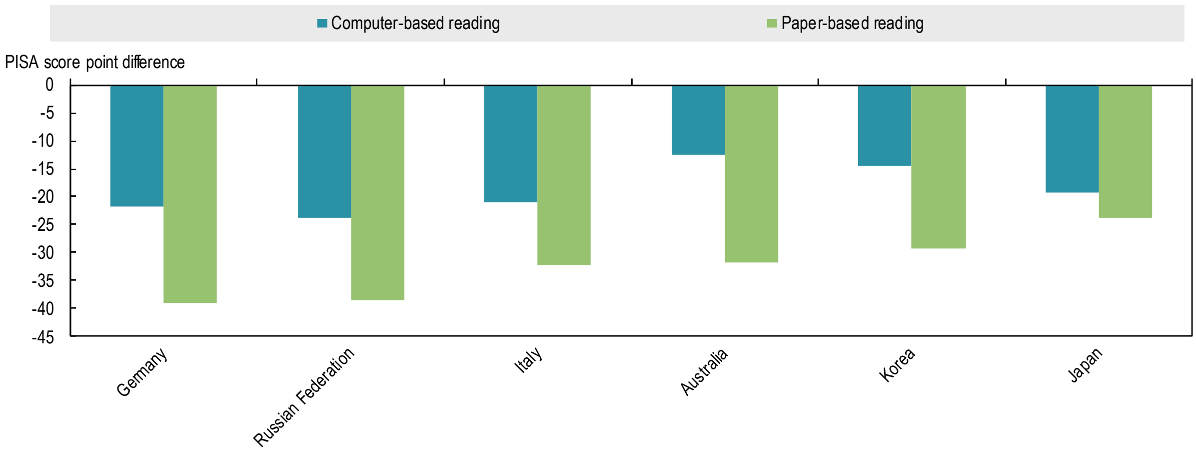
Women's relative disadvantage in the "digital components" of digital literacy

More than ever, reading is key to acquiring knowledge, and mastery of reading is a precondition for individuals' success in all domains of life (OECD, 2010). The pervasiveness of information technology means that reading proficiency is becoming even more crucial and that young people need to master new forms of reading and, hence, literacy skills. In the past, students had to be able to understand, interpret and reflect upon single texts. Although these skills remain important, the change in the medium of delivery of texts, from paper to electronic, from page to screen, is also changing the skills that students need to master and that they will need in the workplace and in society (Goldman et al., 2012; Leu et al., 2015). When accessing digital material, students are not only required to comprehend and interpret extended pieces of continuous texts, including literary texts, but also to deploy information-processing strategies such as analysing, synthesising, integrating and interpreting relevant information from multiple texts and information sources (Rouet, 2006; Spiro et al., 2015). Today's reading is about searching not just for meaning but also for relevant material. It encompasses students' ability to deal effectively with a potentially endless stream of available information by searching, organising and filtering written (but also multimedia) material. As the structure and formats of texts change because of the shift to digital technologies, readers are required to develop and use new cognitive strategies.

New gender gaps in school and in the labour market may emerge as a result of changing requirements in the tasks that individuals need to perform using digital technologies, which require greater visual-spatial ability (Lee, 2007). This may also increase demand for high level ICT-related skills in the economy. Some studies find that women perform less well than men in problem solving tasks on digital technologies, have poorer navigation skills and may be less interested in ICT-related skills than men (Zhou, 2014). Studies examining gender gaps in reading proficiency have identified marked differences depending on the characteristics and requirements of the texts that students were assessed on (Castelli, Colazzo and Molinari, 1998; Lafontaine and Monseur, 2009; Oakhill and Petrides, 2007; Rosen, 2001; Schwabe, McElvany and Trendtel, 2015). Girls tend to do worse on tests that require greater visual-spatial ability and on tasks that require a greater amount of abstract information processing, in the ability to transform a visual-spatial image in working memory, and to generate and manipulate the information in a mental representation (Borgonovi, 2016).

Results presented in Figure 14 indicate that across the 26 countries with available data boys underperformed compared to girls in both the paper-based and in the computer-based reading assessments, but their underachievement was considerably smaller in the computer-based reading assessment. Figure 14 further suggests that the difference in boys' underachievement compared to girls in the two tests is pervasive: in 21 out of the 26 countries considered in the analysis (6 of which G20 economies, shown in the figure) boys' underachievement in the computer-based reading test was smaller than their underachievement in the paper-based reading test. In the remaining 5 countries the difference in boys' underachievement in the two tests was in the expected direction, though estimates are not sufficiently accurate to be able to draw definitive conclusions.

Figure 14. The gender gap in computer-based and paper-based reading



Notes: Countries are sorted in descending order of the gender gap in paper-based reading. The height of the bars shows the difference between boys' and girls' scores.

Source: OECD (2012a), *PISA* (database), www.oecd.org/pisa/data/..

The gender gap in creative problem solving, collaborative problem solving and attitudes

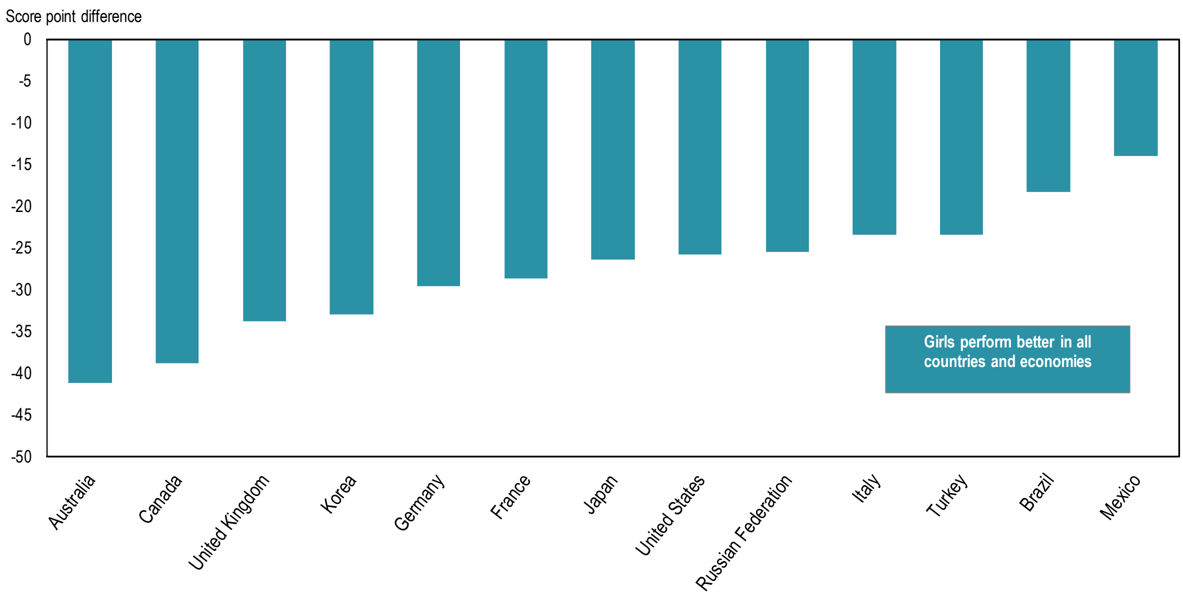
Today's workplaces demand people who can solve problems in concert with others (Autor, Levy and Murnane, 2003). The increase in jobs requiring a high level of social skills has been accompanied by an increase in the wages for such jobs, suggesting that there is higher demand from employers for such skills. For example, wages have risen by over 20% for jobs that require high social skills but low mathematics skills, suggesting that social skills are increasingly of value to employers (Deming, 2017).

The importance of collaboration extends beyond the workplace. Many human activities involve groups of people, from a variety of physical and artistic endeavours to living in harmony with one's neighbours. Almost everyone relies on interactions with other individuals to do what cannot be done alone. Collaboration skills are therefore essential to facilitating such interactions. In particular, collaborative problem solving has several advantages over individual problem solving: labour can be divided among team members; a variety of knowledge, perspectives and experiences can be applied to solve problems; and team members can stimulate each other, leading to enhanced creativity and a higher quality of the solution. But collaboration also poses potential challenges. Labour might not be divided equitably or efficiently, with team members that may be required to work on tasks that they are unsuited for or dislike. Some team members may freeride while others not see individual returns to their work. Conflict may also arise among team members, hindering the development of creative solutions (OECD, 2017c).

The latest PISA 2015 study was the first ever international effort to monitor the collaborative problem solving skills of students worldwide. As shown in Figure 15, results indicated that girls outperform boys in collaborative problem solving (515 points compared with 486 points, on average across OECD countries). Furthermore, in every economy that participated in the collaborative problem solving assessment, girls significantly outperformed boys. The differences were greatest in Australia (and in other non-G20 economies including Finland, Latvia, New Zealand and Sweden), where girls scored over 40 points higher than boys, on average. In the G20 economies taking part in the study, girls outperformed boys by at least 14 points.

These findings contrast with the gender differences observed in individual problem solving, which was tested in PISA 2012 (OECD, 2014). In that case, individual problem solving did not involve any collaboration and, in fact, the problem solving test was designed to identify students' ability to deal with problems that they had not previously encountered and that required active and strategic exploration. The test was designed to require minimal literacy, numerical and mathematics abilities and was delivered on a computer, as for the collaborative problem solving assessment.

Figure 15. The gender gap in collaborative problem solving



Notes: All gender differences in collaboration problem solving performance are statistically significant. Economies are ranked in ascending order of the score-point difference in collaborative problem solving performance between boys and girls.

Source: OECD (2015b), *PISA* (database), www.oecd.org/pisa/data/, Tables V.4.1a and V.4.3a.

In the assessment of individual problem solving, boys scored 7 points higher than girls, on average across OECD countries, and were 1.5 times more likely than girls to be top-performers. Although different groups of students were measured in 2012 and 2015 and the assessments are not directly comparable to one another, the results suggest that it is the collaborative component of the PISA 2015 problem solving assessment that favours girls.

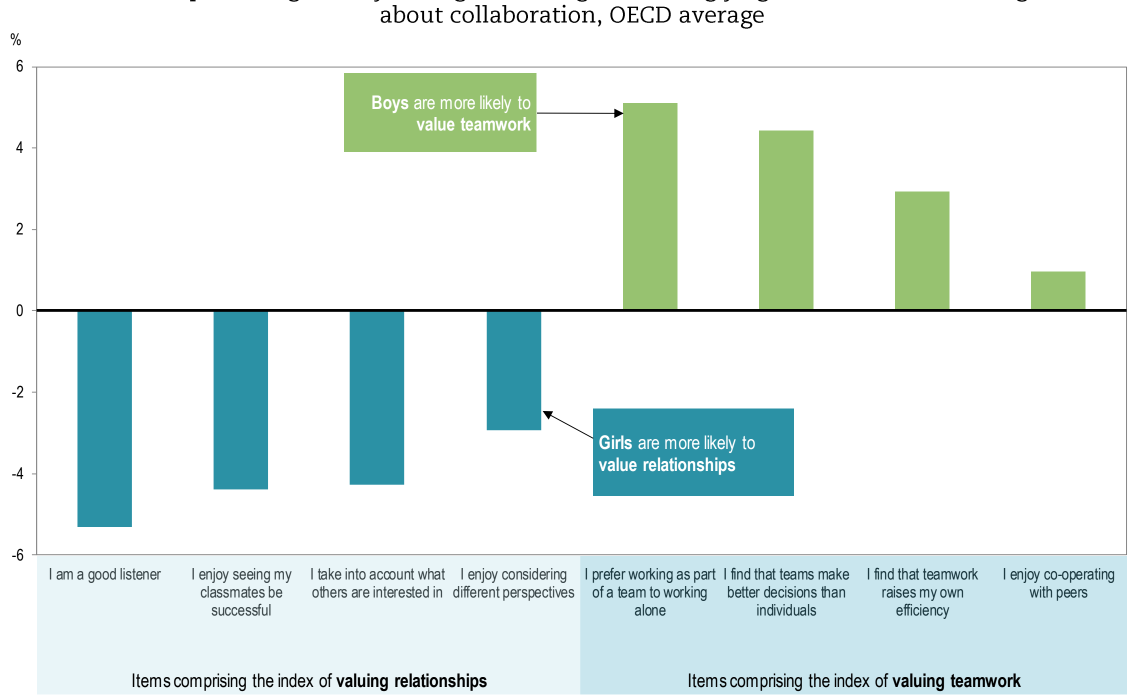
Even though the PISA data shows that girls are more proficient than boys at collaborating with others, examining gender gaps in attitudes towards collaborative problem solving reveals that girls may not necessarily benefit from their greater proficiency in the workplace and in their daily lives. They may lose out to more individualistic colleagues and peers, unless these qualities are recognised and valued by managers and individuals responsible for human resources.

The PISA 2015 student questionnaire asked students whether they strongly agree, agree, disagree, or strongly disagree with eight statements related to their attitudes towards collaboration: "I prefer working as part of a team to working alone", "I am a good listener", "I enjoy seeing my classmates be successful", "I take into account what others are interested in", "I find that teams make better decisions than individuals", "I enjoy considering different perspectives", "I find that teamwork raises my own efficiency", "I enjoy co-operating with peers". Responses to these eight statements are combined into two indices of co-operation: valuing of relationships and valuing of teamwork. The four statements that comprise the index of valuing relationships are related to altruistic interactions, when the student engages in collaborative activities not for his or her own benefit: "I am a good listener"; "I enjoy seeing my classmates be successful"; "I take into account what others are interested in"; and "I enjoy considering different perspectives". By contrast, three of the four statements that comprise the index of valuing teamwork are related to what teamwork, as opposed to working alone, can produce: "I prefer working as part of a team to working alone"; "I find that teams make better decisions than individuals"; and "I find that teamwork raises my own efficiency". Each index is standardised to have a mean of 0 and a standard deviation of 1 across OECD countries.

Figure 16 indicates that girls were significantly more likely than boys to agree or strongly agree with the four statements that comprise the index of valuing relationships. For example, on average across OECD countries, girls were 5.3 percentage points more likely than boys to report that they agree or strongly agree that "[they] are a good listener". Moreover, this difference is significant and in favour of girls in 54 of the 56 economies that conducted the collaborative problem solving assessment; in the two other economies, the difference is not significant. Gender differences are most pronounced in Italy and Latvia, where there is a 10 percentage point gap. By contrast, boys were significantly more likely than girls to report that they agree or strongly agree with the four statements that comprise the index of valuing teamwork. The difference is most pronounced for the statement "I prefer working as part of a team to working alone", with which boys were 5.1 percentage points more likely than girls to agree or strongly agree. This difference is significant and in favour of boys in 38 of 56 countries; it is significant and in favour of girls in only one region: Beijing-Shanghai-Jiangsu-Guangdong (China) (a 4.1 percentage point gap). For G20 economies, the gender gap is widest in Canada, where it exceeds 10 percentage points (OECD, 2017c).

Figure 16. Gender differences in attitudes towards collaboration

Differences in the percentage of boys and girls who agreed/strongly agreed with the following statements about collaboration, OECD average



Note: All differences are statistically significant at the 5% level.

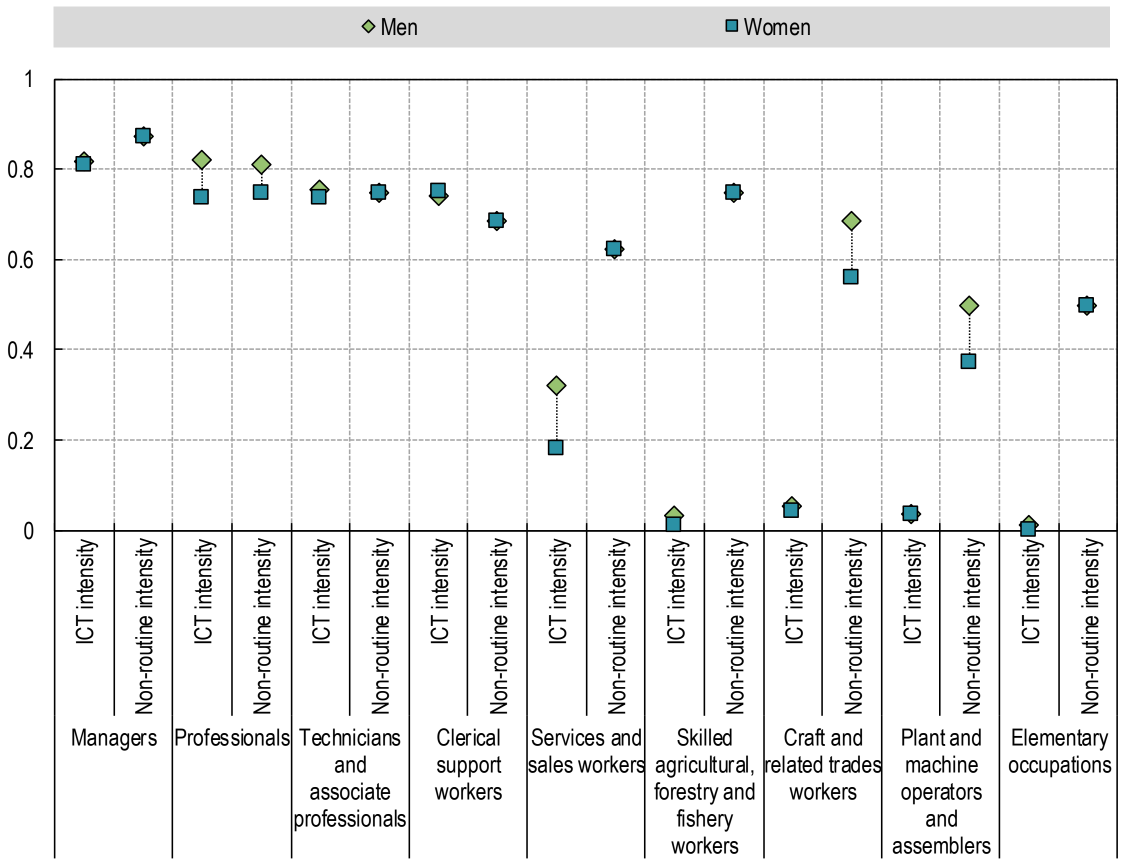
Source: OECD (2015b), *PISA* (database), www.oecd.org/pisa/data/, Tables V.5.4a and V.5.4b.

Women at work: A high hurdle race

Digitalisation is profoundly changing what people do on the job, how and where they work, and therefore affects the type of skills and skills mix they need to be successful in their careers. Workers increasingly use ICTs on the job, and even those who do not need to use digital technologies may see the nature of their work changed, as tasks get increasingly automated and workers are asked to perform a relatively higher share of non-routine tasks.

Data from the OECD Survey of Adult Skills (Programme for the Assessment of Adult Competencies [PIAAC]) show that the most skilled occupations, such as managers and professionals, exhibit a more intensive use of ICTs and perform relatively more non-routine tasks than less skilled occupations (Figure 17). Non-routine intensive jobs are those where workers' degree of freedom to change or choose the sequence of their tasks, the way they work, and plan and organise their work is highest (see Marcolin, Miroudot and Squicciarini [2016] for details). While no difference emerges between men and women in the use of ICTs for low-skilled groups of occupations, such as elementary occupations or craft and trade ones, in some of these groups of occupations women perform relatively more routine tasks than men. As the digital transformation continues to unfold and pervades all sectors, including those where the uptake of digital technologies is only marginal at present, women in low-skilled occupations may therefore experience greater changes in their work than men. This may be due to the possible substitution of (parts of) their tasks by machines and to the consequent need to perform different tasks on the job. High skilled women in professional occupations may also face important changes on the job in the future, especially if today, on average, they make a lower use of ICTs and perform more routine tasks than men.

Figure 17. Occupations' exposure to digitalisation by gender



Notes: ICT = information and communication technology. The intensity of ICT use at work builds on information on the frequency with which workers perform a range of tasks using a computer and the Internet. The non-routine intensity of jobs reflects workers' degree of freedom to change or choose the sequence of their tasks, the way they work, and plan and organise their work.

Source: OECD calculations based OECD (2012b) and OECD (2015c), *Survey of Adult Skills (PIAAC)*, www.oecd.org/skills/piaac/.

More than being endowed with one specific type of skill only, workers need to have a mix of skills to best address the digital transformation of their jobs. Countries with workers having a skills mix that is well aligned with the skills requirements of technologically advanced industries can specialise in these industries more than other countries (OECD, 2017d). In addition, as the workplace becomes more exposed to digitalisation, workers tend to perform more reading, writing, numeracy, and communicating and management tasks, thereby involving a broad range of skills (OECD, forthcoming a). When a mix of skills including problem solving skills in technology-rich environment as well as literacy and numeracy skills is considered, working women in most OECD countries are as likely as or slightly less likely than men to be low performers, but are less likely than men to be high performers or, having a well-rounded skills mix (Figure 18). The gender gap among high performers is particularly high in countries like Austria, Japan and Norway. In economies such as Singapore and the Russian Federation, the proportion of workers lacking basic skills and of those with well-rounded skills set is very similar between genders, whereas in the case of Singapore while the proportion of women and men lacking basic skills is very similar, relatively less women than men have well-rounded skill sets.

Figure 18. Skills mix of countries' workers by gender

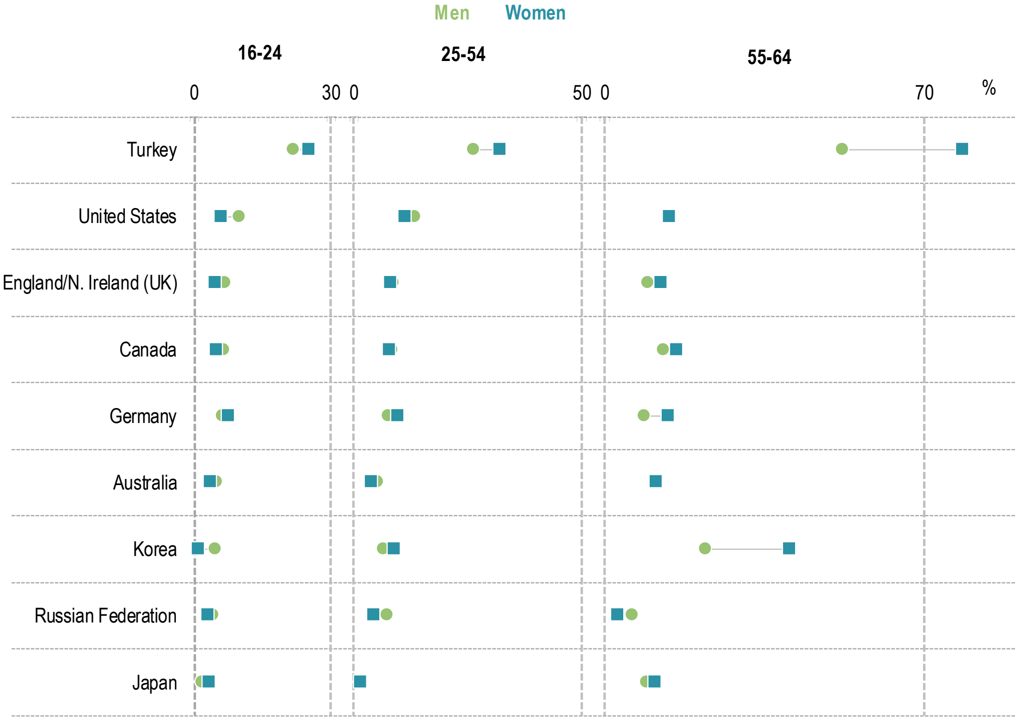
Notes: Workers lacking basic skills score at most Level 1 (inclusive) in literacy and numeracy and at most Below Level 1 (inclusive) in problem solving (including failing ICT core and having no computer experience). Workers with a well-rounded skill set score at least Level 3 (inclusive) in literacy and numeracy and at least Level 2 (inclusive) in problem solving.

Source: OECD calculations based on OECD (2012b) and OECD (2015c), *Survey of Adult Skills (PIAAC)*, www.oecd.org/skills/piaac/.

In addition to being endowed with a range of cognitive, digital and social and emotional skills, the digital transformation and the changes that it brings about require individuals to continue learning over their lifetime. In most OECD countries, older working women are more likely than men to lack basic skills in literacy, numeracy and problem solving in technology-rich environments that are foundational for continued learning (Figure 19). Training and learning also takes time, and requires having the necessary financial incentives and resources. For women this may represent a problem, especially if family responsibilities hinge mainly upon them. Evidence from PIAAC shows that, in all countries considered, the share of female workers reporting family responsibilities as main barrier to participating in education and training is always higher than that exhibited by men (Figure 20).

Figure 19. Share of workers lacking basic skills by age group, gender and country

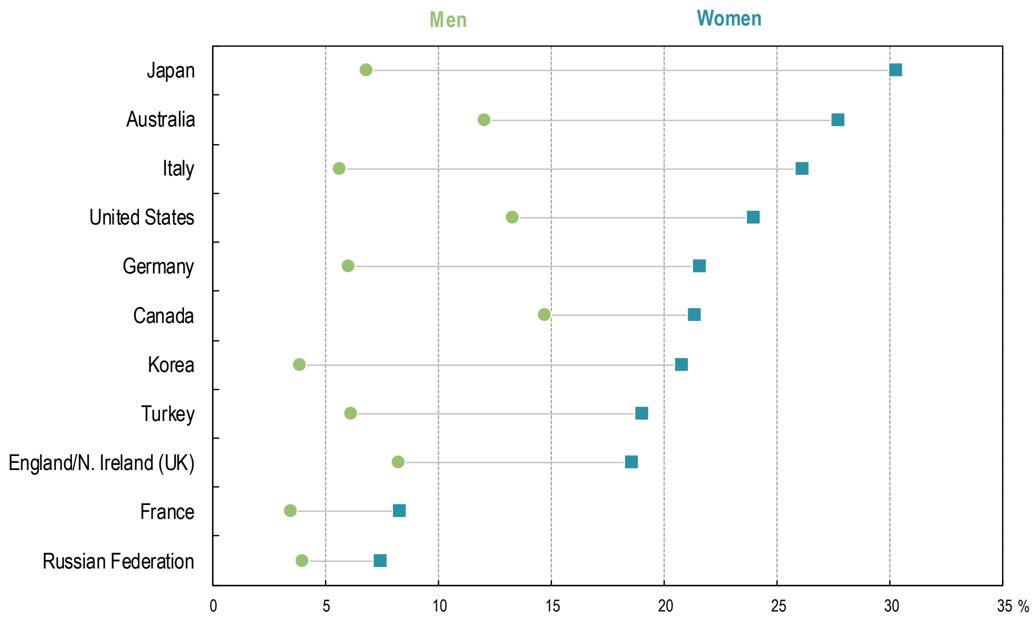
Share of youth (16-24), prime age adults (25-54) and older people (55-65)



Note: Workers lacking basic skills score at most Level 1 (inclusive) in literacy and numeracy and at most Below Level 1 (inclusive) in problem solving (including failing ICT core and having no computer experience).

Source: OECD calculations based on OECD (2012b) and OECD (2015c), *Survey of Adult Skills (PIAAC)*, www.oecd.org/skills/piaac/.

Figure 20. Share of workers reporting family responsibilities as main barrier to participation in education and training



Note: Each mark indicates the share of workers aged 25-45 in each country who, in the 12 months prior to the survey, wanted to participate in (more) learning activities but whose most important reason preventing them from participating in such activities was "I did not have time because of child care or family responsibilities".

Source: OECD calculations based on OECD (2012b) and OECD (2015c), *Survey of Adult Skills (PIAAC)*, www.oecd.org/skills/piaac/.

This calls for the need to remove the obstacles to adult education for all workers, and for women in particular. More flexible opportunities for adults to upgrade their skills, including easing access to formal education may help in this respect. Co-ordination across a range of institutions and actors including education and training institutions, employers, but also social policy institutions can help address the specific barriers that women face. Existing data suggest that women are also less likely than men to participate in MOOCs, which can be generally accessed for free and cover a range of topics. Delivering information to workers and working women more specifically, on the range of available training opportunities can also encourage them to participate more.

Conclusions

The analysis presented in this chapter illustrates gender differences in digital literacy among 15 year-old students and compares these differences to gender differences observed when text comprehension is measured through standard paper-based testing instruments. The chapter also sheds new light on gender differences in previously unexplored dimensions of individuals' skill set, going beyond mapping achievement in curricular subjects like mathematics, science and text comprehension to explore gender differences in creative problem solving and collaborative problem solving. The chapter also identifies gender differences in attitudinal and behavioural dimensions of learning among 15 year-olds, since these have been shown to be crucial if boys and girls are to be able to exploit the opportunities that the digital transformation brings (OECD, 2015a).

A second section discusses ICT use at work and the emerging need for workers to be endowed with a set of skills, rather than displaying high level competencies along one single dimension. It analyses differences between men and women in the exposure of their jobs to digitalisation, in the skills endowment needed to face these changes and in the barriers that they may face to continue learning and to participate in adult education.

The novel evidence proposed suggests that, in the future, working women will have to adapt to important changes triggered by the digital transformation, which points to the importance of life-long learning and capacity building approaches. At the same time, new generations of women entering the labour market will need to try and benefit to the highest extent – and as much as men – from the new job opportunities that the digital era is creating. At the age of 15, the gender gap in terms of skills for the digital area is not clear-cut: girls underperform boys in specific digital-related skills, but they outperform boys in collaborative problem solving skills, which are increasingly valued by employers. At a later age, women face bigger hurdles, which are due to a wide array of factors, including those related to their family status, and the broader societal, economic and technological environment in which they are embedded. When a mix of skills is considered working women seem less likely to be high performers than men. Moreover, women often face extra barriers to participation in adult education. This calls for a comprehensive approach to addressing gender gaps in skills, career choices and employment outcomes. Action in this area is especially important in light of recent evidence that finds that the field of study shapes, in a causal way, labour market outcomes, has intergenerational effects on children's education and affects other important dimensions of a person's life including the choice of a partner (and partners' earnings, as a consequence) (Artmann et al., 2018).

Chapter 3

JOBS AND SKILLS IN THE DIGITAL TRANSFORMATION

As the digital revolution unfolds and contributes to change the nature and content of jobs, the demand for skills changes. This chapter explores whether women are equipped with the right skills to participate and succeed in the digital world of work. It first provides descriptive evidence on whether and to what extent men and women differ according to their educational background, age and endowments of different types of cognitive and non-cognitive skills. It then analyses the returns to skills, in terms of wages, and shows that the gender wage gap cannot be fully explained by the differences that emerge in terms of skill endowments between women and men: accounting for workers’ skills on the job decreases but does not eliminate gender wage disparities.

Jobs and skills in the digital transformation: Bridging the digital gender divide?

As the digital revolution unfolds and contributes to change the nature and content of jobs, skills demand also changes. Solid cognitive skills, coupled with the ability to solve problems as well as to learn and think creatively, are important to face the challenges and enjoy the benefits of the digital transformation. While operating machines or working on assembly lines traditionally required little more than literacy and numeracy skills, workers in the knowledge economy may need to be equipped with a wider range of skills, which encompass problem solving, ICTs, self-organisation or interpersonal skills. A large fraction of the workforce, however, may not be endowed with the skills required in this new technological paradigm, and risks being left behind in a digitally intensive labour market.

With the aim to shed light on the breadth and depth of the digital gender divide and to uncover its root causes, this chapter explores whether women are equipped with the skills needed to navigate the digital economy and how to make digital societies more inclusive. Evidence from the "computer revolution" of the '80s and '90s suggests that digitalisation might benefit women more than men, in light of women's better cognitive skills relative to manual or motor skills (Welch, 2000; Autor, Levy and Murnane, 2003), as well as their being better endowed with interpersonal skills – which have become more important with the spread of computers (Borghans, ter Well and Weinberg, 2014). This point was also highlighted in the previous chapter.

Previous analysis carried out to support implementation of the G20 Roadmap for Digitalisation (OECD, 2018a), attempted to provide new, comparable cross-country evidence about workers' skill endowments in 31 OECD countries and partner economies. It distinguished between cognitive skills (i.e. skills acquired through education such as literacy and numeracy), non-cognitive skills (i.e. skills that are generally only partially learned at school and that relate to people's attitudes and interpersonal skills) and personality traits.[1] It further showed how demand for these skills differs in digital intensive and less digital intensive sectors, and therefore the extent to which digital technologies are complementary or substitute to the different degrees of competencies that workers display on the job. Lastly that report provided a first assessment of how these skills are rewarded on the labour market and whether such rewards differ between men and women.

The present study builds on that work to uncover the gender differences that emerge in terms of both skill endowments and rewards in digital vs. less digital intensive industries, to shed light on the role that skill demand and supply may play in explaining the larger observed female-male wage gap in digital intensive industries (OECD, 2017e). The digital transformation can shape these patterns in multiple ways, two of which are addressed in more detail here:

- How are technical skills such as ICT and advanced numeracy (STEM) skills, as well as skills which complement these technical skills on the labour market, distributed between men and women? What differences emerge?
- Are the rewards to these skills different in the case of men and women? Do differences vary depending on the digital intensity of the sectors in which workers operate?

These questions are addressed while duly accounting for other aspects known to co-determine the (gender) skill and wage gap. Such aspects include human capital endowment in terms of schooling and work experience; the choice of the number of hours worked, a decision which itself hinges upon the division of household tasks and of family duties; workers' age and health; as well as workers' occupation, industry of employment and the size of the firm worked in.

The first part of this chapter provides descriptive evidence on how men and women differ according to some of these observable characteristics, and in particular their educational background, age and skill endowment.

In almost all G20 economies for which data are available, more women than men completed tertiary education in 2015, but the aggregate picture changes when considering the field of study: a significantly lower proportion of women than men continues to graduate in engineering, manufacturing and construction, or ICTs. When women do graduate in these fields and go on to the labour market, they still display on average lower skills than male graduates. Although there is evidence that women display greater literacy and often collaborative problem solving skills than men at the age of 15, this gap in literacy is bridged by the age 27 for the average individual, while men's advantage in numeracy skills increases with age.

In its second part, this chapter shows that higher average wages for men compared to women (i.e., the so-called gender wage gap) cannot be fully explained by the differences that emerge in terms of skill endowments between women and men. Accounting for workers' skills on the job decreases but does not eliminate gender wage disparities. Moreover, the digital transformation may contribute to a widening gender wage gap. Digital intensive sectors display greater gender wage disparities than less digital intensive sectors, even after considering a number of features of workers and their job places. These differences are partially explained by the fact that the skills that are most in demand in digital intensive sectors, namely advanced numeracy, management and self-organisation skills,[2] are also those that are less frequently displayed by women, as compared to men. In this respect, the fact that women are generally better endowed with literacy, accountancy and selling, and ICT skills does not support labour demand in these sectors much.

A second reason for the persistence of the gender wage gaps is the existence of gender-specific returns to skills, which are explored by holding the skill endowment of workers constant. That is, men are found not only to be better endowed with the skills that are most needed in the digital era but, when endowed with equal skills, are better paid for them (especially in the case of advanced numeracy and managing skills) in digital intensive industries. These results are robust to controlling for a wide array of individual, industry and occupation-related characteristics. Women, conversely, appear to extract a higher premium for their ICT skills: in both digital and less digital intensive industries, women seem to receive an additional wage premium on their ICT skills. This may, among others, be explained by women being relatively more productive when performing the same (amount of) ICT-related tasks than their male colleagues.

The third part of this chapter looks at the gender skill and wage gaps from the perspective of self-employed workers. The discussion distinguishes between "standard" self-employed individuals[3] and own-account workers who have little say over the way they carry out their work (similar to the dependent-self-employed). In the absence of good data on gig workers, this is a valuable comparison to make because, in practice, many gig workers (though not all) will share characteristics of the dependent self-employed. Skills which are typically associated with self-employed individuals such as managing and communication and self-organisation, are more present in self-employed workers than in employees, but the overall figure for the self-employed is driven by "standard" self-employed workers. Own-account workers who have less say about the way they carry out their work generally exhibit lower skills than employees and other self-employed, and also receive much lower wages.

Across all considered employment types, in digital intensive industries men exhibit higher skill endowments than women. This result is nevertheless reversed in less digital intensive industries. Notable exceptions to the general patterns observed emerge in the case of advanced numeracy and numeracy competencies, which are generally higher for men than for women. Moreover, female dependent self-employed workers show on average higher self-organisation skills and readiness to learn than men in the same employment type, independent of the digital intensity of the sector considered.

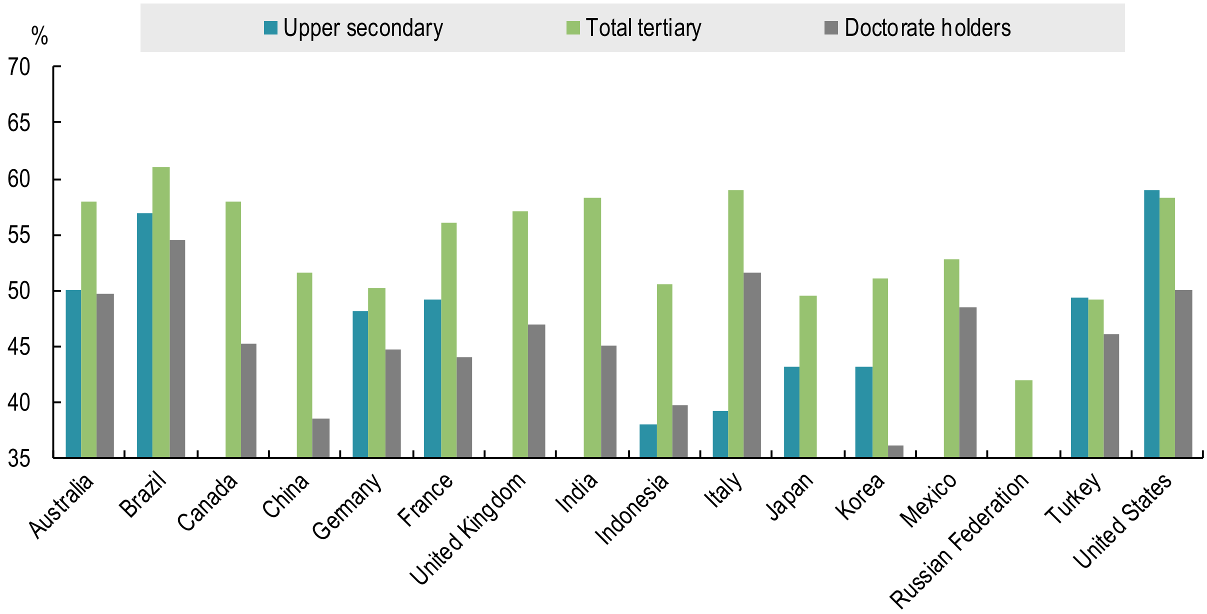
The last part of the chapter reflects on policy implications. As the digital transformation progressively affects production in more and more industries, including those that are less digital intensive at present, having fewer of the key skills that are demanded may lead to greater wage inequality between men and women. While women at present exhibit a comparative advantage in ICT-related tasks, their relatively lower endowment of advanced numeracy skills, management and communication and self-organisation skills may contribute to increasing the gender wage gap and, more broadly, put them at a disadvantage as the digital transformation unfolds.

Educational attainment and skills: Do men and women differ?

While gender gaps persist in many areas of economies and societies, for all countries at any level of economic development, during the last decades significant progress has been achieved in promoting education for girls. Education has a clear impact on labour market outcomes at later stages in life, and closing the education participation gap between boys and girls is bound to help reduce the skill and wage gender gap in the workplace.

Figure 21. Share of women graduates, by educational attainment, 2015

As a percentage of total graduates in that education category



Notes: "Upper Secondary" refers to both upper secondary education (International Standard Classification of Education [ISCED] 2011 Level 3) and post-secondary non-tertiary education (ISCED 2011 Level 4). "Total Tertiary" includes all types of tertiary-level qualifications – i.e. short-cycle tertiary qualifications (ISCED 2011 Level 5), bachelor or equivalent level qualifications (ISCED 2011 Level 6), master or equivalent level qualifications (ISCED 2011 Level 7), and doctoral or equivalent level qualifications (ISCED 2011 Level 8). Missing values reflect information in the "data cannot exist" and "not applicable" categories.

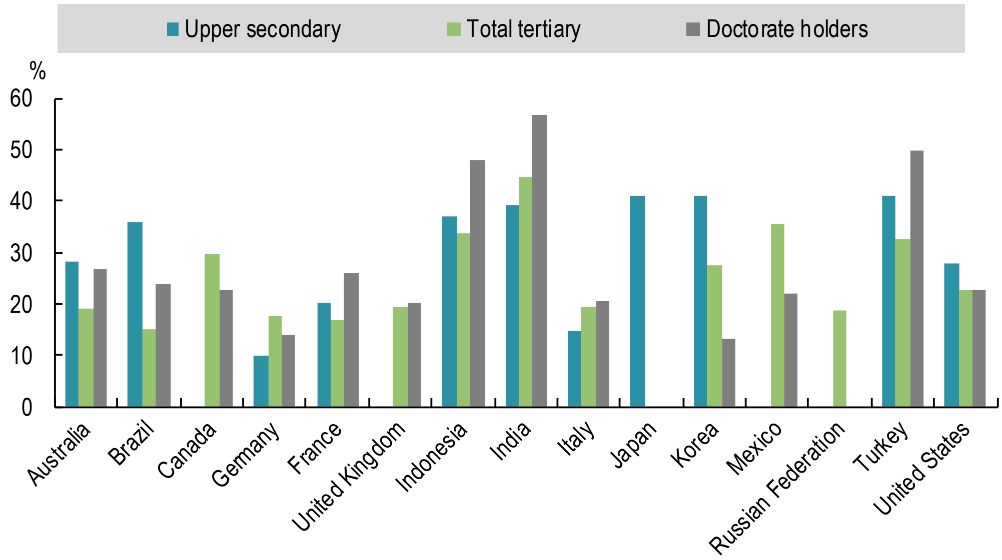
Source: OECD computations based on data from (OECD, 2017f), *OECD Education at a Glance 2017: OECD Indicators*, http://dx.doi.org/10.1787/eag-2017-en.

In almost all G20 economies for which data are available, more women than men completed tertiary education in 2015 (Figure 21). The share of women, however, declines from 54% to 45 % when looking at graduates of doctoral studies (cross-country unweighted averages). Looking at the share of women having completed upper secondary or post-secondary non-tertiary education suggests the need to further improve education opportunities for young girls, especially in some countries.

Gender differences become larger when taking into account the graduates' field of specialisation. Women are the majority of tertiary graduates in education (74%), health and welfare (69%) and in arts and humanities (63%), but not in engineering, manufacturing and construction (24%) or ICTs (25%). For non-ICT studies in STEM, the split is more even, as 52% of tertiary graduates are women.[4] Figure 22 highlights that while in many countries the share of women who graduate in ICT studies[5] is very low, the gender balance is more favourable to women in India, Indonesia and Turkey, for both overall tertiary and doctoral education.

Figure 22. Share of women in graduates of ICT studies, by educational attainment, 2015

As a percentage of total graduates in that education category and field

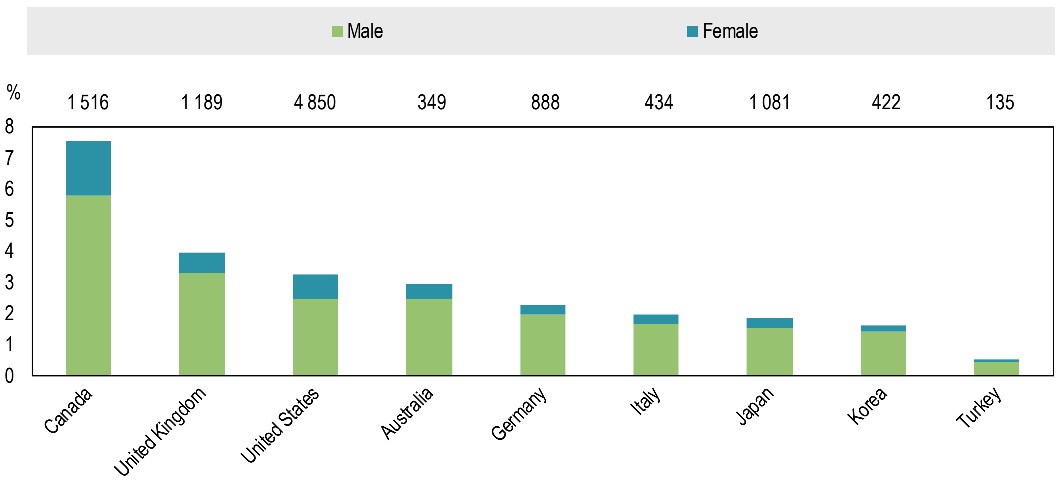


Notes: "Upper Secondary" refers to both upper secondary education (International Standard Classification of Education [ISCED] 2011 Level 3) and post-secondary non-tertiary education (ISCED 2011 Level 4). "Total Tertiary" includes all types of tertiary-level qualifications – i.e. short-cycle tertiary qualifications (ISCED 2011 Level), bachelor or equivalent level qualifications (ISCED 2011 Level 6), master or equivalent level qualifications (ISCED 2011 Level 7), and doctoral or equivalent level qualifications (ISCED 2011 Level 8). Fields of education are classified according to the 1997/2011 ISCED classification of fields of education. Missing values reflect information in the "data cannot exist" and "not applicable" categories.

Source: OECD computations on data from (OECD, 2017f), *OECD Education at a Glance 2017: OECD Indicators*, http://dx.doi.org/10.1787/eag-2017-en.

Figure 23. ICT specialists, selected G20 economies, by gender, 2015

As a percentage of total workforce, and total number of ICT specialists (thousand)



Notes: ICT specialists correspond to International Standard Classification of Occupations 2008 (ISCO08): 133, 251, 252, and 351, if not stated otherwise. Due to data availability constraints, data for Canada consists of National Occupation Classification [NOC] 21 (Professional occupations in natural and applied sciences) and 22 (Technical occupations related to natural and applied sciences), with ICT being only 217 (Computer and information systems professionals) and 228 (Technical occupations in computer and information systems).

Sources: OECD calculations based on the following sources. Canada: Labour Force Survey; United Kingdom, EU28, France, Germany, Italy, Spain and Turkey: European Union Labour Force Survey (EU LFS); United States: Current Population Survey (CPS); Australia: Labour Force Survey; Japan: 2015 Population Census; Korea: Local Area Labour Force Survey; South Africa: Quarterly Labour Force Survey.

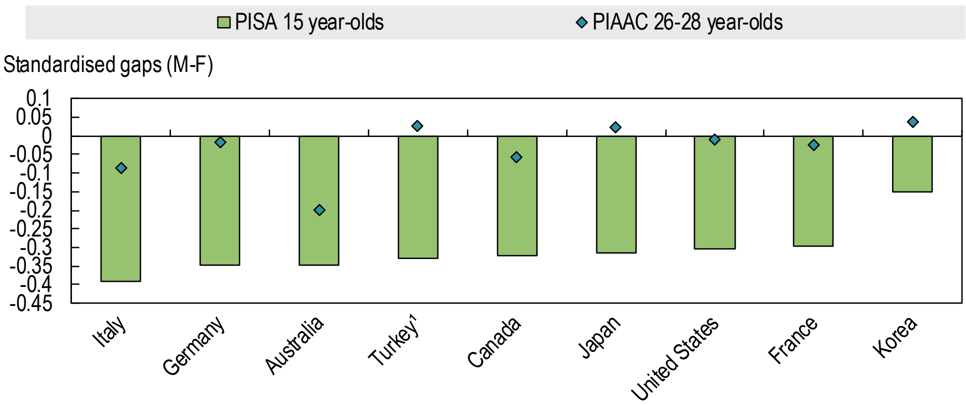
Figure A3.1 provides a more refined classification of fields of education, in particular regarding the overall category "engineering, manufacturing and construction" (although data are available for a different set of countries only): the share of women in chemistry and chemistry engineering (51 %) is indeed larger than in the overall category of engineering, manufacturing and construction[6] (24 %). However, the share of women in the sub-categories electrical engineering (12 %) and mechanical engineering (9 %) is much lower.

OECD (2017e) also shows that differences in the careers of male and female workers can originate early in teenage years, when choosing the field of specialisation in education. At 15 years of age, on average across OECD countries, only 0.5 % of girls wish to become ICT professionals, against 5 % of boys, and twice as many boys as girls expect to become engineers, scientists or architects. These gender-specific expectations about the future profession exist in 15 year-olds independently on their success in related specific subjects at school.

This translates into very few women entering the labour market as ICT specialists and in women representing a very low share of such workers. The number of ICT specialists in the workforce can be assessed by looking at employment by occupation data.[7] Employment figures related to the 2015 show that, in G20 economies for which data are available, the proportion of female ICT specialists ranged between 13% (Korea) and 32% (South Africa). When it comes to total numbers of ICT specialists the United States stand out with almost 5 million workers, of which one million and half are women, as shown in Figure 23. While these numbers need being considered with care, as some figures may be partly over or underestimating the phenomenon due to occupational classification conversion-related challenges,[8] they nevertheless show the relatively marginal role that women play in the world of ICT specialists.

Evidence from the OECD PISA and PIAAC surveys further highlights that some differences in cognitive skills exist between genders at the age of 15, with girls showing on average higher literacy abilities than boys (Figure 24). These differences disappear by the age of 27, when no statistical difference can be found on average between male and female scores to the literacy test in PIAAC. Regarding numeracy, instead, 15 year-old boys perform better than girls at the same age, and the gender gap is even greater among 26-28 year-olds than for 15 year-olds, although it remains quantitatively small for many of the countries considered.[9] Furthermore, the average PIAAC worker of any age having attained a tertiary education degree displays a much lower gender gap in literacy scores (in favour of women) than the average individual having achieved a primary education degree. Conversely, the male advantage in numeracy skills is increasing with the educational level attained by the individual (Borgonovi et al., 2017).

Figure 24. Standardised gender gaps in literacy in 15 year-olds (PISA) and in 26-28 year-olds (PIAAC)



1. PIAAC round 2 countries for which PISA 2003 data were used to identify performance at age 15. All gender gaps are statistically significant at the 5% level at age 15 and no gap is statistically significant all age 26-28.

Note: The standardised gap refers to the difference in the mean scores of males – the mean scores of females divided by the pooled standard deviation. Countries are ranked in descending order of the gap in literacy in PISA.

Source: Borgonovi et al. (2017), "Youth in transition: How do some of the cohorts participating in PISA fare in PIAAC?", http://dx.doi.org/10.1787/51479ec2-en based on data from OECD (2012b) and OECD (2015c), *Survey of Adult Skills (PIAAC)*, www.oecd.org/skills/piaac/ and OECD (2000) and OECD (2003), *PISA* (database), www.oecd.org/pisa/data/..

Figure 25, focusing on problem solving skills, shows that gender gaps across age groups need not be the same for all cognitive skills. Across all countries, younger workers exhibit better problem solving skills than older workers, with intergenerational differences often being higher for women than for men. For about half of the countries, women display slightly higher average scores for problem solving than men at a young age. The good problem solving skills of young women contribute significantly to raising the average population score in countries where 30% or fewer workers have a medium or high ability to solve problems in technology-rich environments. This is the case, for example for Turkey, where the share of young women with such abilities is 24% and is considerably higher than that of young men (15%).

The relative low frequency of women's enrolment in STEM or ICT-related studies and occupations suggests that women may face barriers, including those raised by social expectations and cultural norms, which make entering these studies and professions very costly for them. One may thus expect that these women are especially proficient in STEM or ICT tasks. Skill-related indicators proposed by Grundke et al. (2017) help address this question. These encompass both workers' cognitive skills, which are assessed through tests in PIAAC, namely literacy, numeracy, and problem solving; and indicators of the frequency with which workers perform certain tasks on the job. The latter provide information on some of workers' cognitive abilities, namely ICT-related skills, "Advanced Numeracy" -skills, and "Accountancy and Selling", as well as about non-cognitive skills such as "Managing and Communication" and "Self-organisation", and socio-emotional skills like "Readiness to learn and creative problem solving". Table A3.1 summarises the PIAAC items used to isolate these skill indicators.

Figure 25. Problem solving in technology-rich environments, 2012 or 2015

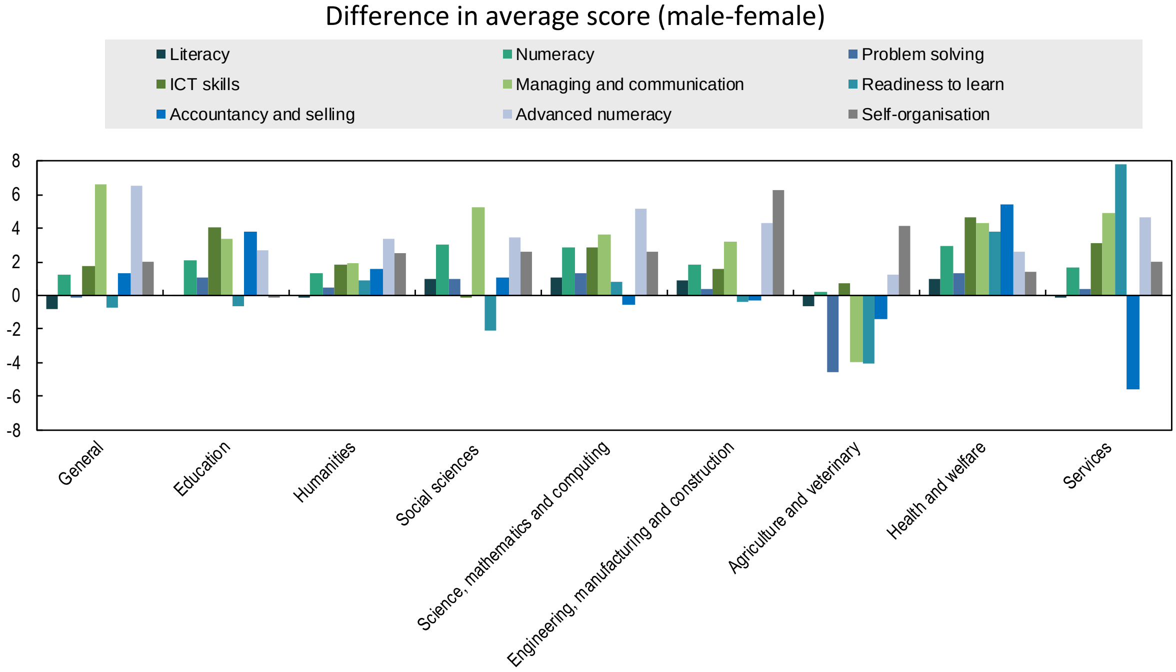
As a percentage of workers with medium and high performance, by gender, for workers aged 25-34 and 55-65

Note: The worker-level skill indicators are scaled between 0 and 100, then averaged by gender and age group giving equal weight to each country in the sample. The graph plots the differences between these averages by gender.

Source: OECD (2017a), *OECD Science, Technology and Industry Scoreboard 2017*, http://dx.doi.org/10.1787/sti_scoreboard-2017-graph92-en.

Figure 26 shows that a gender gap in average skill exists among workers who have pursued tertiary education in all fields except those in "agriculture and veterinary".[10] The gender gap is more or less important depending on the type of skill considered, but is generally positive, including for graduates in traditionally female-dominated fields such as "Education" and "Health and Welfare".[11] However, the figure does not take into account the different skill levels characterising occupations which require studies in the same field (e.g. doctors and nurses). That said, in all fields of education but one, the gap in problem solving, managing and communication and self-organisation is positive, that is men are better endowed with skills than women. When it comes to advanced numeracy and numeracy skills men always display better skills, no matter the field of education.

Figure 26. Gender gaps in average scores by field of achieved tertiary education, PIAAC individuals, 2012 or 2015



Notes: ICT = information and communication technology. The worker-level skill indicators are scaled between 0 and 100, then averaged by gender using sampling weights. The graph plots the differences between these averages by gender (male-female). Individuals who did not achieve tertiary education, did not report any field of tertiary education, or graduated in the fields "Generic education" are discarded. The sample covers the following 31 OECD countries and partner economies: Australia, Austria, Belgium (Flanders), Canada, Chile, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Greece, Ireland, Israel, Italy, Japan, Korea, Lithuania, the Netherlands, New Zealand, Norway, Poland, the Russian Federation (excluding Moscow), Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Turkey and the United Kingdom (England and Northern Ireland), the United States. Bars above the x axis denote skills where men have a relative advantage compared to women. Bars below the x axis show skills for which women exhibit a relatively better endowment, as compared to men.

Source: OECD calculations on PIAAC data (OECD, 2012b, 2015c).

Assessing returns to skills: A regression analysis of the demand for skills

There is broad consensus that generating and adopting new technologies, including digital ones, requires workers to be endowed with certain (sets of) skills allowing them to cope with and thrive in the digital transformation. However, little empirical evidence exists about the skills that are most demanded. As the digital transformation will ultimately affect all industries, including those that at present are not very digital intensive, it is important for policy to understand which skills to invest in, and how to help workers cope with the opportunities and challenges brought by the digital transformation. Also, it is important to understand whether a gender divide exists regarding the skills needed for the digital era and to ensure that women and men are well-equipped for the challenges ahead.

To investigate how the digital transformation affects the demand for different types of skills, i.e. cognitive as well as non-cognitive skills and personality traits, this section looks at the extent to which workers' skills are rewarded and whether rewards differ depending on the digital intensity of sectors.[12] If salaries reflect how the demand for skills is met by labour market supply, skills that are in short supply should command extra returns. With this rationale in mind, this study assesses whether returns to skills differ between industries that are more digital intensive, as compared to those that have undergone the digital transformation to a lesser extent. Higher returns in digital intensive industries should help identify those skills that are in high demand in jobs that are more exposed to the digital transformation, and may represent a much needed complement to the deployment of digital technologies at the workplace (also see Grundke et al., 2018).[13]

The analysis is carried out on data from PIAAC. This extensive survey covers 31 OECD countries and partner economies[14] and provides a wealth of information about workers' skills, the tasks they perform on the job, and their workplace, among others. The rich set of individual-level information available makes it possible to estimate the role of skills in determining wages with greater accuracy than has been possible in the past.[15] As workers' cognitive skills (namely literacy, numeracy and problem solving in technology-rich environments) are assessed through externally assessed tests, using PIAAC further allows the containment of possible mismeasurement issues.

Moreover, using the six task-based skill indicators proposed in Grundke et al. (2017) as in Figure 23 above, it is possible to shed light on how other types of skills relevant for performance on the job and for firm performance are rewarded. These estimates of the returns to these task-based skills take into account country, industry and occupation specificities as well as the cognitive skills of workers.

Finally, to define digital and less digital intensive industries, the analysis builds on recent OECD work on the taxonomy of digital intensive sectors (Calvino et al., 2018). The taxonomy reflects the degree to which sectors have been permeated by the digital transformation and takes into account some of the many facets that the digital transformation may take. These include digitalisation's technological components (proxied by a sector's intensity in ICT investment, purchases of intermediate ICT goods and services, and robots); its human capital requirements (i.e. ICT specialists); and one of the new forms characterising markets in the digital era, namely e-commerce.[16]

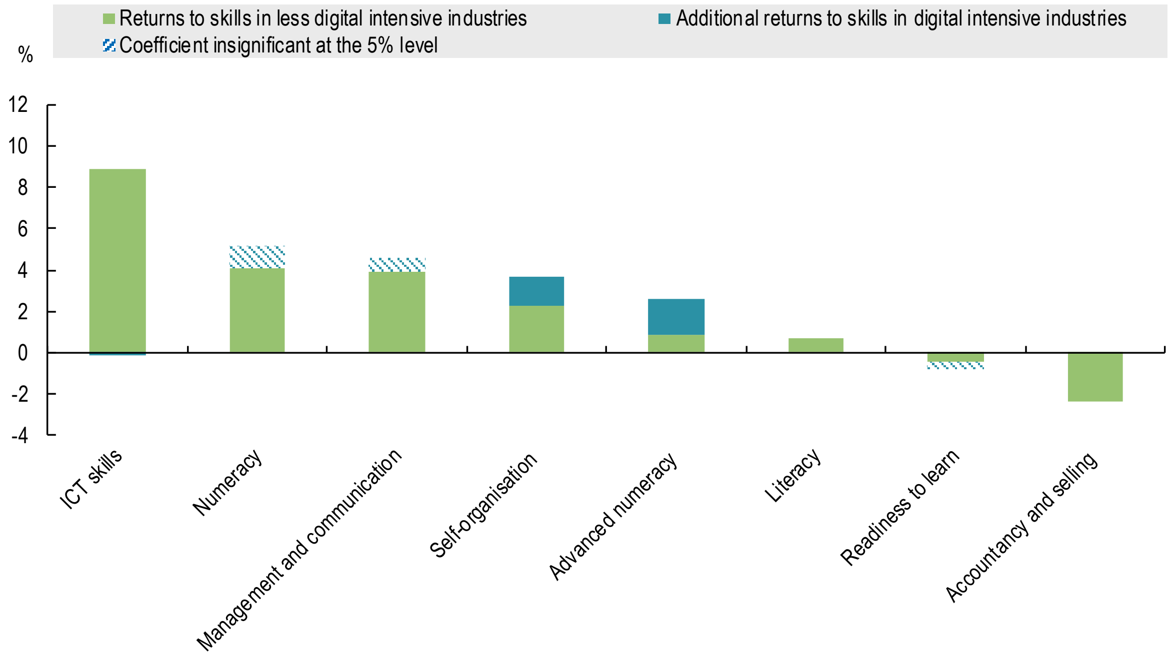
Which skills for the digital era?

Figure 27 shows that for two types of skills, labour market returns are significantly higher in digital intensive industries than in less digital intensive industries. These are advanced numeracy skills and self-organisation skills. Also, management and communication and numeracy skills appear to command a higher premium in digital intensive industries; the coefficient for management and communication skills is significantly different from zero when self-employed workers are included in the analysis (Table A3.3.).

The fact that these skills command a premium in salaries and bonuses suggests that they are relatively more valued in digital intensive sectors. This may be due to workers in digital intensive industries needing to operate in a more independent and/or decentralised fashion (e.g. through telework), or because they need to communicate across disciplinary boundaries and in diverse and sparse teams. Also, higher rewards may be due to the performance of relatively more non-routine tasks, or to having to deal with continuously changing settings, environments in which technical skills coupled with self-organisation and management and communication skills are increasingly important.

The results shown in Figure 27 are not driven by the observable characteristics of workers generally known to relate to higher wages or higher skill levels, such as workers' years of education, age and gender, as such characteristics are duly accounted for in the estimations (for details see the Methodological Annex). Also, results are net of all other observable skills of workers, as well as country-specific characteristics and industry-specific features. This is important because countries and industries differ in average productivity, capital or innovation intensity, and these may in turn shape wages and thus returns to skills. Finally, the results in Figure 28 are also not driven by the occupational category that workers belong to, as the regressions control for all unobserved characteristics of the ISCO08 2-digit occupation categories. This ensures that the analysis indeed captures variations in the skills and tasks requirements of jobs within occupational categories and independent of general occupational characteristics. In addition, the type of estimates performed ensures that the extra wage premia that workers' skills command in digital intensive industries are not driven by the occupational composition of digital and less digital intensive industries.[17]

Figure 27. Additional labour market returns for various types of skills in digital intensive industries, 31 OECD countries and partner economies, 2012 or 2015



Notes: ICT = information and communication technology. Labour market returns to skills are based on Ordinary Least Squares (OLS) wage regressions (Mincer equations) using data from PIAAC and the pooled set of 31 OECD countries and partner economies. The skill measures are based on PIAAC and are taken from Grundke et al. (2017). Digital intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018). The specifications include the sample of all employees. The figure shows the percentage changes in wages for an increase in skills by one standard deviation. Shaded bars signal that the coefficient is not significant at the 5% level. For detailed results see Table A3.3, column 1.

Source: OECD calculations based on PIAAC (OECD, 2012b, 2015c).

Are women endowed with the skills needed to thrive in the digital era?

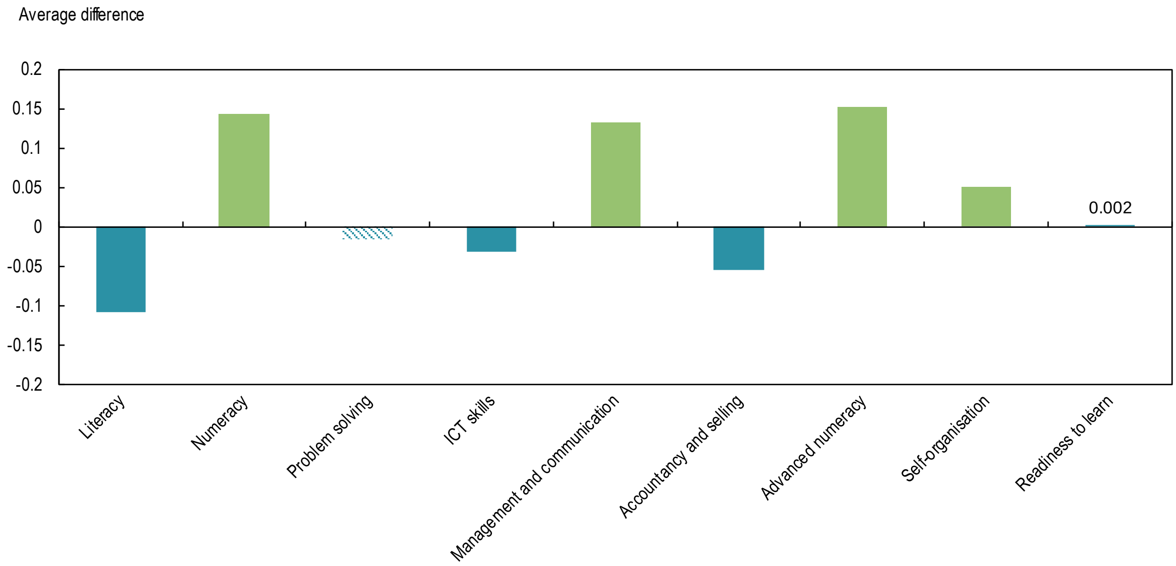
To gain a better understanding of what is driving the digital gender divide, it is important to understand whether women are endowed with the skills needed to thrive in the digital era and whether men and women differ in this respect. If women are less endowed with the skills needed for the digital era compared to men, the already existing wage inequality between men and women is likely to increase as the digital transformation unfolds.

Figure 28 suggests that men are generally better endowed with the skills that command an extra wage premium in digital intensive industries. Independent of the age or the education of the individual as well as of the country, the industry, the size of the firm or the occupation the individual works in (and whether the individual works part time or not), men are generally endowed with higher numeracy and advanced numeracy skills as well as with higher task-based skills related to self-organisation and management and communication (also see Table A3.4).

This result is worrisome. As the digital transformation unfolds and progressively affects all industries, including those that are less digital intensive at present, the fact that women are relatively less endowed with the skills that are especially needed in the digital transformation will likely contribute to widen the already existing gender wage gap. To avoid that this happens and to try and narrow the current gender wage gap, governments need to ensure that women are well equipped with advanced numeracy skills, and that they are provided with the opportunity to increase their management and communication and self-organisation skills. In their current jobs, women would need to increasingly be tasked with management and communication duties and be enabled to develop and apply their self-organisation capabilities. Figure 28 among others in fact implies that, within each detailed occupation category considered, men are currently conducting significantly more management and communication and self-organisation tasks than women.

Figure 28. Difference between men and women, 31 OECD countries and partner economies, 2012 or 2015

Difference in standardised skill scores (male-female), conditional on covariates



Notes: ICT = information and communication technology. Differences in standardised skill scores between men and women are conditional on the covariates. The skill measures are based on PIAAC and are taken from Grundke et al. (2017). For each skill variable, an OLS regression of workers skill endowment on the covariates from the wage regressions in Figure 27 (except for the interaction terms, see Table A3.4) are estimated using data from PIAAC and the pooled set of 31 OECD countries and partner economies. For each of these regressions, the bars show the coefficients for a dummy variable for being male (taking the value 1 if the individual is male and 0 if female). Shaded bars signal that the difference between men and women is not significant at the 5% level. Bars above the x axis denote skills where men have a relative advantage. Bars below the x axis denote skills that women are better endowed with.

Source: OECD calculations based on PIAAC (OECD, 2012b, 2015c).

On the bright side, however, as women are generally better endowed with literacy skills and with ICT and accountancy and selling skills than men (or conduct more ICT-related tasks compared to men in the same occupation) suggests that women are not short of all skills needed for the digital transformation. Although the present analysis does not find higher returns to ICT skills in digital intensive as compared to less digital intensive industries, the increasing use of ICTs is an important feature of the ongoing digital transformation. This is also confirmed in Table A3.4, which shows that independent of many individual and work related characteristics as well as country, industry and occupation-specific characteristics, workers in digital intensive industries have on average much higher ICT skills than workers in less digital intensive industries.

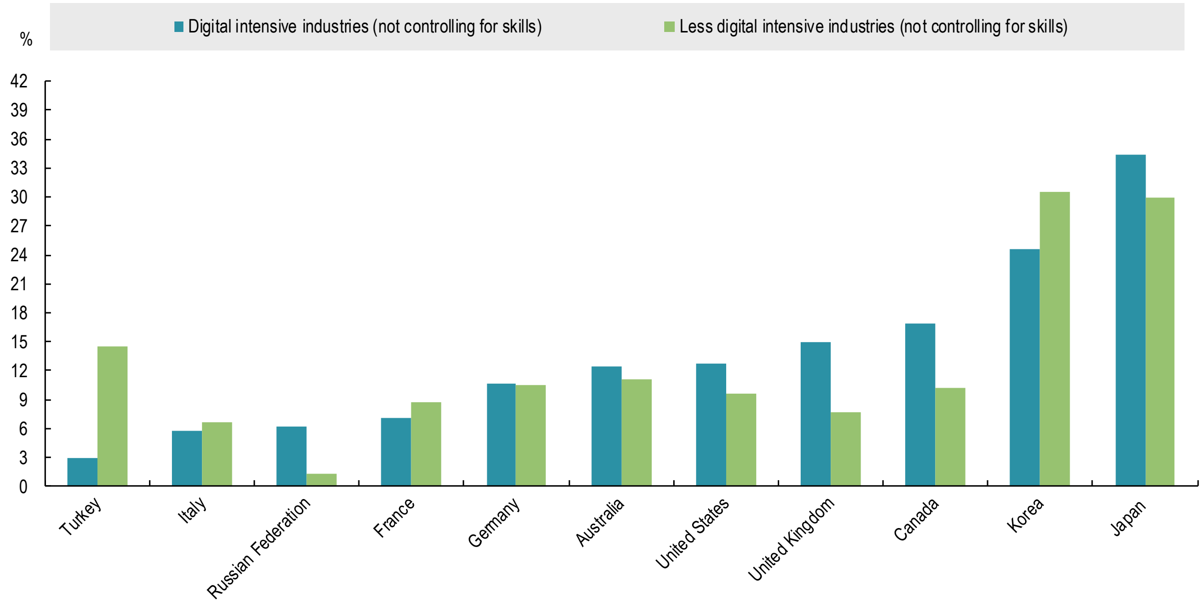
Also, the present analysis shows that when cognitive and task-based skills as well as country, industry and occupation-specific characteristics are held constant, ICT skills generally command the highest wage returns compared with any other type of skills (Figure 27). Thus, the observed relatively higher endowment of ICT skills of women may contribute to narrow existing wage inequalities between men and women.

Digitalisation and the gender wage gap

Given that men seem to be better endowed with the skills commanding higher wage returns in digital intensive industries, one would expect that the gender wage gap (the wage difference between men and women) should be higher in digital compared to less digital intensive industries. As Figure 29 shows, this is the case and this could further aggravate the pay gap between men and women as these jobs grow.

Figure 29 shows that when the observable skills of individuals are not controlled for, the gender wage gap is higher in digital intensive as compared to less digital intensive industries, in most of the countries in the sample. If one of the possible explanations for the observed difference is that men are better endowed with the skills that are particularly needed for the digital transformation, the gender wage gap in digital intensive industries (compared less digital intensive industries) should decrease once controlling for the skills of the workers.

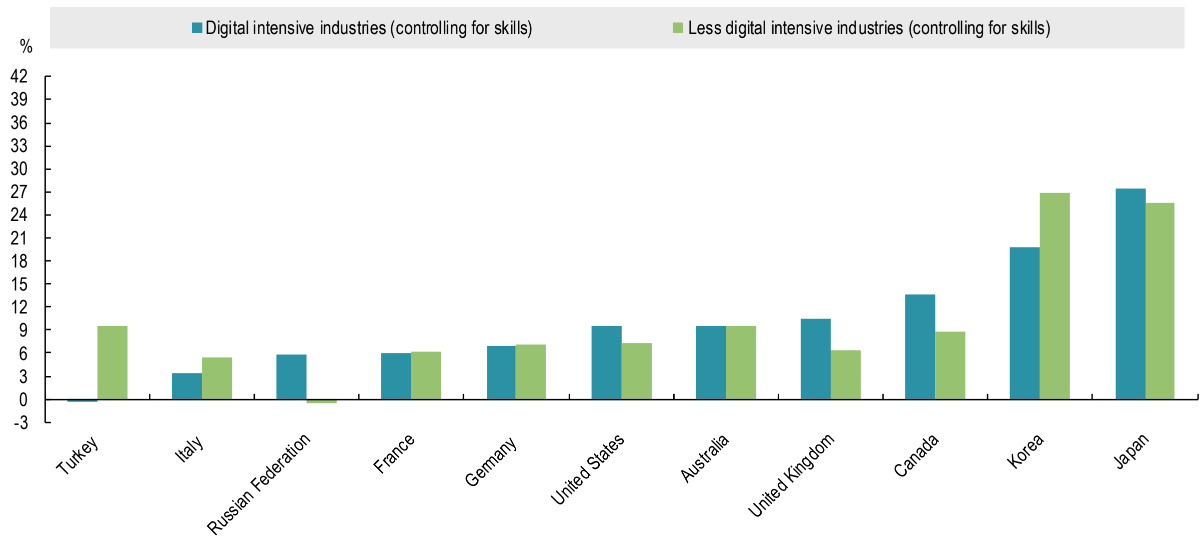
Figure 29. Gender wage gap by country in digital vs. less digital intensive industries (not controlling for skills)



Notes: The figure shows the differences in hourly wages for men and women in percent (for the sub-samples of employees in digital vs. less digital intensive industries, respectively). Digital intensive industries are defined using a new measure for digital penetration Calvino et al. (2018). The estimates for the gender wage gap are based on OLS wage regressions (Mincer equations) using data from PIAAC and control for the same covariates as in Figure 27 and Figure 28, except for all the skill variables which are excluded here.

Source: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Figure 30. Gender wage gap by country in digital vs. less digital intensive industries (controlling for skills)



Notes: The figure shows the differences in hourly wages for men and women in percent (for the sub-samples of employees in digital vs. less digital intensive industries, respectively). Digital intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018). The estimates for the gender wage gap are based on OLS wage regressions (Mincer equations) using data from PIAAC and control for the same covariates as in Figures 27 and 28 (in particular for all skill variables). The skill measures are based on PIAAC and are taken from Grundke et al. (2017).

Source: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Figure 30 as well as Tables A3.2 and A3.3 in the Annex of Chapter 3 show that this is indeed the case. When controlling for the skills of workers, the gender wage gap in digital intensive industries decreases more than the one observed in less digital intensive industries. Depending on the country they live in, men earn on average between 3% and 27% more than women in digital intensive sector, and 2% to 28% more in less digital intensive industries. Thus, to avoid a scenario where the digital transformation further increases gender-specific income inequalities, women need to be equipped with advanced numeracy skills and be given more possibilities to increase their management and communication and self-organisation skills. This entails performing more management and communication as well as self-organisation tasks on the job.

Another important insight emerging from Figure 30 is that even when for controlling for a wide array of cognitive, non-cognitive and social skills of workers, the wage gap between men and women remains considerable and is larger in digital intensive than in less digital intensive industries. Such remaining differences may be the results of many factors, including longer out-of-work spells for women and lower working hours due to household duties (although in Figure 30 working part time is taken into account), differences in gender roles and the gender division of labour (Goldin, 2014; Blau and Kahn 2017), and discrimination. Also, although controlling for a wide array of cognitive, non-cognitive and social skills, this study cannot cover the full spectrum of skills and psychological attributes that are important on the labour market and that influence workers' wages. These too may contribute to explaining the remaining gender wage gap.

The digital gender divide revisited: Gender-specific skill returns

Another possible explanation of why the gender wage gap remains higher in digital intensive compared to less digital intensive industries, even when controlling for the skills endowments of workers, could be related to differences in skill returns between men and women. If digital intensive industries reward men more than women for certain skills, and if this is not the case in less digital intensive industries, the gender wage gap should be higher in digital intensive compared to less digital intensive industries, even when holding the skills endowment of the workers constant. Figure 31 shows the skill returns for men and women in digital vs. less digital intensive industries.

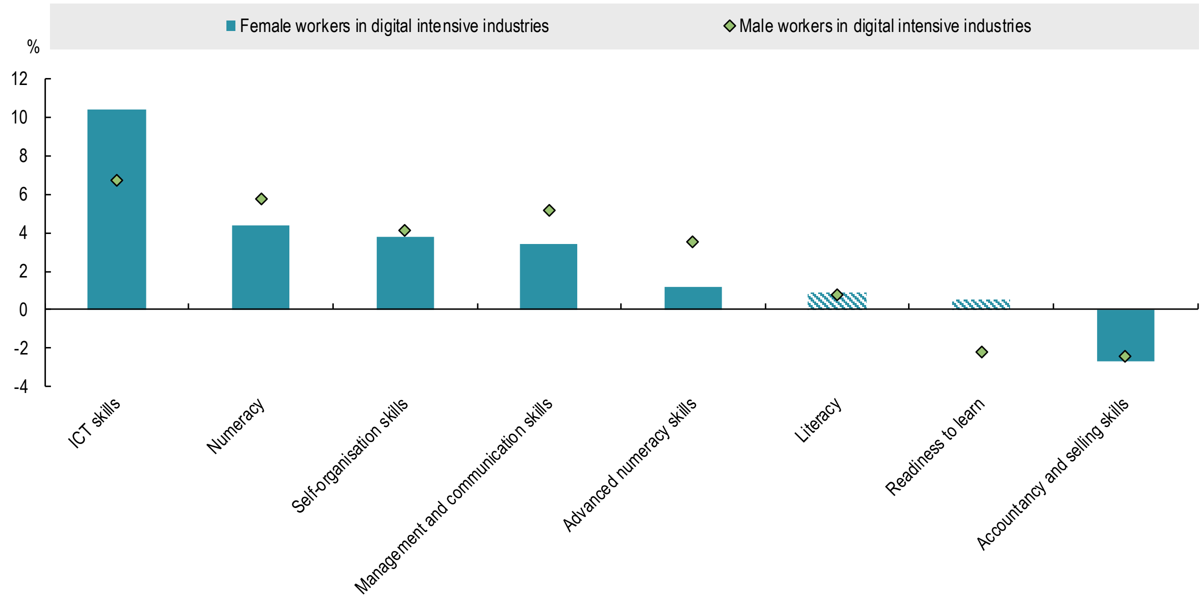
In addition to being better endowed with the skills needed for the digital era (Figure 28), men receive higher returns to these skills in industries which are more intensely permeated by the digital transformation (Panels A and B of Figure 31). The returns to advanced numeracy and management and communication skills are significantly higher for men than for women in the digital intensive industries, other characteristics held constant (Panel A). This is not the case for less digital intensive industries, as shown in Panel B. Again, these results are not driven by the observable characteristics of individuals (such age, education, working part time or not) nor by characteristics of the country, industry or the occupation or the size of the firm individuals work in (Table A3.6).

But why are returns to advanced numeracy and management and communication skills higher for men than for women in digital intensive industries, and why is this not the case for less digital intensive industries? One possible explanation relates to the women being discriminated against with respect to their expected performance in advanced numeracy and management and communication tasks, which might be more severe in digital intensive industries. This could lead to contracts that pay women a lower salary, despite them having the same skill endowments and performing the same type of tasks of their male counterparts. Another explanation might be that male networks are stronger in digital intensive industries and that wage bargaining outcomes and bonus payments are higher for men, in particular when it comes to jobs that require advanced numeracy, management, and communication. .

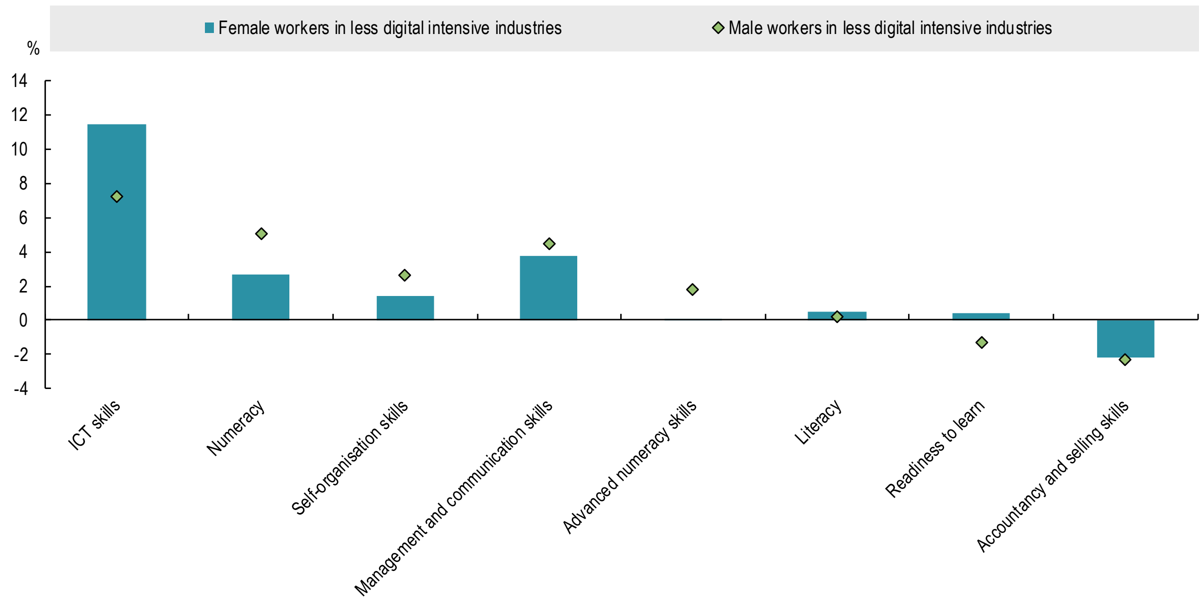
Furthermore, on the basis of the data available for this study, it cannot be ruled out that productivity effects may explain the different returns to task-based skills between men and women in digital intensive industries. Because advanced numeracy and management and communication skills are measured based on information on the frequency of tasks carried out on the job, it might well be that although men conduct as many advanced numeracy or management and communication tasks than women, they might be more productive in these type of tasks in a digital intensive environment. For example, if digital intensive industries are more dynamic and require more competitive behaviour and negotiation skills than less digital intensive industries, women conducting management and communication tasks might have a disadvantage compared to men. Recent evidence suggests that women are less willing than men to negotiate and compete and are generally more risk averse (for reviews, see Bertrand [2011]; Croson and Gneezy [2009]).

Figure 31. Labour market returns to skills by gender across 31 OECD countries and partner economies, 2012 or 2015

A: Digital intensive industries



B: Less digital intensive industries



Notes: ICT= information and communication technology. Labour market returns to skills are based on OLS wage regressions (Mincer equations) using data from PIAAC from 31 OECD countries and partner economies. Panel A only includes employees working in digital intensive industries, whereas Panel B includes employees working in less digital intensive industries. Digital intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018). Skill measures are based on PIAAC and are taken from Grundke et al. (2017). The estimates by gender are obtained through including an interaction term of the skill variable and the dummy variable for being male (taking the value 1 if the individual is male and 0 if female), whereby the wage regressions control for the same covariates as in Figures 27, 28 and 30). The figure shows the percentage changes in wages determined by an increase in skills by one standard deviation. Hashed bars indicate that the returns to skills for women are not significant at the 5% level.

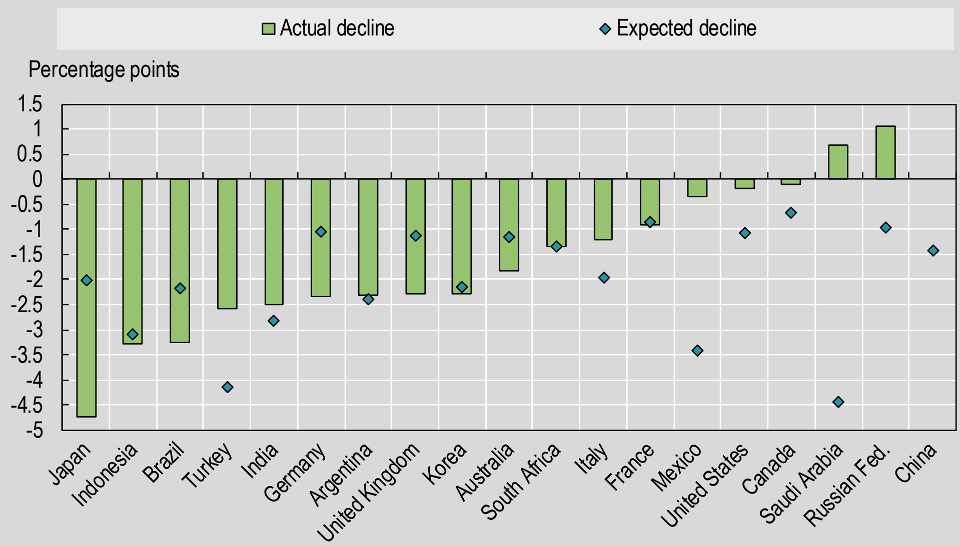
Source: OECD calculations based on PIAAC (OECD, 2012b, 2015c).

The results in Figure 31 also indicate that in both digital and less digital intensive industries, women seem to receive an additional wage premium on their ICT skills. This may be explained by women being more productive compared to men when performing the same (amount of) ICT-related tasks. As ICT tasks[18] comprise many reading and writing tasks (Table A3.1), the generally higher literacy skills endowment of women (Figure 28) might contribute to explain why they are more productive when performing these ICT-related tasks compared to men. While, as said, the current comparative advantage in ICT-related tasks that women exhibit may help decrease the gender wage gap, in particular because skill returns for ICT skills are high compared to other skills (Figure 27), it is important to ensure that women are also well equipped with advanced numeracy skills. Further, they must also be able to improve their management and communication and self-organisation skills on the job, as these skills seem to be especially important for the digital transformation.

BOX 6. ACHIEVING THE G20 TARGET TO REDUCE THE GENDER GAP IN LABOUR FORCE PARTICIPATION: WHERE DO WE STAND?

At their 2014 Summit in Brisbane, G20 leaders committed to reduce the gender gap in labour force participation observed in 2012 by 25% by 2025 (the so-called "25 by 25 target"). This would be achieved by implementing a set of key policy principles that G20 Ministers of Labour had agreed on in 2014 to improve the quality of women's employment. The G20 target was adopted in recognition that narrowing this gap could help foster greater gender equality in the labour market and boost economic growth.

Figure 32. Actual vs. expected decline in gender participation gap, 2012-17



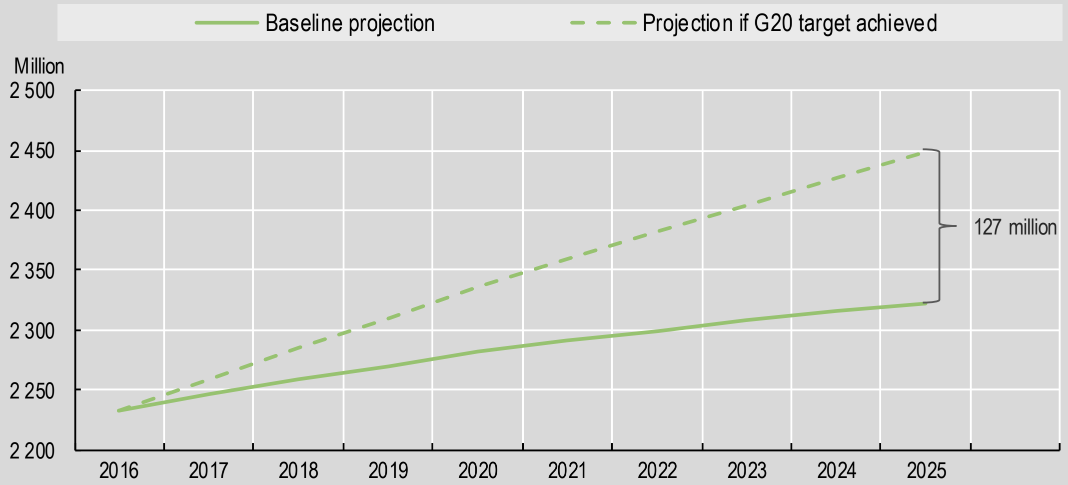
Notes: The actual decline refers to the observed change in the gender gap between 2012 and 2017 (2016 for Russia and Saudi Arabia and 2015 for India). The expected decline in the gender gap between 2012 and 2017 refers to 5/13ths of the overall target decline of 25% in between 2012 and 2025 (4/13ths for Russia and Saudi Arabia and 3/13ths for India). For China, no recent data are available to calculate the actual decline in the gender gap and the data for 2012 have been projected to calculate the expected decline in the gender gap. The data refer to the population aged 15 and over for India and 16-64 for Spain and the United States.

Sources: OECD calculations based on national labour force surveys and, for China, census data.

Since 2012, most G20 economies have made good progress (Figure 32) in narrowing the gender gap in participation, with particular large decreases recorded in Brazil, Indonesia and Japan. The gender gap increased in only a few countries, possibly reflecting a cyclical pick-up in men's participation from a crisis-affected low in 2012. In 2016, this gap in participation rate between men and women aged 15-64 was estimated to be around 26 percentage points for the G20 economies (57% for women vs. 83% for men), ranging from a low of

7 percentage points in Canada to a high of 58 percentage points in Saudi Arabia. The reductions that countries have recorded in the gender gap can be benchmarked against the decline that would be "expected" if countries make steady reductions each year between 2012 and 2025 to achieve the gender gap target. A few countries, most notably Australia, Brazil, Germany, Japan and the United Kingdom, are ahead of their target as they recorded a greater decline in the gender gap than required to stay on target.

Figure 33. Projected increase in the G20 labour force if G20 gender target achieved



Notes: The baseline scenario assumes that labour force entry and exit rates by five-year age group and gender are fixed at their average level observed during 2006-16. The target scenario assumes that the G20 target of reducing the gender gap in participation is achieved progressively over the period 2016-25 and adjusts participation rates of women accordingly given the projected baseline rates for men.

Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

Achieving the G20 gender target would result in a considerable boost to the G20 labour force by around 130 million in 2025 (Figure 33).[1] This amounts to a 5.7% increase in the total G20 labour force relative to the projected level under the baseline scenario. The increase in the labour force is more substantial in those countries with the largest gender gap currently. For instance, the increase in India would be almost 13% as a result of 65 million more women joining the labour force if the G20 target is reached.

1. The increase in the G20 labour force is obtained by comparing projections of the labour force under the target scenario with a baseline scenario. The baseline scenario assumes that labour force entry and exit rates by five-year age group and gender are fixed at their average level observed during 2006-16. The target scenario assumes that the G20 target of reducing the gender gap in participation is achieved progressively over the period 2016-25 and adjusts participation rates of women accordingly given the projected baseline rates for men.

Self-employed workers in the digital transformation

Digital technologies can open the way to more flexible ways of working, whether this means "non-standard work" such as part-time, temporary or self-employment opportunities, or facilitating work at a distance. Such enhanced flexibility can also help foster better "matches" of employers and prospective employees. Technologies can thus reduce existing gender gaps in multiple ways, including by means of fostering women participation in the labour market, e.g. after maternity leave or through a better combination of household production and formal work. However, as noted in OECD (2017b) and ILO (2017), more flexibility can also raise concerns about job-quality and work-life balance, with possible negative consequences for gender disparities.

This section provides first evidence of skill and wage gender gaps for workers who exhibit a specific type of flexibility, i.e. the self-employed. The analysis distinguishes between "standard" self-employed individuals, and self-employed who have a relation of dependency with a client, i.e. dependent self-employed workers. The definition of "dependent self-employed" workers is here adapted from Eurofound (2015) and OECD (forthcoming b) to fit the availability of information in PIAAC. Self-employed individuals are workers for which at least two of the following three features apply:

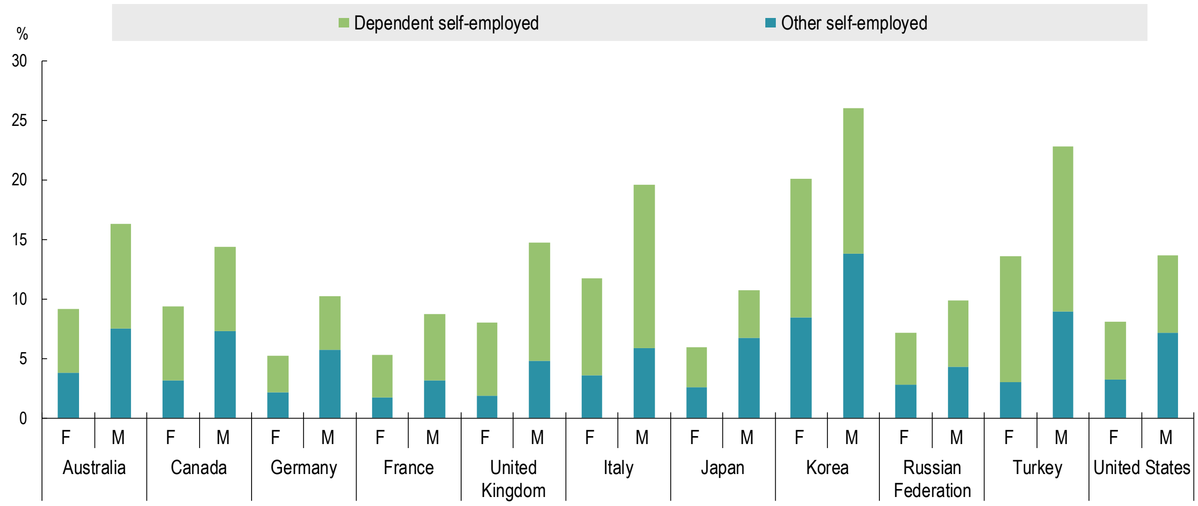
- they have no hiring or firing power on others
- they have only one employer
- they cannot easily change at least two of the following features of the job: order of tasks, speed of work, or how to do the work.

While PIAAC is not ideal for identifying the dependent self-employed (in particular it does not allow identifying those who are in a state of economic dependency vis-à-vis a single client), it nonetheless allows the identification of those own-account workers who have little say about the organisation of their own work.

The dynamics of dependent self-employment can provide insights on labour market outcomes of "gig" workers, with whom they share similarities. In many cases (and whether they like it or not), gig workers will be classified as self-employed and, among those, a great number will be dependent on a single employer/ platform. The two concepts are not fully overlapping as, for instance, certain "gig" figures such as crowdworkers and homeworkers are relatively free to choose the order or pace of tasks they perform. Similarly, many dependent self-employed workers do not operate through a platform and perform jobs that existed long before the digital transformation, and cannot be considered as "gig". As a result, the current definition cannot distinguish between "true" digital or platform workers and more established forms of subcontracting like e.g. editors or gardeners (see e.g. Torpey and Hogan [2016] about the challenges of counting gig workers). Current constraints in data reporting on the individuals' employment status or employer, however, prevent the development of a better definition and measurement of gig workers. These difficulties notwithstanding, the proposed operational definition of dependent self-employed workers signals their more limited flexibility and ability to choose the features of their work than other self-employed individuals. This may imply different employment opportunities and possibilities to adjust job-length spells for dependent and other self-employed workers, including for men and women.

Figure 34 reports the proportion of dependent self-employed, other self-employed individuals and employees in total workers for a given gender. On average across the countries considered, women are more likely to work as employees than men (91% vs. 85 %), while a slightly higher proportion of men are active as dependent self-employed (8% vs. 6 %). A higher proportion of both men and women can be characterised as dependent self-employed than other forms of self-employed workers.

Figure 34. Share of dependent self-employed workers in female and male workers, selected PIAAC countries, 2012 or 2015



Note: Proportions are calculated using sampling weights. The sum of employees, dependent self-employed and other self-employed workers of a given gender gives 100 %. "F" means female and "M" male.

Source: OECD calculations based on PIAAC data (OECD, 2012b, 2015c).

Unreported evidence shows that ICT skills and the skills which are typically associated with self-employed individuals such as managing and communication and self-organisation, are more present in self-employed workers than in employees, but the overall figure for the self-employed is driven by non-dependent self-employed individuals. Dependent self-employed workers generally exhibit lower skills than employees and independent self-employed with the exception of self-organisation and accountancy and selling.[19] However, similarities between self-employed and employees, exist, too: men, on average, display greater numeracy and advanced numeracy skills than women, independent of the type of employment. Women, conversely, do better than men in literacy as well as readiness to learn.[20]

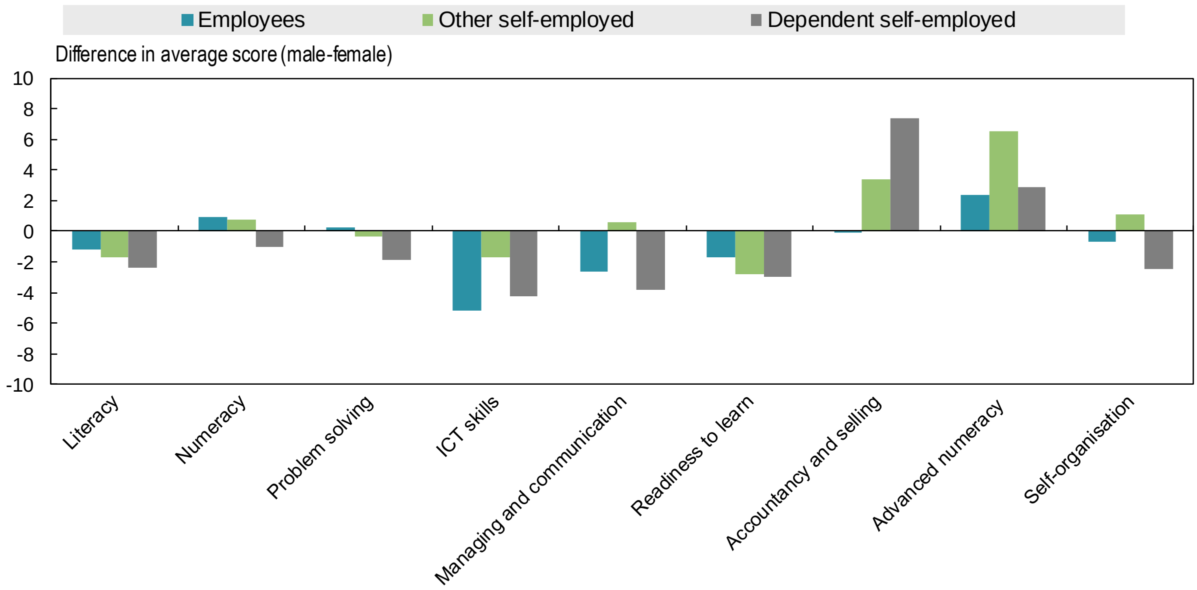
These differences become less clear when considering the digital intensity of industries in which individuals operate (Figure 35). The unconditional skill gap is generally positive in more digital intensive industries, and negative in less digital intensive industries, independent of the individuals' employment status. There are exceptions, though: advanced numeracy and numeracy competencies are generally higher for men than women, independent of the digital intensity of the industry considered, and especially in the case for other, non-gig self-employed. Women, instead, on average display higher ICT skills when employed in less digital intensive industries and no gender differences emerge for employees in digital intensive industries. Female dependent self-employed workers show on average higher self-organisation skills and readiness to learn than men in the same employment type.

The average self-employed worker earns less per hour, and a dependent self-employed worker even less, than an employee, once all other observable individual features are taken into consideration, as well as the characteristics of the country, the industry and the occupation where individuals work (see Table A3.3). The magnitude of this "penalty" for dependent self-employed workers is three times higher than the wage "penalty" for being a woman rather than a man (see Table A3.3, columns 2 and 3, and Table A3.6, column 4). Lastly, when estimating wage regressions only for the sub-sample of non-dependent self-employed workers, it appears that they are particularly rewarded for their ICT skills and managing skills (Table A3.3, column 5). For the sub-sample of dependent self-employed workers, ICT and numeracy skills seem to be especially important for these types of workers.[21]

Figure 35. Gender gaps in average skill scores by employment type, 2012 or 2015

A. Digital intensive industries

B. Less digital intensive industries



Notes: ICT = information and communication technology. The worker-level skill indicators are scaled between 0 and 100, then averaged by gender and employment type using sampling weights, splitting the sample between digital intensive and less digital intensive industries. The graph plots the differences between these averages by gender and does not control for other covariates. The sample is reduced to the individuals who report the necessary information to account for their dependent self-employed status, and covers the following 31 OECD countries and partner economies: Australia, Austria, Belgium (Flanders), Canada, Chile, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Greece, Ireland, Israel, Italy, Japan, Korea, Lithuania, the Netherlands, New Zealand, Norway, Poland, the Russian Federation (excluding Moscow), Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Turkey, the United Kingdom (England and Northern Ireland) and the United States. Panel A only includes employees working in digital intensive industries, whereas Panel B includes employees working in less digital intensive industries. Digitally intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018).

Source: OECD calculations based on PIAAC data (OECD, 2012b, 2015c).

Conclusions

The analysis presented in this chapter provides evidence that the digital transformation is changing the demand for skills and that men and women are differently equipped with the skills needed in the digital era. Strengthening women's skills can play an important role in narrowing the gender wage gap. In particular, the comparative advantage that women display in ICT skills, and the relatively higher reward that these skills command can contribute to reduce wage disparities between men and women, given an economy – like the digital one – where ICT skills are important. Government action can ensure that these skills are provided through education and life-long learning.

The analysis, however, also shows that the skills that are in high demand in digital intensive sectors, i.e. self-organisation, managing and communication, and advanced numerical skills, are more frequently displayed by men than women. Narrowing the gender wage gap may thus require policies aimed to equip female workers with more advanced numeracy (STEM) skills. This may imply encouraging greater female enrolment in STEM studies, facilitating women's access to STEM-related apprenticeships, and targeting existing gender biases in curricula and parental preferences (see Chapter 5 for policy examples already in train in G20 economies).

Progress in the diffusion of digital technologies may provide further opportunities for workers to participate in the labour market with flexible schedules, including from home or with greater geographical mobility. This can in turn help parents combine work and family duties, and promote female formal employment as a consequence. If labour market rewards to experience rise over time, allowing women to cumulate working experience is likely to reduce the gender pay gap. These gaps in the United States, for instance, tend to be lower in industries where working arrangements are more flexible (Goldin, 2014). However, these benefits may come at the cost of lower job quality (OECD, 2017b; ILO, 2017): more flexible working times and places can translate in longer working hours and a less neat separation between work and personal life. Granting workers the "right to disconnect" from electronic job devices at the end of the working day, along the lines of what was implemented in France in 2017, may ensure that flexibility does not simply translate in greater stress.

The analysis proposed in this chapter focused on the role of skills in the digital transformation, which did not depend on workers' country, sector or occupation of employment, nor on a number of observable characteristics of the worker herself. Nevertheless, the digital transformation can also affect gender divides through these channels, which have been identified in empirical analyses such as Olivetti and Petrongolo (2016) who show that differences in industry structure explain more than 80% of international differences in labour demand of men and women. An industrial structure oriented towards manufacturing generally see greater participation of men in the workforce, while one that is more oriented to services is seemingly conducive to greater women participation.

Finally, a number of aspects of the gender skill and wage gap could not be explained in the analysis. The observed "residual" gaps can be shaped by a number of economic and social phenomena, one of which is discrimination. Distinguishing the exact importance of discrimination, however, is empirically not feasible with the data at our disposal. Furthermore, the part of the residual gap which is due to discrimination may be overstated, in case men display higher levels of unmeasured productivity, or understated, if women are better endowed with skills that are unobservable. Cultural norms which are not country-, industry- or occupation-specific also contribute to explain the "residual" gap found in the analysis. Governments may consider leveraging digital technologies to: 1) raise awareness on gender discrimination; 2) dispel stereotypes, for instance about the split in household production duties between women and men; and 3) about the jobs that "suit" men but not women, especially those that use STEM-related skills.

Notes

1. Evidence on psychological attributes had hardly been explored before in this context by the economic literature (see e.g. Bertrand [2011]; Blau and Kahn [2017]).

2. Management and communication skills activities involve communicating with and managing other people, whether they are co-workers or not. It relies on information from PIAAC including tasks such as “teaching people” to “planning others’ activities”. Self-organisational skills, arises out of items that are designed in PIAAC to measure these very dimensions. It includes items such as “Work flexibility – Speed of work” or “Work flexibility – Sequence of tasks”. For more details about the methodology used to define and measure these skill factors and the survey items on which these skill factors rely upon see Grundke et al. (2017).

3. This includes self-employed with and without employees. Ideally, the comparison would have been with own-account workers only, but data availability constraints hinder such more accurate comparison.

4. Reported percentages are unweighted averages across 15 G20 economies, i.e. those of Figure 21 excluding China, for which the breakdown by field is not available.

5. Graduated in ICT studies are defined as individuals graduating in ISCED Fields of Education and Training 2013 (ISCED-F2013) category 06, “Information and Communication Technologies”. This encompasses the following detailed fields: 0611 Computer use; 0612 Database and network design and administration; 0613 Software and applications development and analysis.

6. Graduates in engineering, manufacturing and construction correspond to individuals graduating in ISCED Fields of Education and Training 2013 (ISCED-F2013) category 07 “Engineering, manufacturing and construction”.

7. ICT specialists are here defined as workers employed in the following ISCO 2008 3-digit occupations: software and applications developers and analysts (ISCO08 category 251), database and network professionals (ISCO08 category 252), information and communications technology service managers (ISCO08 category 133) and information and communications technology operations and user support (ISCO08 category 351).

8. In the case of Canada, converting data from the Canadian NOC into ISCO08 figures may inflate the figures. Data conversion-related issues also exists, but are less severe, in the case of: United States, which uses CPS occupational categories; Australia, using the Australian and New Zealand Standard Classification of Occupations (ANZSCO); Japan, using the Japan Standard Occupational Classification (JSOC); Korea, using the Korean Standard Classification of Occupations (KSCO); and South Africa, using the South African Standard Classification of Occupations (SASCO).

9. More nuanced insights can be obtained by looking at the entire distribution of cognitive skills, and in particular the best performers. However, even high-achieving girls display less confidence than boys and more anxiety in mathematics. For more details, see OECD (2015a) and Borgonovi et al. (2017).

10. The fields of education in Figure 26 are different from those in Figure A3.1 because PIAAC reports them only in the ISCED2011 classification.

11. Average scores in the pooled sample of 31 OECD countries and partner economies, using appropriate weights. See notes to the graph for further details.

12. Digital intensity here is measured by a sector’s development and adoption of advanced digital technologies, its human resources needed to embed them in production, and the extent to which digital tools are used to deal with clients and suppliers (see Calvino et al. [2018]).

13. For further details about the empirical framework, see also the Methodological Appendix.

14. The PIAAC sample covers the following 31 countries: Australia, Austria, Belgium (Flanders), Canada, Chile, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Greece, Ireland, Israel, Italy, Japan, Korea, Lithuania, the Netherlands, New Zealand, Norway, Poland, the Russian Federation (excluding Moscow), Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Turkey, the United Kingdom (England and Northern Ireland) and the United States.

15. The PIAAC Survey also gathers information on the salaries and bonuses earned by individuals in the year prior to the survey year, as well as information on the industry, occupation and size of the firms that individuals works in, as well as a number of socioeconomic background characteristics for these individuals (educational attainment, age, gender, etc.). Individual gross hourly earnings are expressed in purchasing power parity terms.

16. A single metric combining all these aspects and mirroring the extent to which industries have been undergoing the digital transformation is used to rank 36 2-digit ISIC4 sectors and to subdivide them in two groups.

Depending on whether they rank above or below the median, industries are grouped into two subsets, namely "digital intensive" and "less digital intensive" industries. Examples of digital intensive industries are "Transport equipment" and "Telecommunications", whereas "Chemicals and chemical products" as well as "Basic pharmaceutical products and pharmaceutical preparations" feature among less digital intensive industries (see Table A3.1 for details).

17. Similarly, the report of the Broadband Commission *Working Group on Education: Digital Skills for Life and Work* (Broadband Commission, 2017b) examines how the education sector can ensure that all people develop essential digital skills for life and work. It points out that broadband technologies can help accelerate progress toward the SDGs, but only if people know how to leverage them. The report pays special attention to the 'soft' skills required to thrive a technology-rich world. These include understanding the implications of online activities; recognition of privacy considerations; knowledge of how to engage as responsible citizens in online environments; and awareness of how digital technology, big data and algorithms affect individuals and communities.

18. The ICT tasks considered here relate to the frequency of: word and excel use; programming language use; making transactions through Internet (banking, selling/buying); using e-mails and Internet; having real-time discussions ICT; reading and writing letters, emails, memos; using the computer on the job.

19. These statements are generally robust to controlling for other features of the individual. Table A3.5 shows the association between being a self-employed (dependent or not) worker relative to being an employee, and the skills displayed by the average individual, once other characteristics of the worker (same as in Figure 28) are also accounted for. That more encompassing framework shows that the advantage of the self-employed in readiness to learn (e.g. from Figure 33) is reflecting other characteristics of the individual and of the work place, and that dependent self-employed workers display lower managing and communication skills than employees.

20. These results do not control for other covariates of skills and employment status ("unconditional skill gap").

21. Few results are significant when the regression model is estimated on the sub-sample of dependent vs. non-dependent self-employed workers. It cannot be excluded that the lack of statistical significance in reported coefficients is partly driven by the small number of individuals in that employment category, occupation, industry and country who are also surveyed in PIAAC.

Chapter 4

WOMEN AND INNOVATION: IS THE GENDER GAP SHRINKING IN THE DIGITAL ERA?

Innovation activities are at the core of the digital transformation and it is in the interests of all countries to ensure that they are drawing on the best talent. To help policy makers take a comprehensive approach to promoting gender equality in innovation activities, this chapter provides first-time evidence on gender-specific patterns in innovation output, using data related to patents and to open-source software.

This chapter further provides evidence about the role of women in one important component of the digital transformation, i.e. software creation and use. Experimental indicators using information about a popular open-source software show that the software world is still a very much male-dominated environment, where women are few and far between, play a relatively less important role and are less connected to other software authors than their male colleagues.

The last part of the chapter looks at the role of women in innovative entrepreneurship and sheds light on the extent to which women entrepreneurs are missing out on the opportunities created by globalisation and digitalisation and on the need to boost the presence of women in the supply side of financial markets.

Women in innovation in the digital era: How big is the gender gap?

The importance of innovation for economic growth and for the advancement and well-being of societies is well understood and supported. But very little is known about the role that women play in shaping innovation dynamics. While a number of gender-related studies in areas that are closely related to innovation, e.g. entrepreneurship research, have shown that entrepreneurship is a gendered phenomenon (Minniti, 2009), evidence is scarce when it comes to understanding who does what in innovation activities. The scarce attention devoted to the role of women in innovation stems from a number of factors, including the relative "invisibility" of individual innovators, as compared to the emphasis generally put on innovations themselves, the processes that lead to them, and the companies or universities and innovation systems in which they happen (see Agnete Alsos et al., 2013).

The present chapter contributes to address this shortcoming by providing evidence about the way women contribute to innovative output in G20 economies, as proxied by patents, and the role that women play in the development of open-source software. Both these innovation output types are key for the digital transformation, and shedding light on the role that women play in their development is extremely important to assess the size of the gender gap and inform the design of policies aiming at narrowing it.

Patents and innovation: What role for women?

Patents are intellectual property (IP) rights protecting inventions providing new ways of doing something or offering new technical solutions to problems. They represent a fairly standardised output measure of innovation.[1] Moreover, patent records provide a wide array of information on the invention itself, its development, the technology area(s) the invention contributes to, as well as about the ownership of the invention and who, i.e. the inventors, contributed to its development.

In what follows, women inventors are identified using country-specific gender-name dictionaries applied to the names of the inventors listed in patent documents.[2]

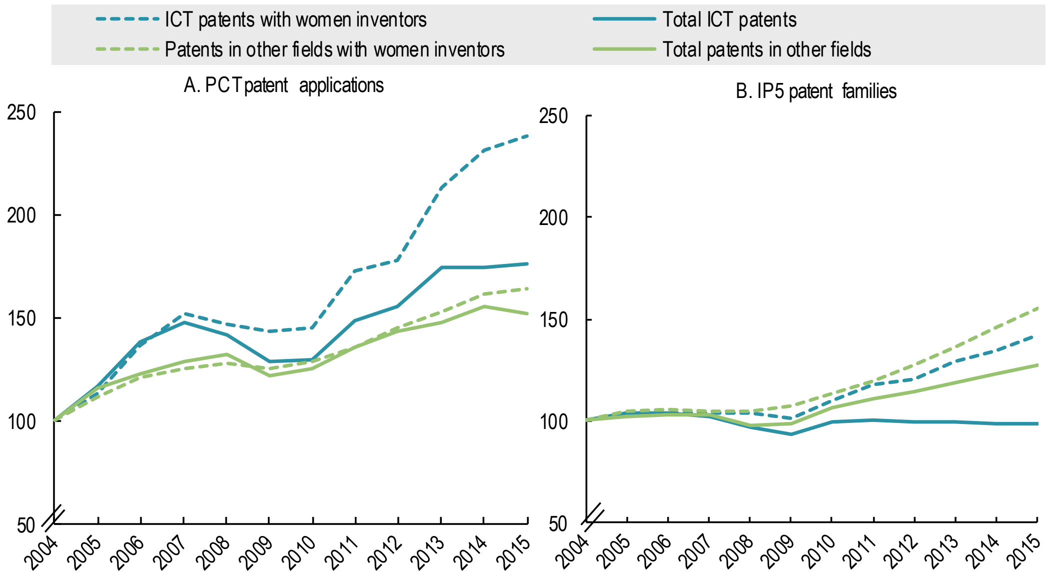
Figure 36 shows the trends of the last decade in terms of number of patent applications filed under the Patent Cooperation Treaty (PCT) as well as the number of patent families[3] within the IP5 (referred to as "IP5 patent families"), invented by G20 residents. Both PCT patents and IP5 patent families capture patents protected internationally, and thus allow for more meaningful comparisons (see Dernis et al. [2015] for further details).

Both PCT and IP5 patent families show an increasing participation of women in inventive activities, as measured by the number of patents featuring at least one woman in the team of inventors. Also the participation of women increased at a faster pace than the average rate at which all patent applications grew during the period 2004-15, as can be seen from the dotted line (mirroring patents featuring one or more women in the team of inventors) being generally above the solid line (displaying the general trend), especially when IP5 families are considered. In an area close to the digital transformation, i.e. the development of ICT inventions, the participation of women increased relatively more than in all other technological domains.

While the PCT makes it easier to file applications in multiple countries and regions, and applicants can apply for protection in over 140 economies through a centralised application process, PCT applications basically represent an intention to patent, with a time limited protection worldwide until the application is extended to different IP offices.[4] Hence, in the remainder of this chapter, the analysis relies on IP5 patent families only, as these patent families represent a more homogenous group of inventions of higher prospect economic value. To belong to an IP5 patent family, patents must have been filed in at least two IP offices worldwide, one of which being among the IP5 offices.

Figure 36. Patents with female inventors, G20 economies

PCT patent applications and IP5 patent families, index (2004 = 100)



Notes: PCT = Patent Cooperation Treaty; IP5 = five largest intellectual property offices; ICT = information and communication technology. Data refer to patents with at least one woman inventor located in G20 economies in the team of inventors listed in the patent documents. Data are based on whole counts. IP5 patent family figures from 2014 are estimates based on existing data.

Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats.

BOX 7. PATENTING ACTIVITY BY WOMEN INVENTORS

Patent data used in the chapter refer to patent applications filed under the PCT and to patent families filed within the IP5, namely the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the United States Patent and Trademark Office (USPTO) and the State Intellectual Property Office of the People's Republic of China (SIPO).

Depending on a number of factors, including the market strategies that companies pursue, innovators may want to protect the very same invention in different countries. This being the case, they need to file a set of related patent applications in each national or regional office where protection is sought: the first patent filing made to protect a given invention worldwide (the so-called "priority" filing) is often followed by (a series of) subsequent and related filings, thus giving birth to a so-called patent "family" (see Martínez [2011] for details).

To avoid counting several times those patents that have been filed at different IP offices with the aim of protecting the very same invention, patent portfolios need to be consolidated on the basis of the families that patents belong to. The definition of IP5 patent families presented in this section relies on families of patent applications with members filed in at least one of the IP5, provided that another family member has been filed in any other office worldwide (see Dernis et al. [2015] for further discussion of IP5 families).

The identification of women inventors is based on a methodology that relies on country-specific gender-name dictionaries applied to inventors' names listed in patent documents (for details, see Martínez, Raffo and Saito [2016]). Owing the difficulties that arise in disentangling the names of inventors by gender, and the limitations of gender-name dictionaries for some Asian countries triggered by transliteration issues, the precision of the gender allocation of inventors varies by country. More than 80% of the inventors' names have been attributed to gender for most G20 economies, except for China and Korea where the recall rate (i.e. the ability of the model to find all the relevant cases within a dataset[1]) is lower. As a consequence, statistics on female inventors in China and in Korea may be biased, and they have therefore not been included in aggregated figures for the G20 area.

Unless otherwise specified, patents are accounted for by filing date, according to the inventors' residence and gender, using fractional counts. Figures for 2014 are incomplete, due to the publication delays that apply to all patents and to patents being filed in several jurisdictions.

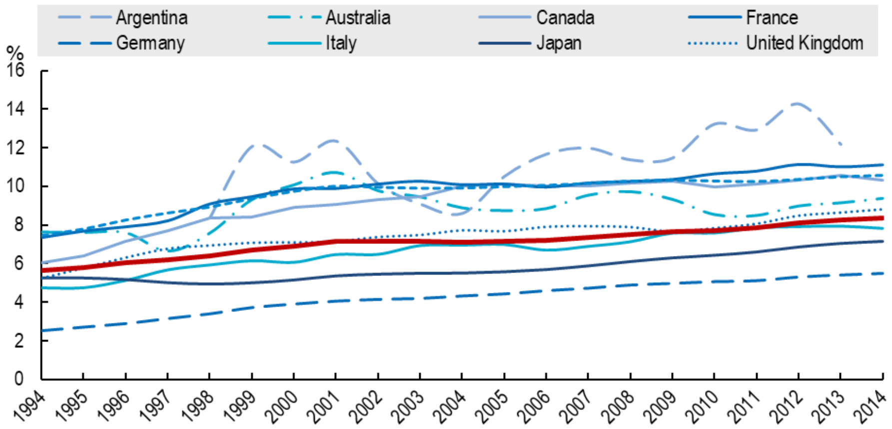
Patents in ICT-related technologies are identified using the list of International Patent Classification (IPC) codes in Inaba and Squicciarini (2017). Patents are allocated to technology fields on the basis of their IPC codes, following the concordance provided by the World Intellectual Property Organization (WIPO, 2013).

1. The precise definition of recall is the number of true positives divided by the number of true positives plus the number of false negatives.

Figure 37 shows the trends observed across two decades in the share of patents featuring at least one woman in the team of inventors. Data relate to a selected group of G20 economies.

Figure 37. Share of patents invented by women, selected G20 economies

As a percentage of total IP5 patent families invented in countries

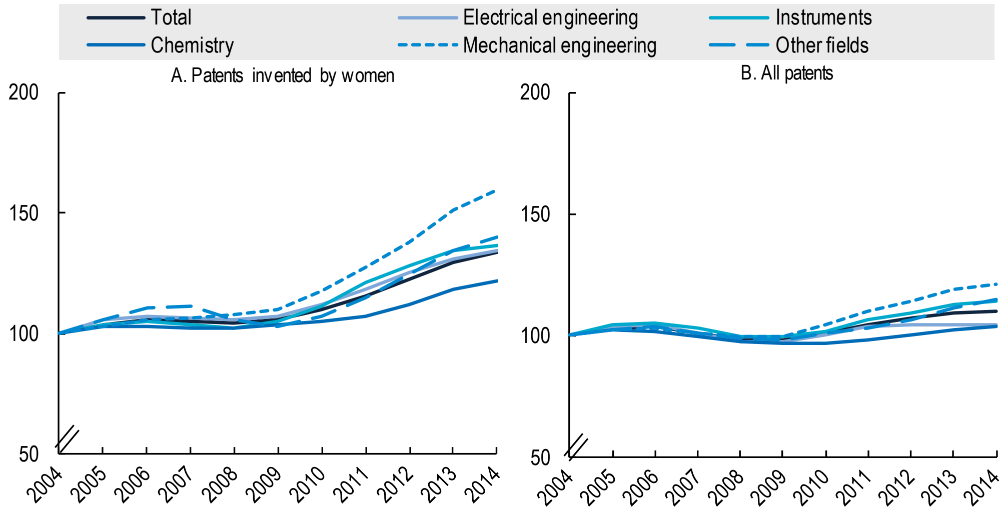


Note: The share of patents invented by women refers to the number of patents with women inventors located in a given country divided by the total number of patents invented in the country.

Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats.

Figure 38. Inventions made by women, by technologies, G20 area

IP5 patents invented by women and total patents, index (2004 = 100)



Notes: Index based on three-years moving averages. IP5 patent family figures for 2014 are estimates based on existing data.

Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats.

As can be seen, during the period considered, the relative share of inventions made by women increased in G20 economies, reaching 8.4% in 2014, compared to a level of 5.6% in 1994. In 2014, more than 10% of inventions originating in Argentina, France, Canada and the United States were due to women. The contribution of women in inventive processes was lowest in Germany (5.5%) and in Japan (7.2%).

The overall trends observed were the result of an increased participation of women in inventive activities across all technology sectors in which inventions can be patented. This can be clearly seen in Figure 38 which further shows that women's presence increased more rapidly in inventions related to "Mechanical engineering" technologies, whereas their contributions to "Chemistry" patenting evolved at a slower pace.

Evidently, overall trends hide country-specific developments, which can be better appreciated by looking at the extent to which women in different countries contributed to the inventive output generated in five main technology area, namely: "Electrical engineering", "Instruments", "Chemistry", "Mechanical engineering", and "Other technologies" (Figure 39). "Electrical engineering" is the technology area that is more closely related and encompasses most developments in digital technologies.

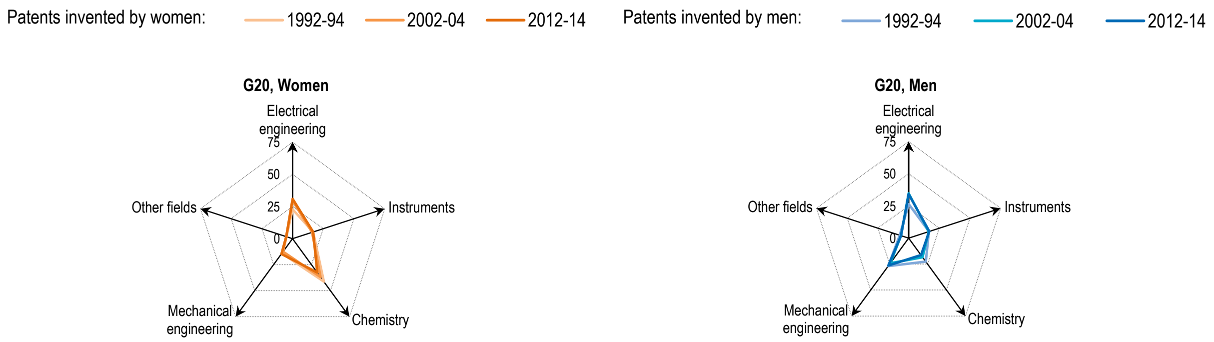
In the G20 area, in the years 1992-94, 2002-04 and 2012-14, female inventors slightly shifted the focus of their inventive activities towards "Electrical engineering" and lowered their contributions in the "Chemistry" field. In 2012-14, 33% of the patent portfolios of female inventors' referred to "Chemistry", compared to 41% in 1992-94, whereas the share of patents in "Electrical engineering" reached 31% in 2012-14, from a level of 23% two decades before.

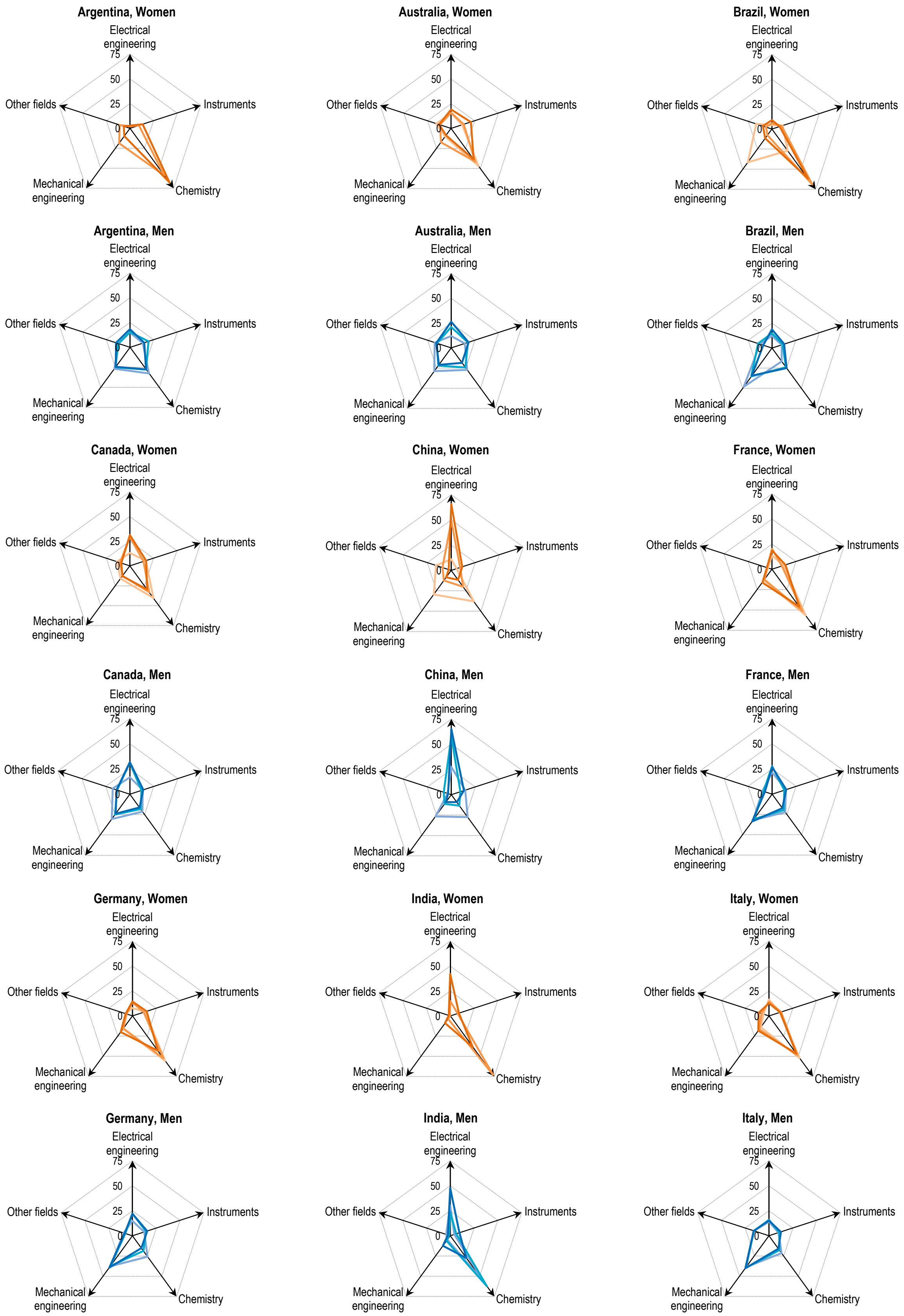
In most G20 economies, "Chemistry" nevertheless remains the technology area where women inventors contribute to the highest extent, on average, during the period 2012-14. The shares of "Chemistry" related patents featuring at least one woman among the inventors are highest in South Africa (69%), Argentina (68%), Brazil (62%), Mexico (52%) and Saudi Arabia (52%). In France, Germany, Italy and the Russian Federation, the proportion of patents in "Chemistry" invented by women ranged between 40% and 50%.

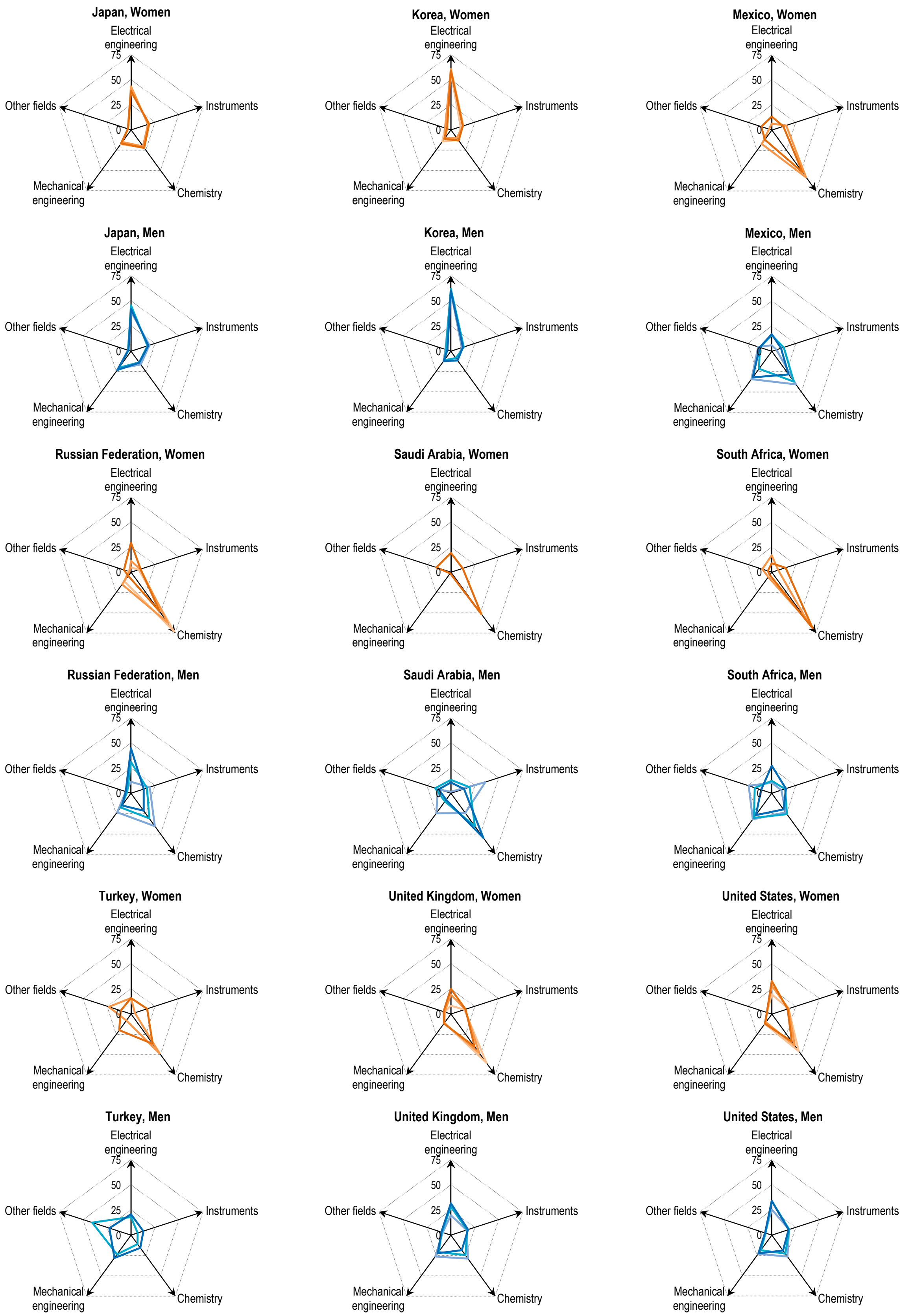
In the G20 area, about 31% of patents invented by women referred to "Electrical engineering", compared to almost 15% in "Mechanical engineering". The proportions are the largest in Asian countries: in China and in Korea, electrical engineering represents respectively 66% and 59% of patents invented by women. In the United States and Canada, about one-third of patents invented by women protect inventions related to electrical engineering. The proportions are at the same level as those observed in patents invented by men located those countries. In South Africa, Brazil and Argentina, this proportion ranges from 9% to 3% of patents filed by women.

Figure 39. Patent portfolio by technologies, by gender, G20 economies, by alphabetical order, 1992-94, 2002-04 and 2012-14

Share of technologies in patents invented by women or by men (%)




Argentina, Women
Electrical engineering
75
50
25
0
Instruments
Chemistry
Mechanical engineering
Other fields
Australia, Women
Brazil, Women
Argentina, Men
Australia, Men
Brazil, Men
Canada, Women
China, Women
France, Women
Canada, Men
China, Men
France, Men
Germany, Women
India, Women
Italy, Women
Germany, Men
India, Men
Italy, Men



Notes: Data are incomplete for China and Korea. Figures are presented for countries with more than ten IP5 patent families filed during the periods considered. Figures for 2014 are incomplete.

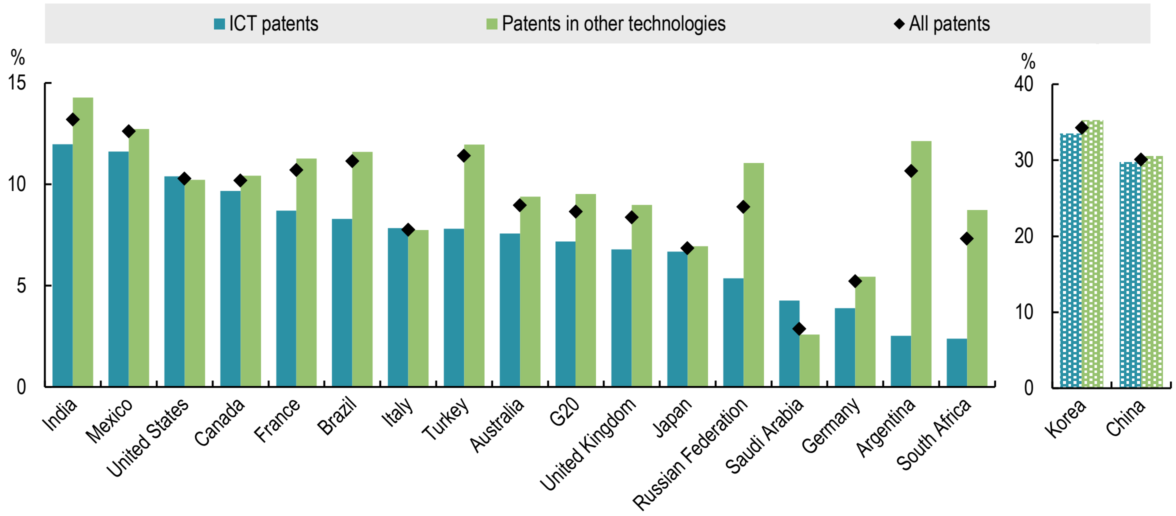
Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats.

In China (66%), Japan (39%) and Korea (59%), the figures exhibit a great specialisation of women in patents related to "Electrical engineering". In India, during the last decade female inventors shifted their contribution from "Chemistry" to "Electrical engineering", with the two technology domains accounting for about 40% each of patents invented by women in the latest years.

Figure 40 presents figures by country of the share of patents invented by women in G20 economies over the period 2010-15, as a percentage of total IP5 patent families invented in these countries. It further highlights the contribution of women inventors to the development of ICTs, as compared to their contribution in all other technological domains.

Figure 40. Patents invented by women, G20 economies, 2010-15

As a percentage of total IP5 patent families invented in countries



Notes: ICT = information and communication technology. The share of patents invented by women refers to the number of patents with women inventors located in a given country divided by the number of patents invented in the country, by technology. Figures from 2014 onwards are based on incomplete data. Only countries with more than 50 IP5 patent families in 2010-15 are included. The indicator is overestimated for China and Korea.

Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

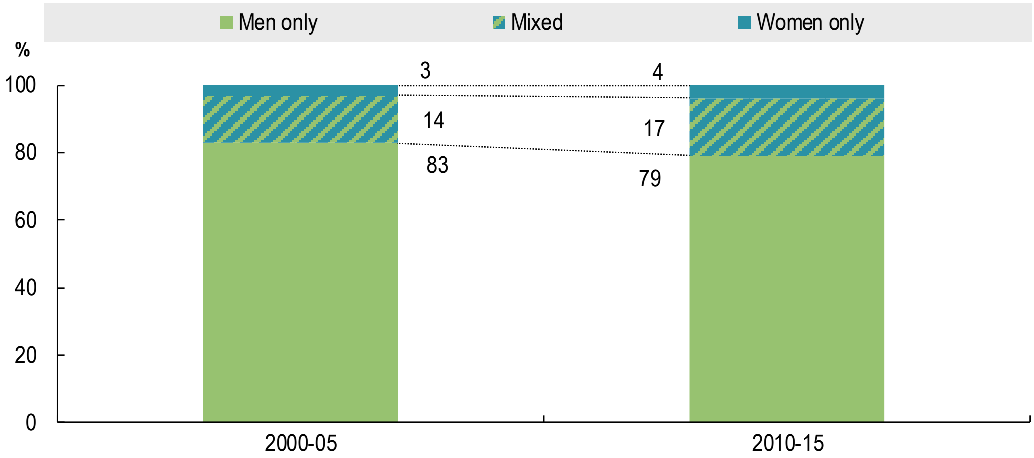
Among G20 economies, in 2010-15, India, Mexico and Turkey reported the highest shares of patents invented by women. High proportions of patents invented by women were also observed in Korea and in China, although the figures cannot be fully compared with those of other countries for the reasons mentioned before. In G20 economies, over the years 2010-15 female inventors appeared generally less active in ICT-related patents compared to other technology domains, except in the United States and Saudi Arabia. These figures need to be considered with care, as countries differ substantially in the overall number of IP5 patent families filed and therefore, in absolute numbers, figures may (and) look different from those emerging when ratios are considered. There are many factors that may contribute to explain the figures at hand, including education and industry-specific characteristics, as well as selection effects determined by e.g. culture, social norms and peer pressure.

Linking the statistics in Figure 40 with those shown in Figure 36 suggests that, while female inventors have been increasing their contribution to the development of ICT inventions, women nevertheless continue to play a relatively less important role in the development of technologies that are key in the digital era, and a relatively less important role of the one they play in other technological domains.

Narrowing the gender gap can be achieved not only by empowering women, but also by facilitating men and women working together, to erase differences and biases. The size of the challenge that lies ahead in this respect can be appreciated by looking at the extent to which women and men collaborate in inventive activities, and by shedding light on how the gender composition of teams of inventors has evolved during the last decade in the G20 area.

Figure 41. Composition of inventors' team by gender, G20 area, 2000-05 and 2010-15

Percentage of IP5 patent families by gender composition of inventors' team



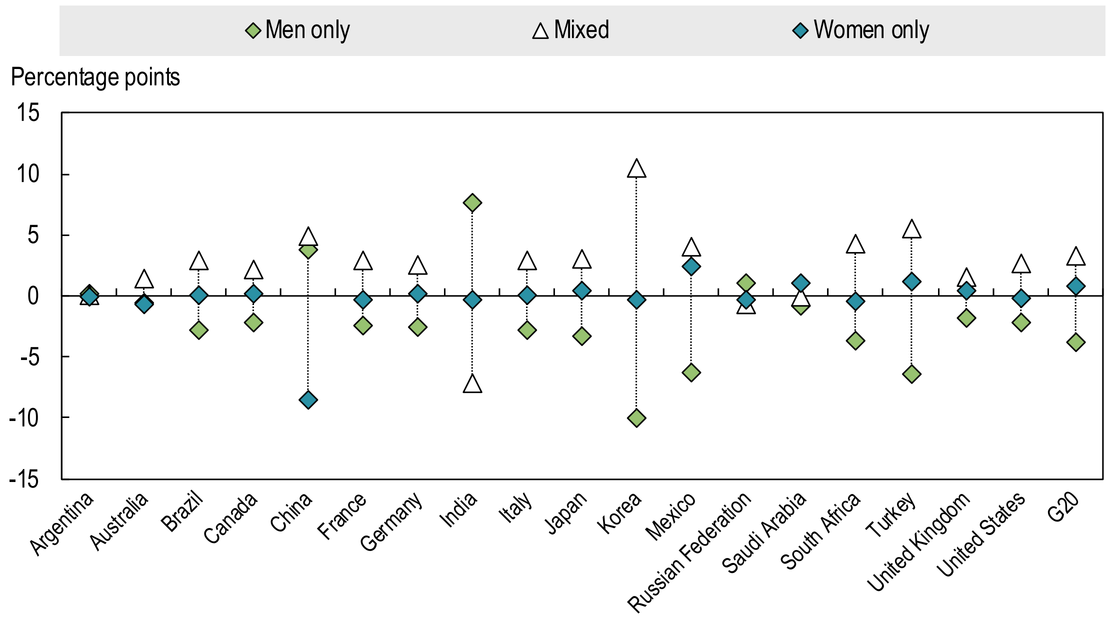
Note: The indicator is based on whole counts of IP5 patent families by inventors' country.

Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

As can be seen in Figure 41, in 2010-15, 17% of IP5 families were invented by mixed teams of men and women, up by three percentage points only from the period 2000-05. The share of inventions made by teams of only women represented nearly 4% of patents in the period 2010-15, compared to 3% observed in 2000-05. If progress towards a greater participation of women in inventive activities continues to be this slow, women may need half a century to become equal partners in inventive activities. If the observed pace were to be maintained, women's participation in patenting activities – either in the form of women-only teams or as part of mixed teams of inventors – would reach about 49% only in 2080.

Figure 42. Evolution of gender balance in inventors' teams between 2000-05 and 2010-15

Differences in the gender composition of inventors' team, IP5 patent families



Notes: The indicator is based on whole counts of IP5 patent families by inventors' country. Data are incomplete for China and Korea. Figures are presented for countries with more than 50 IP5 patent families filed during the periods considered.

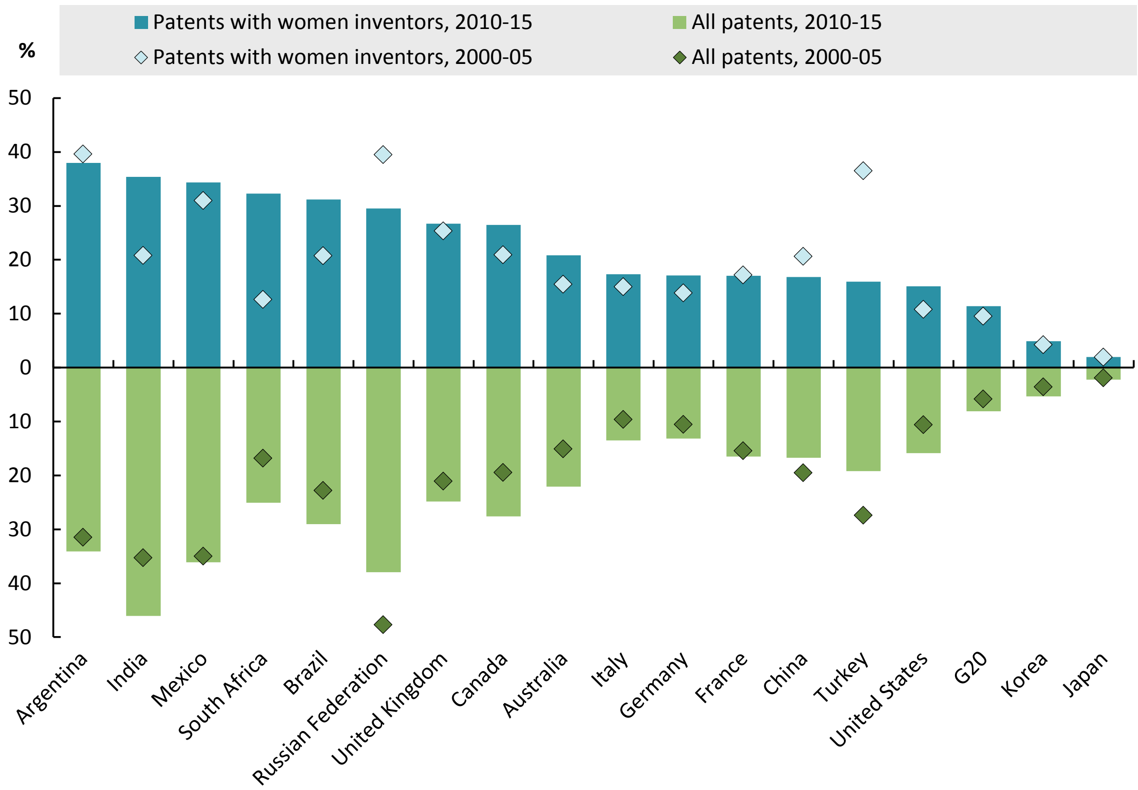
Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats.

The overall figures observed in Figure 42 and the extent to which gender balance increased among teams of inventors resulted out of diverging country-specific patterns (see Figure 43). On the one hand, G20 economies including Korea, Turkey, China and South Africa exhibited notable increases in the proportion of mixed man-women teams of inventors. On the other hand, in most G20 economies the share of women-only inventors' teams remained substantially unchanged, when not decreasing, between the two periods considered. It is nevertheless encouraging to see that on average, in the G20 area, the proportion of both women only and of mixed teams of inventors increased, albeit only slightly so in the case of women-only teams.

Another important tool to be leveraged in the quest to achieve gender equality is having women participate in international teams of inventors, so that they can strengthen their networks, benefit from collaboration and from knowledge spillovers and, more generally, be able to find the best partner(s) for their inventive activities. Evidence based on international co-inventions (Figure 43), measured as the share of inventions that include at least one foreign co-inventor in total patents invented domestically, shows that in 2010-15 on average in G20 economies the level of international co-operation of teams featuring female inventors was higher than the average observed for all patents. International co-inventions, which generally increased across most countries during the periods 2000-05 and 2010-15, saw Argentina, India, Mexico, South Africa and Brazil as the G20 economies featuring the highest share of international co-inventions with female inventors. On the opposite side of the spectrum, Korea and Japan displayed the lowest shares of international co-operation among inventors, and the lowest involvement of women.

Figure 43. International collaboration of women inventors, 2000-05 and 2010-15

International co-inventions as a percentage of IP5 patent families

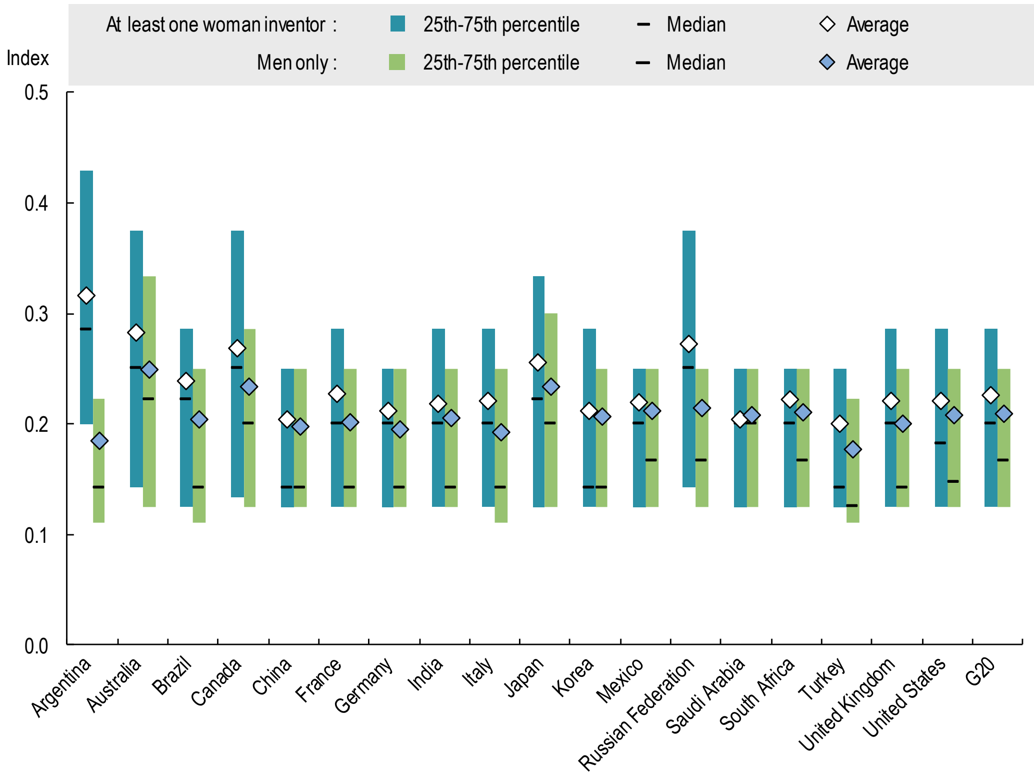


Notes: Patents with women inventors refer to patents with at least one woman inventor located in the country. As names of inventors from Asian economies are difficult to disentangle by gender, data are incomplete for China and Korea. Data are based on whole counts.

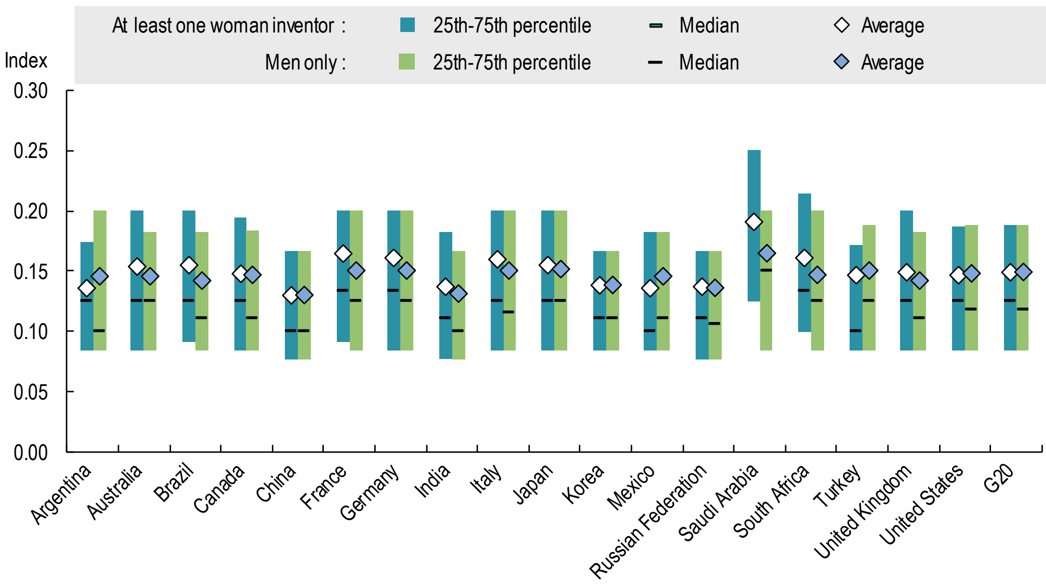
Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats.

Figure 44. Average normalised patent scope, by gender composition of the team, 2012-14

A. EPO patents within IP5 patent families



B. USPTO patents within IP5 patent families



Notes: Average normalised patent scope index by inventor's location. Figures are presented for countries with more than 20 patents by gender type filed in the offices considered.

Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats.

Finally, when it comes to inventive activities, it is important not only to look at their quantity, but also at their "quality", i.e. the technological and economic value of patented inventions, and the possible impact that these might have on subsequent technological developments.[5] It has been long argued that the quality of patented inventions varies widely from patent to patent and that the likelihood to patent inventions of a given quality varies at firm and industry levels. Hence, in order to understand the role played by women in inventive activities it is important to look at whether the inventions they (contribute to) generate are of higher or lower value of those generated by their male counterparts.

Panel A in Figure 44 uses EPO data and shows that when it comes to the scope of patents, i.e. the technological breadth of inventions as proxied by the number of IPC technology classes[6] inventions are allocated to, inventions featuring at least one women in the team are on average of wider scope (and hence more valuable) than those conceived by men-only teams. Also, by comparing average values with median values (i.e. those values dividing the top 50% from the bottom 50% of patents, in terms of value), it can easily be seen that, in general, the top 50% of patents featuring at least one female inventors are of greater although more dispersed value that those arising out of men-only inventors' teams. The bottom panel of Figure 44 further shows the extent to which the inventions generated by teams composed of at least one woman and men-only teams differ in their scope for patent families having been filed at the USPTO.

While generally higher average values are exhibited by inventions generated by teams including at least one woman, differences between men and women-related patents do not appear as stark as those observed in the case of patent scope at EPO, with the exception of Saudi Arabia. Also, Mexico, Argentina and Turkey are the only G20 economies where men-only inventive teams seemingly outperform, on average, mixed or female-only teams, although slightly so.

Overall, the results of the analysis based on patent data call for a greater inclusion of women in inventive activities, not only for the sake of women themselves, but also for stronger overall economic growth and enhanced societal well-being. Inventions arising out of mixed teams or of women-only groups appear to generally be more economically valuable and higher impact from a technological viewpoint than those seeing the involvement of men only.

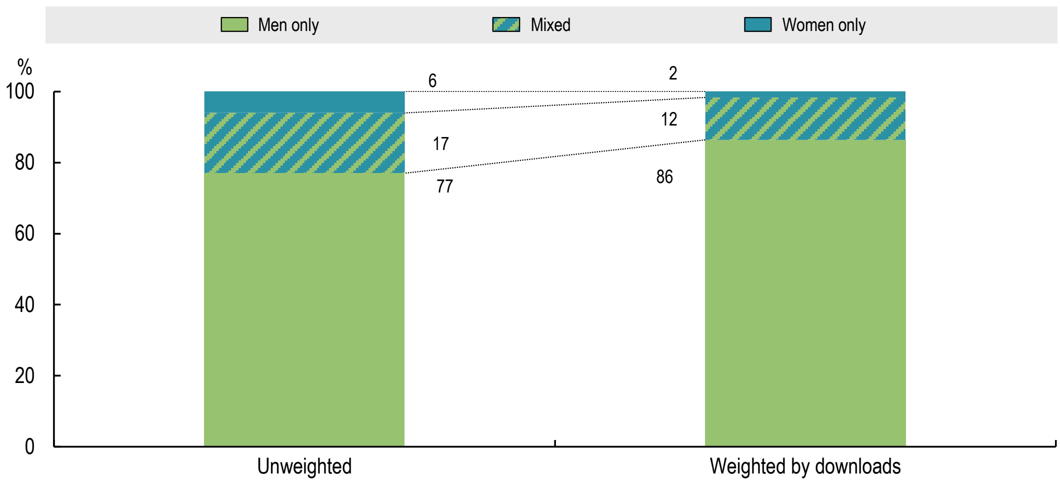
Software: Still mainly about (male) geeks?

As innovation goes increasingly digital, software use and creation become key assets for the digital transformation.

Experimental indicators using information about a popular open-source programming language for data analysis, R, shows that about three-quarters (i.e. 77%) of the 12 000 R-based software packages created during the period 2012-17 were produced by teams composed of only men. Women-only teams accounted for a mere 6% of such packages, whereas the remaining 17% came out of mixed teams of software developers (Figure 45).

Figure 45. Gender composition of teams producing R-based software packages

Number of packages and downloads, October 2012 – December 2017

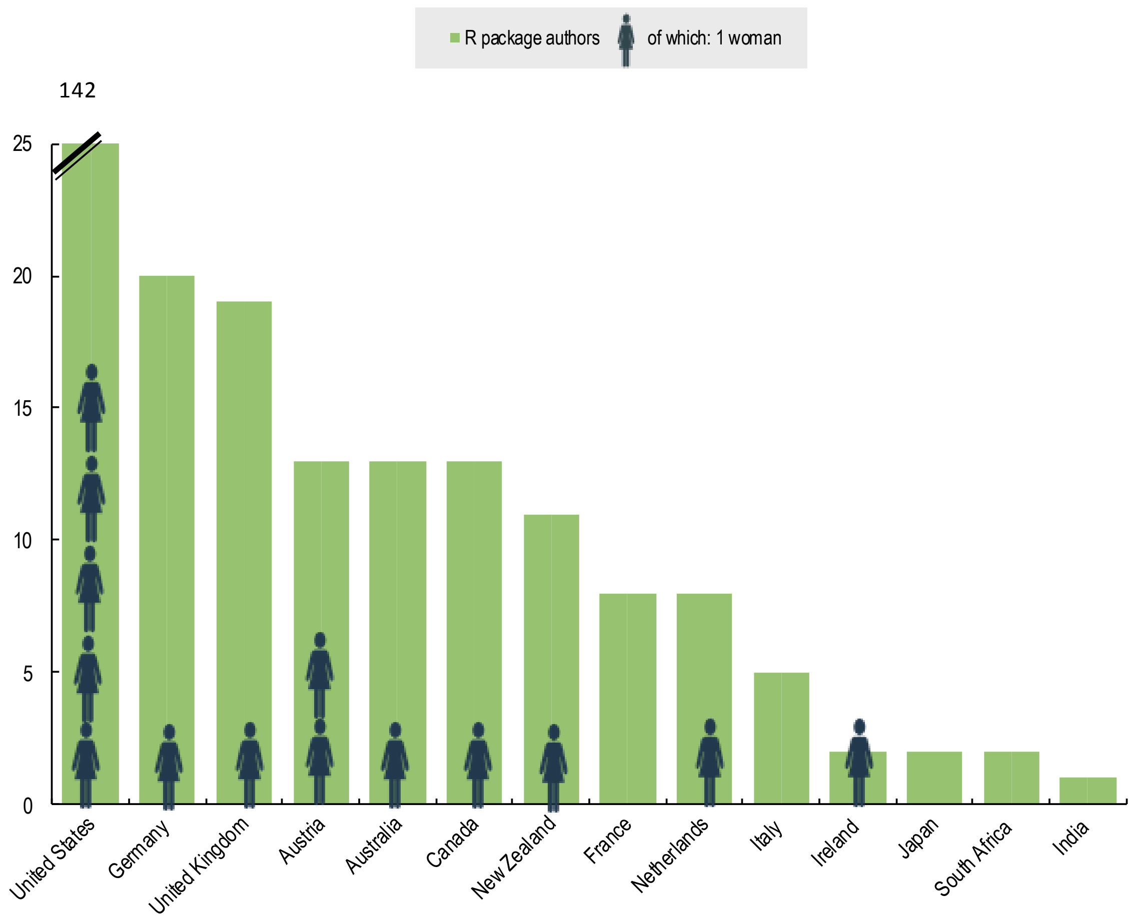


Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

A look at the downloads of these R-based software packages, which can be taken as a sign of the use of such software, unveils the marginal role of women in the software world: the vast majority of (86%) of download-weighted packages were authored by men-only teams against a tiny 2% of packages authored by teams solely made of women.

Figure 46. R package authors

Data related to top 300 package authors



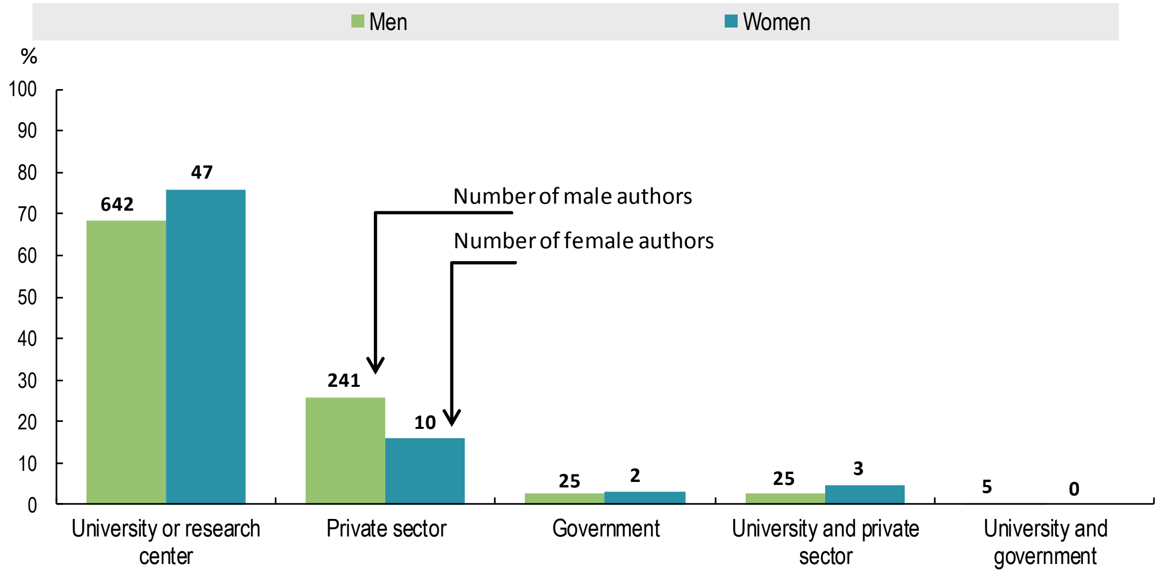
Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

Looking at the location of top R-based software package authors shows that in many countries software is a male-only affair (Figure 46). Given the growing importance of “big data” analytics to the digital economy, its role in machine learning-related developments and, consequently, in artificial intelligence, this gap is of concern both in terms of engagement of women as well as potential unintended biases that may be embedded in various applications due to a lack of diversity.

Considering the professional affiliation of the top 1 000 R package authors (weighted by package downloads, to account for their usefulness and/or importance), around 70% of male and 75% of female authors are found to be affiliated only to a university or public research centre, while 25% of male and 15% of female authors are affiliated to a private sector organisation. Meanwhile, fewer than 5% of authors of either gender are affiliated to a government organisation, or are jointly affiliated to a mix of these three categories. Figure 48 clearly highlights the importance of the universities and research centres in the development of core statistical tools, and the relative under-representation of women, particularly among top private sector coding teams.

Figure 47. Professional affiliation of R package authors as a share of total

Data related to top 1 000 package authors



Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, based on data extracted from The Comprehensive R Archive Network (CRAN), https://cran.r-project.org/ (last accessed January 2018).

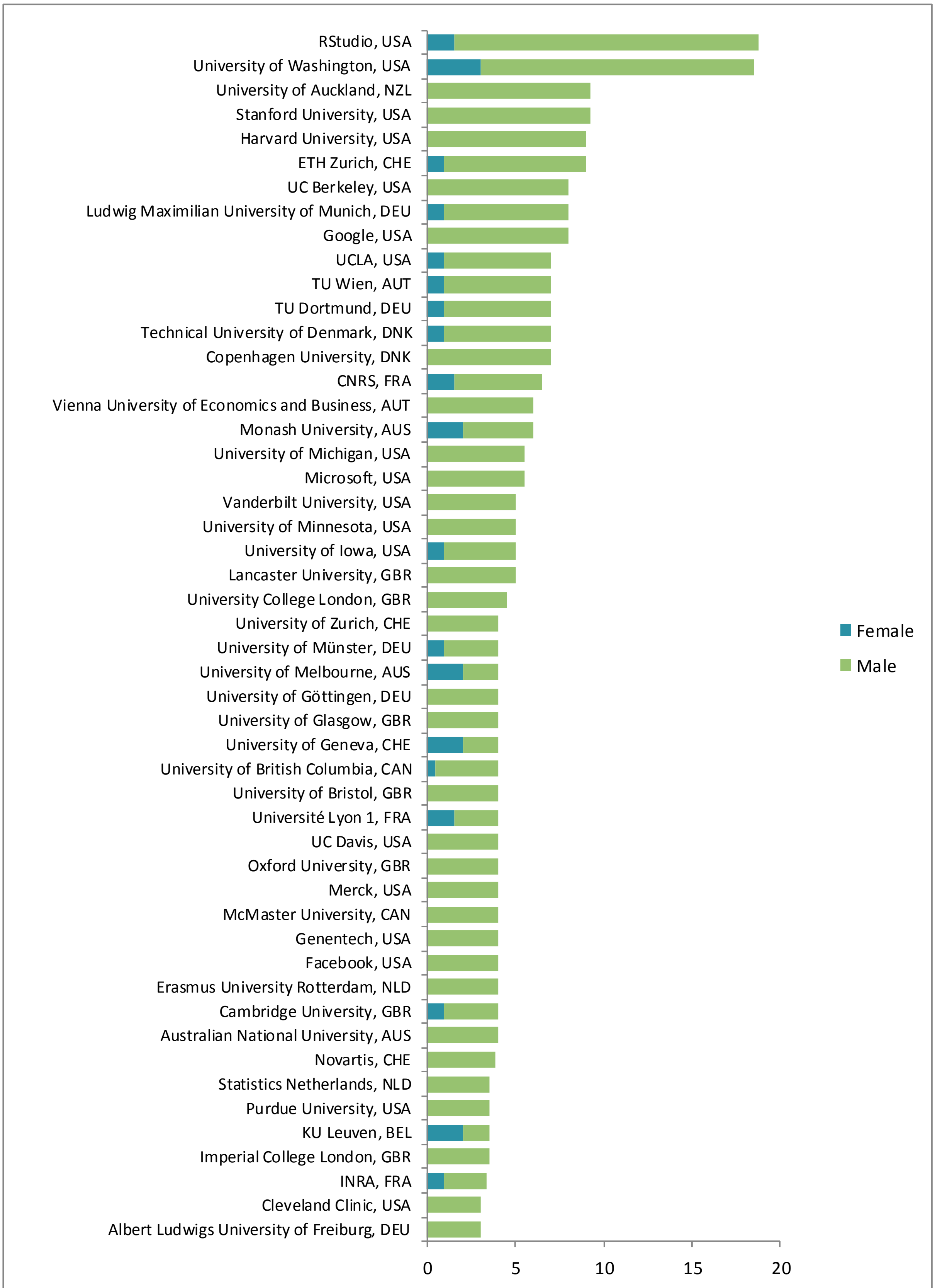
A glance at the top private and public institutions by number of R package authors (within the sample of the top 1 000 most downloaded R package authors) confirms that women are few and far between. Within the top 50 institutions, public sector institutions appear again as those with the highest number of top R package authors (although several top tech and pharmaceutical companies show up, such as Google, Facebook, Merck and Novartis). These institutions are located in large part in the United States, Germany, Switzerland, Austria and the United Kingdom.

Finally, Figure 49 displays the co-authorship network[7] emerging among the top 1 000 most downloaded R package authors. Each point represents an author, and the thickness of the links mirror the number of packages co-authored between each pair of authors (i.e. the thicker the line, the more frequent the collaboration between the authors involved). The network clearly shows that female authors (in orange) are relatively few, and are poorly represented within the core network of package co-authorship. This entails that they play a relatively less important role in the software world and many of them (displayed in the periphery of the graph) are less connected than their male colleagues.

The lack of diversity, including gender diversity, in the world of open-source software, has been recognised already by many in the community of R users and efforts have been made to change the existing gender imbalance. For instance, RLadies[8] was created in 2012 with the aim of achieving "proportionate representation by encouraging, inspiring, and empowering people of genders currently under-represented in the R community". In 2015, the R Foundation also set up a taskforce[9] on women and other under-represented groups to help address the diversity issue. There seems to be awareness in the R community about the need to address the existing gender imbalances, although other language seems to suffer from even greater under-representation of women.[10]

Figure 48. Top 50 institutions by number of R package authors, by gender

Data related to top 1 000 package authors



Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, based on data extracted from The Comprehensive R Archive Network (CRAN), https://cran.r-project.org/ (last accessed January 2018).

The findings in this analysis are in line with those presented in the EQUALS' research group inaugural report,[11] which includes an analysis focusing on online communities for developers to learn, share their programming, and build better software as well as careers such as GitHub, Stack Overflow and HackerRank. The survey points to two key findings: first, there are significantly fewer women involved in software developing. For example, of approximately 100 000 software developers using Stack Overflow, only 4% are female; of GitHub's 5 500 surveyed users only 2% are female; and on HackerRank, the gender gap in software development is approximately 16% with only 25 000 respondents being female. Further, the survey datasets indicate that women on all three software developer platforms are relatively more passive users than men. Women on Stack Overflow were not only less likely to have a registered account; they were more likely to use the site more passively, viewing questions and answers on the site without responding or posting questions themselves. Also on GitHub, women were found to be more "following" other developers' repositories instead of contributing code.

Figure 49. Co-authorship network graph of top R package authors, by gender

Data related to top 1 000 package authors

Source: OECD (2018e), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats, based on data extracted from The Comprehensive R Archive Network (CRAN), https://cran.r-project.org/ (last accessed January 2018).

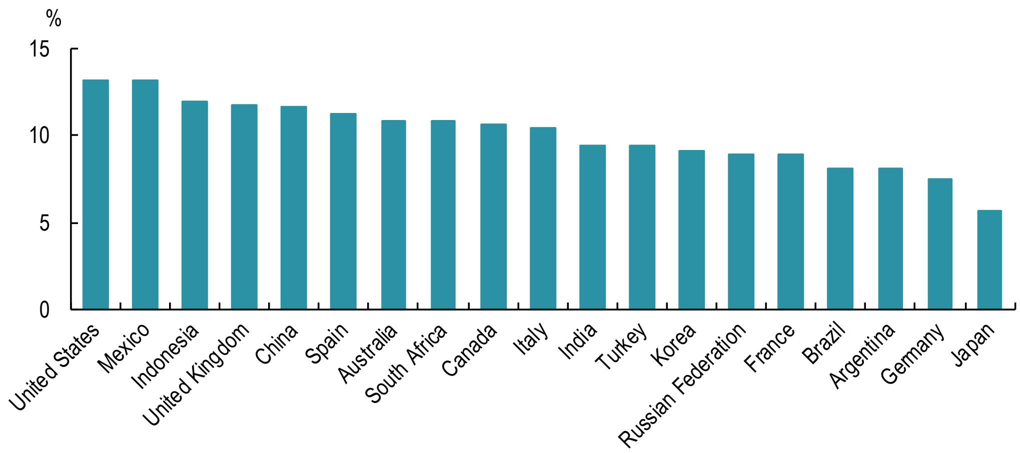
Innovative entrepreneurship is essential for economies

Despite the role of entrepreneurship as an engine of social inclusion, the gender gap in entrepreneurship is striking and persistent, with men being nearly twice as likely as women to be self-employed (OECD and European Union, 2017), and three times more likely than women to own a business with employees across OECD countries (Piacentini, 2013).

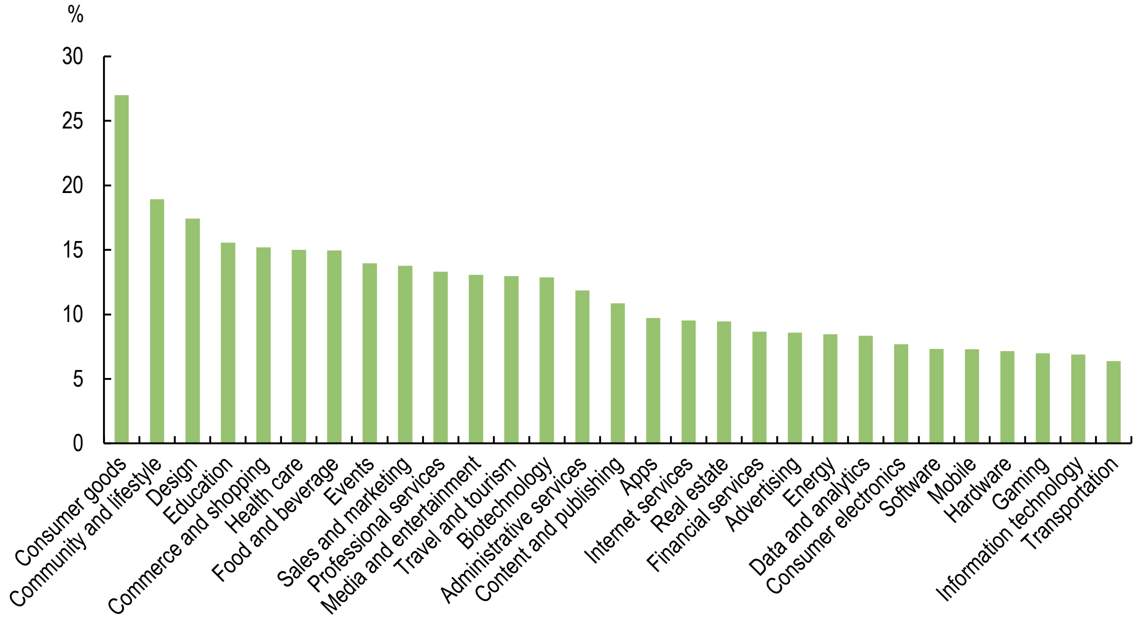
Women entrepreneurs also appear to be missing out on the opportunities created by globalisation and digitalisation – women-operated businesses are less likely to export, and less likely to engage in international business-to-business transactions (OECD, 2017k). Perceptions, once again, may be playing an important role: only 37% of women in OECD countries *believe* that they have the skills to start a business, compared to 51% of men. Moreover, new female entrepreneurs are only half as likely as men *to expect* to create at least 19 jobs over the next five years (OECD and European Union, 2017).

Figure 50. Share of females among start-up founders

A. By economy



B. By sector



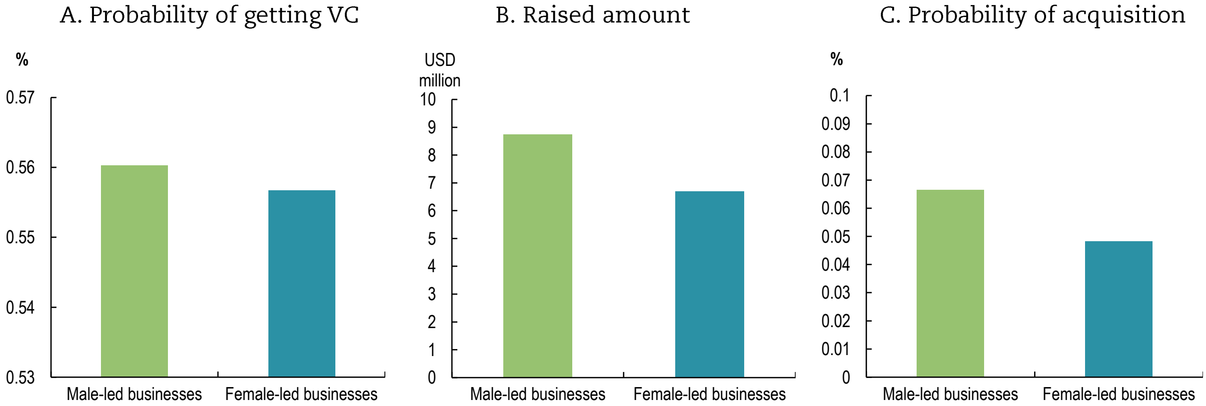
Note: Percentage of females in the sample of founders of companies less than ten years old and for whom gender is known.

Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

Among innovative start-ups looking for VC investments, the gender gap is even more striking: only 11% of such start-up founders are female. This share varies substantially across countries and sectors; however, even at best, female entrepreneurs represent less than a third of all start-up founders (Figure 50). Unleashing the full potential of female entrepreneurial talents is needed to make women strive.

Not all start-up founders look for investors in the VC market to help get their businesses off the ground, but those who do, know how difficult the pitching process can be. Recent OECD analysis based on Crunchbase data[12] finds that raising capital is even more difficult for female-owned firms (Breschi, Lassébie and Menon, 2018): in a sample of 25 000 start-ups operating across a wide set of countries and sectors, female-led business ventures, i.e. start-ups with at least one female founder, are significantly less likely to be funded. Even if they are funded, they receive on average 23% less funding than male-led start-ups, even after controlling for the location and the nature of the start-up, as well as for the education level and professional background of start-up founders (Figure 51). Female-led start-ups are also 30% less likely to have a positive exit, i.e. be acquired or to issue an initial public offering. This is consistent with well-known anecdotes reporting "a particularly toxic atmosphere for women in Silicon Valley" (Burleigh, 2015) (and in other start-up hot-spots).

Figure 51. The gender gap in start-up funding and acquisition



Notes: The graphs show results from OLS regressions of the three outcomes variables on a set of founders and firms characteristics, and country and sector fixed effects. Bars show the average predicted probability of receiving VC, the amount of funding conditional on getting VC and the probability of acquisition for male- and female-led businesses. The advantage of this way of representing the data is that it gets rid of potential confounding effects such as education or prior experience of start-up founders.

Source: OECD (2018d), *Empowering Women in the Digital Age: Where Do We Stand?*, www.oecd.org/going-digital/empowering-women-in-the-digital-age-brochure.pdf.

Several factors may contribute to explain the gender gap in entrepreneurship and determine the gap in start-ups activity and VC investment (Johnstone et al., forthcoming). Among them:

- It may be yet another reflection of the widespread gender gap in STEM studies, which are particularly relevant for acquiring the skills needed to thrive in the innovative entrepreneurship world.[13]
- Differences in attitudes towards risk may also play a role, as women are generally more risk averse than men with regard to financial decisions (Croson and Gneezy, 2009) and less likely to try to start a new venture after a failure.
- Gender differences in network formation and in social network ties to secure VC funding (Stephan and El-Ganainy, 2007) can be playing a significant role. In a similar vein, "homophily" may be influencing equity financing, with investors – who are disproportionately male – more likely to finance other men.

The glass looks half empty if one considers that the share of women acquiring the position of "partner" in VC firms has been increasing in recent years at an extremely slow pace (Crunchbase News, 2017), with the number of female partners at the top one hundred venture firms going up only by 1% in 18 months (i.e. 64 women out of 752 partners at the top 100 VC firms). The same glass may look half full, though, if one considers that even a small increase in female representation in venture firm partnership could translate to a more favourable VC market for female-led start-ups. Evidence show that VC firms with a female partner are more than twice as likely to invest in a company with a woman on the management team (34% vs. 13%); and they are three times as likely to invest in female CEOs (58% vs. 15%) (Diana Project, 2014).

Boosting the presence of women on the supply side of financial markets is surely a step in the right direction. While many G20 economies are increasing support to female entrepreneurs, more needs to be done. Women entrepreneurs have enormous potential for making greater contributions to economic growth, job creation, innovation and social inclusion: some recent estimates suggest that if the entrepreneurship gender gap were eliminated, global GDP could rise by as much as 2% annually (Blomquist et al., 2014).

Conclusions

The participation of women in inventive activities, as measured by the number of patents featuring at least one woman in the team of inventors, increased in the years after 2000, and did so at a faster pace than the average rate at which all patent applications grew during the same period, especially in the case of ICT inventions. Despite this, women continue to play a less important role in the development of technologies that are key in the digital era (across G20 economies, only slightly more than 7% of ICT patents are generated by women), and a relatively less important role of the one they play in other technological domains (about 10%, on average, across G20 economies in 2010-15).

The pace at which this increased participation of women in inventive activities is happening also remains very low. This hurts not only women but society as a whole, as evidence suggest that inventions featuring at least one female inventor in the team are on average of wider scope, and therefore more valuable, than those conceived by teams of only men. Similar patterns, although more nuanced, can be observed when international patent families are considered, with inventions featuring at least one woman that are generally more economically valuable, i.e. they belong to greater international families, than those invented by teams of men only.

Also, experimental indicators using information about a popular open-source programming language for data analysis further show that in many countries also software is a male-dominated area. This is worrisome given the growing importance of “big data” analytics in the digital economy. This gap is of concern both in terms of engagement of women as well as potential unintended biases that may be embedded due to a lack of diversity. Women are particular under-represented in private sector’s top coding teams.

Last but not least, the analysis finds a gap in entrepreneurship and in start-ups and VC investment which points to the existence of socio-cultural gender bias. The gender gap in entrepreneurship is striking and persistent, with men that are nearly twice as likely as women to be self-employed; they are three times more likely than women to own a business with employees across OECD countries; and 90% of innovative start-ups seeking VC investments have been founded by men. Women-owned start-ups receive 23% less funding and are 30% less likely to have a positive exit – i.e. be acquired or to issue an initial public offering – compared to men-owned businesses. Nevertheless, progress appears possible, given that VC firms with at least one female partner are more than twice as likely to invest in a company with a woman in the management team, and three times as likely to invest in female CEOs.

Notes

1. See Griliches (1990) and Nagaoka, Motohashi and Goto (2010) for a discussion.
2. The methodology applied here builds on and refines the one proposed by Martínez, Raffo and Saito (2016).
3. Patent families protect inventions in different countries. Given the territorial nature of patents, a patent application needs to be filed in each one of the patent offices where protection is sought. As a result, the first patent filing made to protect the invention (the priority filing) is followed by a series of subsequent filings and together they form a patent family. See Box 4 for further detail.
4. See OECD (2009) for a thorough description of the PCT system.
5. See Squicciarini, Dernis and Criscuolo (2013) for details.
6. The IPC, established by the Strasbourg Agreement 1971, provides for a classification of patents according to the different areas of technology to which they pertain. A new version of the IPC enters into force each year on 1 January. See www.wipo.int/classifications/ipc/en/ for more details.
7. The figure represents the largest subgraph of the network. Isolated nodes as well as very small subgraphs are excluded to improve readability.
8. See https://rladies.org/.
9. See http://forwards.github.io/.
10. See http://blog.revolutionanalytics.com/2016/06/programmers-gender.html.
11. See http://cs.unu.edu/research/equals-inaugural-report/.
12. OECD analysis based on data from www.crunchbase.com.
13. For instance, in the United States women account for nearly half of employed college graduates age 25 and over, but for only about 25% of employed STEM degree holders and an even smaller share – just about 20% – of STEM degree holders working in STEM jobs. The situation in other OECD countries is very similar (OECD, 2015a). See www.scwist.ca/programs-and-events/make-possible/.

Chapter 5

LEARNING FROM EXPERIENCE: SHARING NATIONAL PRACTICES TO BRIDGE THE GENDER DIGITAL DIVIDE

This chapter provides results from the voluntary stocktaking of national practices on bridging the digital gender divide that G20 economies have undertaken as a follow-up to the 2017 G20 *Digital Roadmap for Digitalisation: Policies for a Digital Future*, and integrates information from a wide range of sources including the ITU's EQUALS Gender Digital Inclusion Map, the G20 German Presidency's #eSkills4girls initiative and information from G20 economies. The analysis provides an overview of ongoing digitally enabled policy initiatives to reduce the gender gap, highlights good practices and provides policy directions for consideration by G20 members. The discussion seeks to identify effective policies in place to address the root causes of the digital gender divide and barriers to women's participation in the digital economy.

Mapping gender-related policies

Acknowledging both the opportunities that digitalisation is providing for economic empowerment, and the challenges of ensuring that the benefits of the digital transformation are shared by all, G20 Ministers responsible for the Digital Economy in their 2017 G20 "Digital Economy Declaration: Shaping Digitalization for an Interconnected World" recognised the importance of bridging the digital gender divide. Specifically, they noted that:

> Half the population of the planet is women yet 250 million fewer women than men are online today. Taking this into consideration, we intend to promote action to help bridge the digital gender divide and help support the equitable participation of women and girls in the digital economy.

The Ministerial Declaration included a *Roadmap for Digitalisation: Policies for a Digital Future* ("the Roadmap"), which committed the G20 to enable all people to adapt and excel in the digital economy and society. Ministers recognised that women face skills, participation and leadership gaps which prevent them from fully participating in the digital economy. To support the equitable participation of women in the digital economy, G20 Ministers responsible for the digital economy declared their intent to share national practices; consider taking action across a range of key policy areas, subject to national circumstances; support initiatives to develop digital financial services that are accessible and appropriate for women; encourage the review of existing digital strategies to ensure they incorporate a gender perspective, increase female participation in STEM education and employment and explore opportunities for developing metrics that capture gender-disaggregated data.

BOX 8. THE EQUALS AND #ESKILLS4GIRLS INITIATIVES

EQUALS is an initiative implemented by ITU, UN Women, GSMA, the International Trade Centre (ITC) and UNU. EQUALS is a broad coalition of programmes with a single mission: to bridge the gender digital divide. The Partnership brings together stakeholders from civil society, the private sector, government, international organisations, and academia to focus efforts through multiple areas of action: access, skills, leadership and research. The Gender Digital Inclusion Map, also referred to as "Action Map" is an interactive and continually updated visualisation tool which can be consulted to discover initiatives that are working towards bridging the gender digital divide around the world. The aim has been to identify key organisations working in this domain, and to understand what constitutes best practice among such projects and to share this knowledge publicly (ITU, 2018a). EQUALS is committed to helping bridge the digital gender skills divide. The purpose is to show what education policies can do to help close skills divides between women and men, building on work done by other groups and coalitions, notably the Broadband Commission, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and ITU.

#eSkills4Girls is an initiative launched under the German G20 presidency with the aim to tackle the existing gender digital divide, in particular in low-income and developing countries. The specific objectives are to globally increase women's and girls' access to and participation in the digital world and to boost relevant education and employment opportunities in emerging and developing countries. This platform is a joint project supported by G20 members and backed by a consortium of leading international organisations including UNESCO, UN Women, ITU and the OECD. The platform aims to collect and disseminate information and knowledge on the issue, to showcase current initiatives as well as good practices and policy recommendations to different stakeholders that are playing an essential part in helping to get more women online and into IT professions. It does not aim to duplicate any existing efforts but rather helps at aligning and linking existing initiatives and stakeholders with each other (eSkills4girls, 2018).

In an effort to better understand the role that policy can play, the German G20 Presidency invited G20 economies, along with partner countries, to respond to a survey collecting information on policies targeted at helping disadvantaged groups, including women and girls. Responses were submitted by Argentina, Australia, Canada, European Union, France, Germany, Italy, Japan, Korea, Mexico, Russia, South Africa, United Kingdom and the Netherlands. In addition to the survey, an inventory of programmes that address the digital gender divide was circulated for countries to update and extend. The inventory built on the ITU's EQUALS Gender Digital Inclusion Map (ITU, 2018a) and the G20 German Presidency's #eSkills4girls initiative (eSkills4girls, 2018) (Box 8).

The momentum from this initiative has been strengthened under the Argentinian G20 Presidency in 2018, with gender established as a cross-cutting priority across the agenda and an exercise to collect high-impact policy examples being undertaken by the Digital Economy Task Force.

G20 economies: Gender-related programmes, initiatives and regulations

The inventory of programmes and initiatives supporting efforts to bridge the digital gender divide that was sent to the G20, along with the survey that builds on the ITU's EQUALS Gender Digital Inclusion Map (ITU, 2018a) and the G20 German Presidency's #eSkills4Girls initiative (eSkills4girls,2018), includes 355 programmes from across the G20 and beyond. The types of programmes and initiatives most commonly used by governments are awareness raising, advocacy, mentorship, training, capacity or community building, scholarships, and networking. In parallel to this exercise, the German G20 Presidency collected national examples of what countries were doing to implement the Roadmap.

Almost half of the initiatives (48%) are found in both EQUALS and #eSkills4Girls mapping exercises. The survey succeeded in capturing about 51 new programmes in G20 economies (i.e. 14%), including Argentina's Ellas Hacen ("They Do") programme, which aims to increase digital literacy among unemployed women, and Australia's Safe Technology for Women ("Women's Safety Package"), which distributes smart phones to women experiencing domestic violence. The rest of the inventory was drawn for about 21% from #eSkills4Girls, and about 8% from EQUALS and the rest from other sources.

At the highest level, strategies for addressing the digital gender divide can provide direction and momentum for change. The UN Broadband Commission has previously analysed references to gender in selected national broadband strategies, finding that only 29% of the plans analysed included relevant references to gender in the categories ICT skills, equal access to ICTs, female empowerment through broadband, and women's role in decision making through ICT use (Broadband Commission, 2013). This propelled the Broadband Commission Working Group recommendation to "Integrate a gender perspective in strategies, policies, plans and budgets", to help ensure that an explicit focus on gender equality is integrated effectively, and that these policies and strategies meet women's needs, circumstances, capabilities and preferences (Broadband Commission, 2017a).

More than half of the countries who responded to the survey indicated they have national strategies, policies or plans in place aimed to reduce the digital divide, which mostly targeted women and girls. Mexico also included actions specifically targeting international migrant women. While Canada did not include women and girls as a target group, they did include immigrants and refugees, which include women. Several countries, such as Italy and Russia, had initiatives that targeted all citizens equally.

Just under half of the respondents indicated that they had regional, state or provincial strategies, policies or plans that include efforts to reduce the digital divide which, once again, was most often targeted at women and girls. The most commonly cited forms of support were: web portals or apps that provide online resources, public information and awareness-raising campaigns, mentoring programmes, technology camps and online courses or training. Only slightly less popular were competitions (e.g. hackathons), although their use increased in initiatives targeted at girls – for example Australia's "Programming Challenge for Girls" in Adelaide.

The majority of the programmes, 60%, have been implemented in at least one G20 economies and almost one-third of the initiatives are not country-specific. Examples are Women in Global Science and Technology, which aims to influence policy at national, regional and international levels by promoting information, knowledge, science and technology strategies enabling women, especially those living in developing countries, to actively participate in knowledge and technology for development; or the Girls in Tech organisation, which is a global non-profit organisation whose aim is to engage, educate and empower girls and women who are passionate about technology. Many countries are actively encouraging women's participation in STEM (Box 9), complemented by a number of company specific efforts aimed at promoting gender diversity, encouraging women in STEM, as well as nurturing and retaining female talent. Companies actively engaged in such activities include large multinationals such as eBay, Cisco, Microsoft, Nokia and Fujitsu.

BOX 9. PROGRAMMES AIMED TO INCREASE WOMEN'S PARTICIPATION IN STEM

A number of countries have put in place measures aimed to engage women and girls in STEM across education systems:

- In 2018-19, the **Australian** government committed USD 4.5 million over four years to support long-term strategic approaches to encourage more women and girls to pursue STEM education and careers. This builds on the initial USD 13 million invested under the National Innovation and Science Agenda to support initiatives focused on women's participation in STEM. Furthermore, in Australia, the Inspiring all Australians in Digital Literacy and STEM measure of the National Innovation and Science Agenda has initiatives focused on increasing the engagement of under-represented groups, including girls. These initiatives are contributing to ongoing efforts across the Australian Government to increase women and girls' participation in STEM, and to bridge the digital gender divide.
- The Meninas Digitais programme of **Brazil** aims to promote the uptake of technology and STEM subjects by means of motivating female high school students, so that they get to know the field and develop their skills. They have the opportunity to attend short courses in many areas of computing.
- Mind the Gap is a **European Union** funded project, carried out by a consortium of partners from the **United Kingdom, Spain** and the **Netherlands**. This project brings together vocational education and training (VET) teachers and individuals working in gender, diversity and STEM-related subjects to address a clear problem: the widening skills gap in the sector and the clear division between men and women. A number of practices will be used to recruit/retain girls in STEM and ensure that they are not lost during the transition to professional work. In addition, Mind the Gap will support VET teachers of STEM subjects to be more inclusive and gender aware in their teaching.
- **Korea** is supporting a research fund for female student research teams in architecture, material sciences and machinery, as well as computers. They are also promoting female talents in the local science and engineering fields by providing field experience programmes reflecting the demand for local industry and companies.
- In **Japan**, to increase the number of female science and engineering professionals who will lead the next generation, the government is carrying out the Riko-challe project to inspire women students to choose STEM careers.
- The NIÑASTEM PUEDEN of **Mexico** is a gender network in which the women oriented to disciplines such as STEM would promote this field of study among young Mexican students. Mexico also supports Codigo X, a programme aimed to consolidate efforts at the national and international levels in industry, civil society, academia and government and promote the inclusion of girls and women in ICTs.
- The **Netherlands'** Ministry of Education, Culture and Science had financed several projects and activities carried out by the non-profit organisation VHTO (the Dutch national expert organisation on girls/women and science/technology). In 2011 funding was for instance provided for the VHTO Talentenkijker (Talent Viewer) project for primary schools (grades 5 and 6, children aged 9 to 12), involving more than 3 500 classes over two years. The project entailed a series of lessons in which boys and girls explored their talents, met STEM-field professionals and learned more about the skills needed for STEM-related jobs. A recent study indicates that the project enhanced teachers' gender-awareness, as well as knowledge of STEM-related studies and professions among children, teachers and parents. Talent Viewer was found to be eye-opening for students and teachers alike, highlighting the role of women in STEM professions, with fewer students viewing STEM as "something for boys" after participating in the project.

- **Germany** launched in 2008 the National Pact for Women in MINT (STEM) Careers to increase women's interest in scientific and technical studies. The initiative is bringing together politics, business, science and the media to improve the image of STEM-related professions in society.
- In the **United States of America**, the Department of Education's programme Race to the Top, launched in 2009, prioritises improving STEM in the grants it awards to states. The Investing in Innovation programme seeks to increase the number of STEM teachers from groups traditionally under-represented in STEM; and the National Science Foundation awards grants to support the ADVANCE programme, which aims at increasing the participation and advancement of women in academic science and engineering careers.
- **South Africa**'s Broadband Policy South Africa Connect: Creating Opportunities, Ensuring inclusion wishes to address high level skills shortage in sectors (both public and private) to meet the specialised needs of knowledge production necessary for innovation.

Alongside the G20 German Presidency's eSkills4Girls initiative, endorsed by G20 Leaders in 2017, there are a range of national programmes that aim to support girls and women in improving their digital literacy and boosting female employment rate in the digital economy. Among them:

- **South Africa**'s initiative – including South Africa's Women's Net – providing tailor-made training on basic digital skills, advocacy and lobbying online.
- **Russia**'s Love2Code courses which teach how to develop mobile applications.

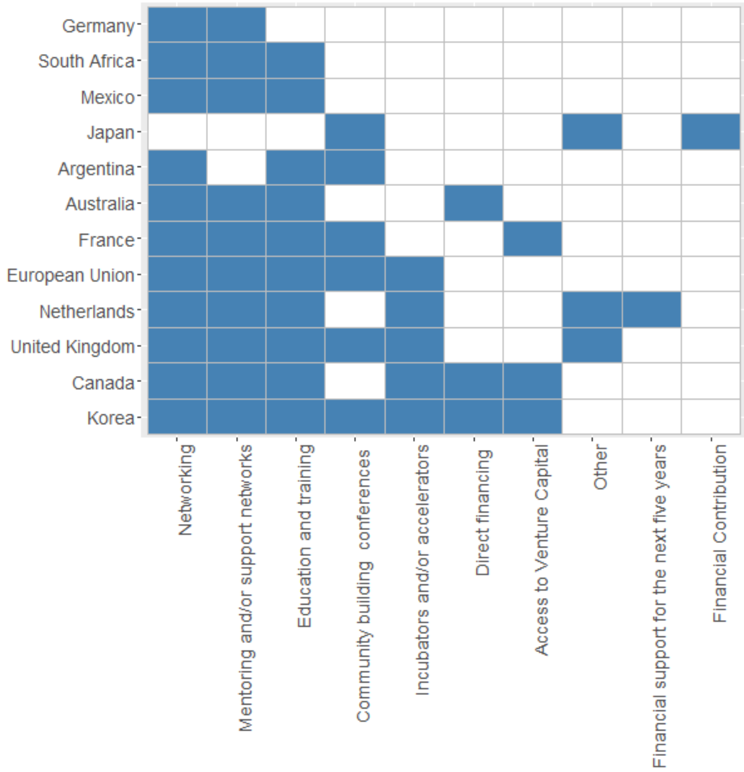
In the Roadmap, G20 Ministers responsible for the Digital Economy acknowledged the need to "encourage digital start-ups through a more entrepreneurial friendly environment as vehicles for innovation, entrepreneurship, employment opportunities and inclusive economic growth". G20 economies responded to the survey indicating that networking, mentoring, education and training were the most common approaches used by countries to support female entrepreneurs.

In addition, G20 economies also use loan guarantee schemes to enforce female entrepreneurs. For example, France introduced in October 2017 a new partnership between the Group bank Caisse d'épargne, the agency Caisse des dépôts and the State for the development of women's entrepreneurship to increase the rate of women entrepreneurs in France by at least 40% in 2020. Germany's "Frauenunternehmen" encourages women to consider entrepreneurship/self-employment as a viable career option by providing them with role models (see Figure 52 for a synthesis of the measures implemented).

Another example to foster female entrepreneurship can be seen through the "SheTrades"[1] initiative launched by the ITC which aims "to connect one million women entrepreneurs to market by 2020". The initiative functions through a multi stakeholder partnership aimed at "enhancing their competitiveness and creating sustainable connections between buyers, partners and women entrepreneurs". Further, its partnership model highlights the complexities related to women's economic empowerment and speaks to the need for establishing commitments between various institutions, government, and private sector.

The G20 survey identified many ways in which countries have started to tackle normative and cultural barriers. Among them are initiatives aimed at community building, financing, networking and providing scholarships. Moreover, the survey found that different countries have started awareness-raising campaigns. For instance, Spain's "Proyecto Tekl@: Llaves para el empleo" aims at making women more aware of their own capabilities and fostering IT literacy among women from rural backgrounds in an effort to increase their employability. Brazil's "#MinasProgramam" is an example of capacity building as it helps deconstruct the notion that men are better able at programming and promotes a basic training space for women who want to know more about programming, but do not know where to start. In addition, mentoring and the increase of female role models in the digital economy are helping to address archaic stereotypes and to improve the perception of digital-related subjects for women and girls.

Figure 52. Measures aimed to support female entrepreneurship



Source: OECD (2017h), *Towards the Implementation of the G20 Roadmap for Digitalisation: Skills, Business Dynamics and Competition*, www.oecd.org/g20/OECDreport_Implementation_G20_Roadmap.pdf.

Countries initiatives aimed at launching national advocacy campaigns and events that promote female role models in the digital economy could help lower hurdles associated with “glass ceilings” that limit women’s ascent in the tech industry. For example, Sheryl Sandberg’s campaign Lean In seeks to develop an active and supportive community for women, and encourages small peer groups to meet regularly to learn and share knowledge on topics including leadership and communication (LeanIn, 2018).[2] Furthermore, the non-profit organisation “Anita Borg Institute for Women and Technology” seeks to connect, inspire and guide women in computing and technology innovation.

Regarding online safety, as part of a larger package addressing Women’s Safety, the European Union’s Office of the eSafety Commissioner has established “eSafetyWomen”, a set of Internet resources helping women to manage technology risks and abuse by giving them the tools they need to be confident when online. The Office of the eSafety Commissioner plans to continually update and add resources to “eSafetyWomen” and will in future include targeted resources for indigenous women, women from culturally and linguistically diverse communities, and women with disabilities.

Respondents were split almost evenly when it came to having laws or regulations regarding gender-related provisions in digital economy policies, programmes and/or plans. One interesting effort in place in Canada requires departments and agencies to determine whether there is a potential gender issue in any policy, programme, initiative or service they propose. Should such a potential exist, the government expects the organisation to fulfil its commitment to undertake a thorough and complete “Gender Based Analysis +” (GBA+) (Government of Canada, 2018). The latter is an analytical tool used to assess how diverse groups of women, men and gender-diverse people may experience policies, programmes and initiatives. The “plus” in GBA+ acknowledges that GBA goes beyond biological (sex) and socio-cultural (gender) differences.

A number of other G20 economies have legislation in place to ensure better equality between men and women as can be seen in Box 10.[3]

BOX 10. POLICY STRATEGIES AND LAWS AIMED TO ENSURE BETTER EQUALITY BETWEEN GENDERS

- **Argentina** has established a Women Economic Development Center to develop a research field oriented to foster women´s inclusion and participation in programmes and services offered by the Secretariat of Entrepreneurs and SMEs as well as other public and private institutions. The centre focuses its work on three main issues: awareness to promote women's economic empowerment-considering them as a change agent with economic impact; networking to connect women with providers, investors, incubators, accelerators, trainers and any other agent that can support the growth of their projects; financial assistance to foster the Secretariat and Ministry´s existing credit lines to women projects.

- **Korea**'s Act of Promotion of Information and Communications Network Utilization and Information Protection, includes Article 14 (Proliferation of Internet) which states that:

  > The Government shall stimulate efficient private and public sector Internet use in order to encourage widespread Internet use, increase the Internet's foundation, increase Internet education and publicity, and design and put into practice actions that end the Internet utilization gap by region, gender and age.

- **France**'s Plan sectoriel mixité et numérique was launched in January 2017 and constitutes a lever for mobilisation and actions to promote equality between women and men in the digital sector, thanks to the joint determination of the public authorities and the private sector. By federating the work of important representatives of digital and public authorities, this plan aims to promote diversity by acting at every stage of women's journey: in orientation and continuing education, in access to employment and entrepreneurship. Examples of measures include:

  - fighting against stereotypes of sex, cybersex and cyber violence
  - initial training, working on the representations associated with digital professions
  - life-long education, promoting the diversity of digital professions and the attractiveness of positions for women
  - promoting the employment of women in the digital sector
  - communicating about the creation of businesses by women in the digital sector.

- **Mexico** published in 2016, in the Official Journal of the Federation, the General Law for Equality between Women and Men (Government of Mexico, 2016), which has the objective to regulate and guarantee equality of opportunities and treatment between women and men. It proposes guidelines and institutional mechanisms that would gear the nation towards the fulfilment of substantive equality in the public and private sectors and promotes the empowerment of women in the fight against all discrimination based on gender.

- In **South Africa**, the whole legislation including the Constitution outlaws gender discrimination and promotes gender equality in all sectors, including the ICT sector. The country has a specific Ministry in the Presidency, the Department of Women, whose mandate is to champion the advancement of women's socio-economic empowerment and promote gender equality. There is also a Commission that focuses on monitoring progress in terms of gender equality.

- The **United Kingdom**'s Equality Act 2010 prohibits discrimination in employment or in the provision of training and education on the grounds of any of the following protected characteristics: age, disability, gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex, and sexual orientation.

While important efforts are being made by national governments to close the digital gender divide, only two countries and the European Union provided examples of time bound targets for women. The targets set out by France, the United Kingdom and the European Union are as follows:

- France required that 40% of entrepreneurs be women in 2017 vs. only 30% in 2012.
- The United Kingdom aims at a 20% increase in the proportion of girls taking A-levels in STEM subjects between 2016 and 2020.
- Three objectives underpin the European Union's strategy on gender equality in Horizon 2020: 1) fostering gender balance in research teams, in order to close the gaps in the participation of women; 2) ensuring gender balance in decision making, in order to reach the target of 40% of the under-represented sex in panels and groups and of 50% in advisory groups; and 3) integrating the gender dimension in research and innovation content, and help improve the scientific quality and societal relevance of the produced knowledge, technology and/or innovation.

Further, the Broadband Commission for Sustainable Development suggests a new target on digital proficiency. By 2025, 60% of youth and adults should have achieved at least a minimum level of proficiency in sustainable digital skills (Broadband Commission, 2018).

Setting targets implies a need for more robust, timely data, in order to monitor and assess progress. In particular, indicators needed to assess gender digital equality fall in the Tier 3 category based on United Nation's criteria for its Minimum Set of Gender Indicators (UN Gender Stats, 2018). The survey highlighted a number of efforts to gather gender statistics:

- The OECD's online "Gender Data Portal" has become a leading global source for statistical indicators on gender equality, and includes about 75 indicators shedding light on gender gaps in education, employment, entrepreneurship, political participation, and social and economic outcomes. For example, the OECD Better Life Index integrates information on gender inequality across its 12 domains of well-being. The OECD Development Centre's Social Institutions and Gender Index (SIGI) is a cross-country measure of discrimination against women in social institutions (formal and informal laws, social norms, and practices) across 160 countries. Further, the OECD "Gender Initiative" monitors the progress made on gender equality, through data and analysis in various fields, and provides best practices for achieving greater equality.
- The Association for Progressive Communications (APC), which undertakes a global mapping of actors and gender-related initiatives related to ICTs aimed to identify key issues and gaps.
- A4A1 (Alliance for Affordable Internet), the Web Foundation, and the APC have developed a common set of indicators on the digital gender divide, building on existing recommendations and methodologies for gender-specific indicators and existing guidelines by ITU and the Partnership on Measuring ICTs for Development Task Group on Gender.
- The ITU has developed disaggregated data on Internet use by women and estimates the digital gender gap in Internet use. Also, the ITU measures and promotes progress towards ITU's Connect 2020 Agenda, in particular towards Goal 2 (Goal 2.5.A) aimed at reaching gender equality among Internet users by 2020.

G20 economies' efforts to support efforts in other countries, especially developing countries

A number of G20 economies implementing a number of measures in relation to the Roadmap further provided information about programmes put in place to support gender-related efforts in other countries, particularly developing ones. In this respect, some of the most active G20 economies include Australia, Canada and Germany. Examples of the types of support initiatives provided in these countries can be seen in Box 11.

BOX 11. G20 ECONOMY PROGRAMMES SUPPORTING GENDER EQUALITY EFFORTS IN OTHER COUNTRIES

Australia has put in place the Girl Effect and Women's World Banking (WWB):

- The **Girl Effect** helps build young women's leadership, voice and agency in Bangladesh through an innovative research model, the Technology Enabled Girl Ambassadors (TEGA). TEGA trains young women aged 18-24 in data collection techniques and mobile technology to collect real-time data in their communities. Thanks to the insights gained by analysing these data, the "Girl Effect" and its partners' programmes can better address the concerns of women and girls. TEGA also build agency and leadership for young women through strengthening their voice, and increasing confidence, leadership and connections through the development of new digital skills.
- Building on **WWB's** experience fostering digital solutions for low-income women throughout the world, Australia is supporting WWB over the next four years to expand their programmes in South East Asia. Increasing the reach and use of digital financial services is a key strategy to help overcome the financial inclusion gender gap. WWB will test innovative programmes such as driving the uptake and use of mobile accounts by women in Indonesia, and supporting digital insurance service providers in Cambodia expand into new areas.

Canada is supporting four initiatives at the global level:

- **GIRLS Inspire** which aims to break the cycle of child, early and forced marriage by increasing access to education and training for girls and women through open, distance, and technology-based learning in select Commonwealth countries with a high prevalence of child marriage.
- **Preparing Haitian Youth for Digital Jobs** aims to create the enabling conditions for young Haitians, especially women and girls, to find employment in the digital economy through the design and evaluation of locally adapted online courses, development of job matching platforms, and support for telecommunications engineers.
- The **Skills for Employability Project** aims to strengthen and expand the African Institute for Mathematical Sciences (AIMS) Industry Initiative (linking AIMS' academic programme, students and alumni to industry to enhance employability post AIMS) and the AIMS Co-operative Programme (Co-op Programme) in Senegal.
- **Improving Prospects for Digitally Enabled Livelihoods** aims to create optimal conditions to enable young Egyptians, mainly women, to take advantage of the entrepreneurial and employment opportunities that the digital economy offers by piloting and testing localised high-quality curricula for the development of digital skills.
- Further, in collaboration with the Nile National University and the Cairo-based Industrial Training Council, Canada develops a curriculum focused on creating digital and business skills to seize employment opportunities by global outsourcing platforms, such as business process outsourcing companies, and on leveraging digital products and services through the development of applications. The aim is to support mainly young women to step out of the informal economy and to take advantage of the entrepreneurial and employment opportunities of the digital economy (IDRC, 2017).

Germany, in addition to the mentioned #Skills4Girls initiative has also the **Girls Innovation Camp** initiative, initiated by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on behalf of the Federal Ministry for Economic Co-operation and Development (BMZ) in co-operation with the Indonesian Ministry of Education and Culture as well as Intel Indonesia. The aim is to address the need to improve gender equality in the workplace by raising the digital skill levels of women. Organised for the first time in 2016, the Girls Innovation Camp offers hands-on training in design thinking for innovation, career guidance and provides an introduction to the basics of teamwork, leadership and gender mainstreaming to female students and teachers. The initiative aims to foster innovation among students and teachers using technology in order to prepare them for jobs in the digital economy. In addition to Intel, GIZ is currently co-operating with other IT companies such as IBM, Axioo or the local developer hub Dicoding.

Complementing policy actions: The role of the private and civil society sectors

There are a range of private sector and civil society initiatives aiming at improving technical access and affordability of broadband and mobile networks, that complement government policy actions and which could also offer lessons. These include the APC' connectivity access project, aimed at shedding light on barriers and best practices to access, coverage and affordability in Africa, Latin America and South Asia. GSMA's Connected Women Commitment Initiative is pushing mobile operators to increase the proportion of women in their mobile Internet and/or mobile money customer base by 2020. To date, 32 mobile operators have made 46 formal commitments to reduce the gender gap in their mobile money and/or mobile Internet customer base across Africa, Asia and Latin America, driving an effort to accelerate the digital and financial inclusion of women. In 2017, enabling solutions had been delivered to more than 17 million women (Broadband Commission, 2017a). Finally, the Women's World Banking mobile money initiative fosters access to financial services and resources by women in developing countries (Women's World Banking, 2018). It already works together with governmental partners as the Australian government (Department of Foreign Affairs and Trade), the Ministry for Foreign Affairs of Finland and the Swedish International Development Cooperation.

In addition, there are many examples of public-private partnerships aimed at building STEM skills for women (Box 12). There are also a number of civil society initiatives that target increasing gender diversity in entrepreneurship and in tech companies, including Astia Silicon Valley, which is a global not-for-profit organisation that aims to provide female entrepreneurs with capital, connections, and guidance to fuel highly innovative, women-led ventures around the globe (Astia, 2018). Further, "Women 2.0" is a media company in the field of female entrepreneurship and technology that offers "content, community and conferences for aspiring and current innovators in technology" (Women 2.0, 2018).

BOX 12. PUBLIC-PRIVATE PARTNERSHIPS AIMED TO IMPROVE STEM SKILLS

Examples of public-private partnerships that aim at bridging the gender skill gap include:

- Microsoft, together with the Australian Business and Community (ABCN) Programme, has initiated the Digigirlz programme and Careers Days to expose high school students to the high-tech world (Microsoft, 2018). The DigiGirlz give middle – ansd high school girls the opportunity to learn about careers in technology, and participate in workshops on digital technologies. Microsoft has also founded the HerTechPath programme to inspire girls to consider a career in technology (Her Tech Path, 2018).
- Ericsson's Connect to Learn programme was launched in 2010 by Columbia University, Millennium Promise and Ericsson with the aim to improve access to quality secondary education for girls, by providing scholarships and bringing ICTs to schools in remote, resource-poor parts of the world, over mobile broadband. To date the initiative covers 22 countries and has benefitted around 80 000 students and engaged 16 mobile operators. Currently, the largest student base is in Myanmar (Ericsson, 2018).
- Nokia started partnering with UNESCO to foster gender equality through a network of partnerships with other corporations, universities and social networks. Nokia's StrongHer employee network promoting gender diversity in the organisation provides best practices for the network's partners to increase female labour participation in all industries, including ICTs (Nokia, 2018).
- The Mozilla Foundation, in partnership with UN Women, launched Mozilla Clubs to train women and girls in digital literacy skills. This project targets women and girls in both formal and informal settings ranging from Vancouver to Papua New Guinea.
- Virtual Skills School is an innovative learning platform by UN Women dedicated to provide a "second chance" to get into a path of increased opportunity and continued learning. The platform provides foundational learning materials on financial literacy and business development (UN Women, 2018b).
- VEON in partnership with the Capital Administration and Development Division and the Federal Directorate of Education in Pakistan have launched the Jazz Smart Schools Programme which is dedicated to improve the quality of education across 75 public female high schools by introducing technology-driven blended learning solutions in the Islamabad Capital Territory (Jazz, 2018).

In addition, a number of initiatives by governmental agencies and international organisations exist:

- The Broadband Commission's Working Group on "Digital Gender Divide" contributes with reviews of existing normative frameworks in order to develop a set of recommendations which address the digital gender divide and foster the equal inclusion of women and girls in broadband access and use, and its Working Group on "Broadband and Gender" analyses the role that ICTs and the Internet can play in advancing gender equality agendas, including equal access to new technologies by women and girls.[1]
- The ITU supports a wide range of initiatives focusing on digital skills and digital literacy, including its Digital Skills Toolkit for the digital economy. The Digital Skills Toolkit includes a series of recommendations on designing digital skills training programmes for women, such as designing skills development programmes for in demand jobs. Further, it includes recommendations for pedagogical adjustments to make them more inclusive of women. (ITU, 2018b) The International Girls in ICT Day campaign (ITU, 2018c), as well as its GEM-TECH Awards, is an annual special achievement award for outstanding performers and role models in gender equality and mainstreaming in the area of ICTs (ITU, 2018d). This campaign has succeeded in incentivising events and digital skills training for 362 000 girls and young women in 171 countries since it was launched in 2011 (Girls in ICT, 2018).
- The ITU-International Labour Organisation (ILO) Digital Skills for Decent Jobs for Youth campaign is a global initiative to scale up action and impact on youth employment in support of the 2030 Agenda for Sustainable Development. It unites the efforts of 22 United Nations entities, the private sector, foundations, governments and other partners, the campaign seeks to incentive a range of stakeholders to train 5 million young women and men with job-ready digital skills by 2030. One of the concrete deliverable stakeholders can commit to undertake is to implement programmes designed to equip more young women with job-ready digital skills (Decent Jobs for Youth, 2018).
- EQUALS is a ground-breaking global initiative delivered by a committed partnership of governments, civil society, the private sector, and research institutions working together to bridge the digital gender divide in the areas of access, skills, leadership, and research. The Skills Coalition, led by UNESCO and Germany, are working to guide global policy on gender transformative skills training and contribute to a digital skills innovation fund.
- UNESCO has launched the MOOC on media and information literacy (MILMOOC, 2018) to empower young girls and boys through providing them with the necessary competence in media and information literacy. UNESCO supports the site with capacity building for youth organisations, including youth organisations involved in promoting gender equality and women's empowerment, to integrate media and information literacy in the policy and operation of their strategy. The site is currently available in English and Arabic.

1. www.broadbandcommission.org/workinggroups/Pages/digital-gender-divide.aspx and www.broadbandcommission.org/workinggroups/Pages/bbandgender.aspx.

Notes

1. See https://www.shetrades.com/en/about#about.
2. Sheryl Sandberg is the Chief Operating Officer of Facebook and founder of Leanin.org.
3. India's Policy for Women 2017 legislation is not included as it was still under preparation at the time of the survey. Under this new policy, efforts will be made to increase women's access to an effective use of digital technologies through promotion of start-ups of women owned enterprises while addressing their access barriers to ICT and digital financial services. Effective use of ICT for education at all levels will be promoted amongst women with emphasis on rural and semi-urban areas.

Chapter 6

BRIDGING THE DIGITAL GENDER DIVIDE: WHAT ROLE FOR POLICY?

Empowering women in the digital era entails putting in place a number of interrelated and complementary policies. They need to encompass measures related to: increasing awareness of the digital gender divide and addressing stereotypes; strengthening women's participation in STEM and in high-technology sectors, as well as women's digital and soft skills; fostering women's entry and re-insertion in the labour market and entrepreneurship; using digital tools to address the digital divide; addressing cyber violence towards girls and women and online security; fostering evidence-based gender-related policy.

Addressing the digital gender divide requires awareness and strong co-operation across stakeholders, and tackling gender stereotypes is fundamental. Girls and women are accumulating disadvantages and face increased barriers to their full participation in the digital world. Girls tend to participate less in disciplines that would allow them to perform well in a digital world (e.g. STEM and ICTs); use digital tools and participate in platforms to a lesser extent, also when it comes to advancing their businesses (in addition to receiving relatively less financing). This comes on top of the traditional obstacles and discrimination they face in the analogue world. Countries need to act promptly to intervene and redress this situation.

Empowering women in the digital era: Key policy recommendations for the G20

New digital tools are empowering, and can serve to support a new source of inclusive global economic growth. To fully seize this opportunity it is essential to step up efforts and ensure that the digital transformation represents a leapfrog opportunity for women and a chance to build a more inclusive digital world. The G20 efforts are an important and timely step forward towards better policies to close the digital gender gap.

The present report has shed light on many of the root causes contributing to the digital gender divide in G20 economies and beyond. Among them, hurdles to access and use of ICT devices and digital technologies, affordability issues, education (or lack thereof) and lack of technological literacy, safety concerns, as well as inherent biases and socio-cultural norms that lead to gender-based digital exclusion. The latter at times may also take the form of a "glass-ceiling", preventing women also in developed economies from expressing and developing their leadership abilities and entrepreneurial endeavours.

While G20 economies have already put in place a number of important actions aimed at narrowing the gender gap, more needs to be done in light of the many worrying signs of a widening digital gender divide and the compounded effect that its different components may have in the future. Hurdles to access, affordability, lack of education as well as inherent biases and socio-cultural norms curtail women and girls' ability to benefit from the opportunities offered by the digital transformation. The combination of girls' relatively lower educational enrolment in those disciplines that would allow them to perform well in a digital world (e.g. STEM and ICTs), coupled with women's and girls' limited use of digital tools and relatively scarcer presence or activity on platforms – e.g. for business purposes – suggest a potential scenario of widening gaps and greater inequality. If one adds to this the fact that women receive comparatively less financing for their innovative endeavours and are often confronted with "glass ceilings" curbing their professional ambitions (especially so in tech industries), the picture that emerges is far from positive and points to a vicious circle that could lead to a widening of digital gender divides.

Policy, especially in the form of co-ordinated and complementary actions, may reverse these trends and forge a more inclusive path. Addressing the digital gender divide requires raising awareness and tackling gender stereotypes, while at the same time enabling enhanced, safer and more affordable access to digital tools and fostering strong co-operation across stakeholders to remove barriers to girls and women's full participation in the digital world. This can be achieved also by means of leveraging digital technologies themselves, and the opportunities that these may offer once made accessible.

This report provides the basis for furthering G20 efforts and constructing an innovative, ambitious, and pro-active G20 agenda to bridge the digital gender divide. The following action areas stand out:

Enhance access to and improve the affordability of digital technologies

Connecting the many million women that still lack access to broadband and mobile networks is of paramount importance to foster a more inclusive digital world. Public national or regional broadband plans, public tenders and (municipal) networks provided through private-public partnerships, as well as the promotion of competition and private investment, coupled with the design and implementation of suitable regulations can help enhance both access and affordability. In addition coverage, especially in remote areas, can be promoted by means of competitive pricing strategies in public tenders, through public-private partnerships (OECD, 2018b) and through municipal networks, which can fill the gaps in underserved areas and provide substantial service in a region, city or smaller town. Finally, universal service can be a way to reach out to rural areas with low population densities (OECD, 2018b).

Access-related policies could be coupled with gender-oriented targets for broadband access and usage. While measures of this type can already be found in national broadband plans, innovation plans or digital agendas of about half of the countries worldwide (AU DSS, 2017), more countries could follow this example and include gender equality targets for Internet and broadband access and use.

Bridging the digital gender gap not only requires infrastructure investments but also making digital technologies more affordable, as cost remains one of the key obstacles for women to access the Internet. In certain low-income households accessing the Internet entails having to sacrifice key household purchases such as food, health care and clothing (OECD, 2018b). Recognising the existence of gender disparities in technology access and use, some G20 economies have put in place programmes aimed at addressing such concerns. Argentina and South Africa, for instance, use financial resources from universal service funds to support ICT access for women and girls; Canada included in its Budget 2017 a new Affordable Access programme assisting service providers to offer low-cost home Internet packages to interested low-income families (OECD, 2018b); Australia has incentives targeting female customers aimed at fostering adoption of ICTs (e.g. discounts on mobile devices). Alternatively, some countries pursue broadband for all and international development programmes as a way to provide Internet access, also and especially to women.

The target expressed by SDG 9c – to connect each woman to the Internet by 2020 – shows that the issue of access is at the top of the international political agenda. But, at the current pace, universal access will not be reached before 2042. Among the ideas put forward to tackle this issue is the redefinition of the "affordable Internet" goal to the "1-for-2-goal", which would entail pricing 1 Gigabyte of Internet access at not more than 2% of a person's monthly income – as compared to the current 5% (A4Ai, 2016). To ensure affordable access, the Broadband Commission (2017a) recommended improved understanding of affordability issues, reduced costs of devices and services, improved network coverage, capacity and quality, and safe and accessible public access facilities to serve women.

Boost skills

Education is one of the most powerful tools that policy makers may leverage to bridge the digital gender divide. It is essential to equip and train women and girls with the skills needed to participate and thrive in the digital transformation, and to educate the rest of society so as to curb socio-cultural norms that discriminate against women and their use of digital means. This could be obtained in several ways. Among them are undertaking campaigns aimed at awareness raising and education that demonstrate that women and girls are well-suited and perfectly able to perform STEM and ICT-related jobs. Showcasing female role models would help convey the idea that female leadership is as "normal" as male leadership. Pedagogical approaches fostering mixed-gender teamwork, especially in STEM-related subjects, could help forge working together with women as the new "normal" and demonstrate the value that diversity brings. Lastly, the pervasiveness of the Internet and of social platforms may be leveraged to convey these messages on a recurrent basis, targeting specific user cohorts and customising messages to make them more effective.

The novel evidence provided in this report shows that, at the age of 15, the gender gap in terms of skills for the digital era is not clear-cut, yet at a later stage, when a mix of skills is considered working women seem less likely to be high performers than men. Moreover, women often face extra barriers to participating in adult education. With the returns to skill analysis here showing that ICT skills can play a role in narrowing the gender wage gap, it is clear that a comprehensive approach to addressing gender gaps in skills, career choices and employment outcomes is needed.

This is particularly the case given the evidence that the skills which are in highest demand in digital intensive sectors, i.e. self-organisation, managing and communication, and advanced numerical skills, are more frequently displayed by men than by women. While to date, many of the G20 economies have efforts to get more women and girls engaged in STEM and to help ensure that the workforce of tomorrow has the necessary skills to succeed, these efforts may need to be reinforced and implemented over long time periods, if they are to succeed.

Part of the solution may be to consider "training the trainers", i.e. support teachers and provide them with the skills needed to deliver a digital skills-related curriculum. When doing so, it would be important to bear in mind gender-related considerations, so that when teaching, e.g. in primary and/or secondary schools, both the material and the teaching methods would facilitate women and girls' upskilling and their integration in the digital world. One variant of this is to offer single sex classes when teaching technical subjects, to use gender-neutral textbooks and to support engagement in extracurricular activities. Online courses, technology camps and mentoring activities are educational instruments that can serve both the pupils and the trainers, providing them with access to frontier knowledge and to best practices.

Finally, fostering private-public partnerships, including between academia and the private sector, can help identify and jointly develop the skills that are demanded by the labour market in the digital era, including STEM skills. This requires reflection on the form that these partnerships can take, and on the sharing of costs that private and public entities should sustain, in order for the labour force of the future to be prepared for the opportunities and challenges raised by the digital transformation.

Facilitate labour market participation and on-the-job learning

The diffusion of digital technologies may offer further opportunities for workers to participate in the labour market while enjoying more flexible schedules related to where and when to work. This may in turn help parents combine work and family duties, and promote formal female employment as a consequence. If skills and labour market rewards grow with experience, as is likely the case for management capabilities, allowing women to accumulate working experience is likely to reduce the gender pay gap. In the United States, for instance, such gaps tend to be lower in industries where working arrangements are more flexible (Goldin, 2014). Furthermore, greater working experience helps build professional networks and allows women to benefit from network externalities, which is likely to further empower working women. However, the benefits of flexibility may come at the cost of lower job quality (OECD, 2017a). It is therefore important to avoid that such flexible arrangements translate into longer working hours and a more blurry separation line between work and personal life, and that flexibility does not simply translate into greater stress.

Participation in the labour market and employment in high-quality, high-pay jobs can be hindered by discrimination. The analysis focusing on the role of skills in the digital transformation showed that while skills account for a substantial part of the gender wage gap, there is a part of the gap that cannot be explained by any of the factors which can be controlled for (including e.g. a worker's country, sector or occupation of employment), nor on a number of observable characteristics of the worker herself. This "residual" gap can be shaped by a number of economic and social phenomena, one of which is discrimination. Distinguishing the exact importance of discrimination, however, is impossible, given that cultural norms which are not country-, industry- or occupation-specific also contribute to the "residual" gap in this analysis.

Policy may want to use digital technologies to raise awareness on gender discrimination, or dispel stereotypes, for instance about the split in household production duties between women and men, to reinforce women's curricula and participation in the labour market and develop women's skills and abilities. One way to enable the upskilling of women and girls both in and out of the labour market, could be make use of MOOCs. Bayeck (2016) explores MOOC learners' demographics and motivations and finds that, while men generally tend to participle in MOOCs to a higher extent, women participate more when group work is included in a MOOC. Also, Bayeck et al. (2018) finds that female and male learners' perception of single-gender grouping differs, and that female students indicated less preference for single-gender grouping. Such perceptions appear to vary across regions, with men in the Asia and Pacific region having a tendency to give more importance to single-gender grouping, more than men and women from other regions of the world. Also, signs of much needed change seem to emerge, with younger participants being less concerned with single-gender groups as compared to older respondents. These findings underline the need to adopt collaborative approaches to teaching and learning to contribute to address gender biases and erase stereotypes.

Foster women's entrepreneurship and engagement in innovation

Entrepreneurship skills have become even more important in a world where digital technologies offer to a greater number of people the possibility to start or develop their own business. But risk aversion, scarce access to seed funding, and rigid social and economic structures which limit the accumulation of funds, can jeopardise both entrepreneurship and the innovation propensity of individuals. Further sharing international experiences and good practices is essential. Participation of women in innovation activities can represent another important step towards greater gender equality. This can be achieved by fostering the creation of mixed men-women teams of researchers and investors, which is likely to reduce biases and enhance performance as a consequence.

Overcome normative barriers, increase safety and foster evidence-based gender-related actions

Policies can be only effective if they also address the underlying factors that prevent women and girls from fully participating in the digital transformation and from enjoying the benefits it offers. This in turns calls for the need to address normative barriers and beliefs and to overcome stereotypes and biases.

Lack of awareness and language barriers may be reduced through promoting joint work with local (male) helpers, who can teach women in rural areas of developing and emerging countries how to use the Internet and other digital technologies. Further, those helpers could interact with women's families and social circles to demonstrate the importance of participating in the digital sphere.

Enabling women's full participation in the digital economy requires reassuring women and girls, as women in developing and emerging economies report sexual harassment and online safety as being among the main reasons for their families' opposition to them owning a mobile phone or using the Internet. Also in both developed and developing economies, safe access to technology is crucial for women to stay connected, take advantage of education and economic opportunities, and get information and support.

Countries structural responses to gender-based violence, for example by prohibiting gender-based violence in digital spaces and protecting women's rights to participate in the digital economy, free from violence. In addition to containing gender-related violence and to sanctioning it when it occurs, countries may in addition provide educational resources promoting the safe use of digital technologies and teaching women and girls how to address safety issues, increasing their resilience and ability to protect themselves in a digital environment, and promoting awareness of support networks. Further, countries should also protect women and policy making must ensure that policies, legislations and regulatory processes uphold digital rights, and that fundamental rights as freedom of speech and privacy are protected.

Collect gender-disaggregated data to inform digital policy

Data by gender are generally insufficient to monitor and evaluate gender-related policies. In order to collect data allowing for the construction of gender-related indicators, and fine-tune existing guidelines for the collection of gender and ICT-related data, countries need to complement existing data.

The Broadband Commission suggests to add more detailed and consistent evidence concerning the digital gender gap, particularly at national and subnational levels. The Working Group's proposed actions include: 1) collecting, analysing, and tracking data; 2) researching women's access to and use of the Internet; and 3) publishing and sharing data and research. The Working Group recommends that sex-disaggregated data and research should be published and shared among stakeholders in a safe and secure manner, within the limits of data protection requirements, privacy considerations, and commercial confidentiality (Broadband Commission, 2017a). More generally, it would be important for initiatives to be co-ordinated and actors to work together to leverage the knowledge and expertise of each stakeholder group, and commit to achieving concrete and measurable impact.

A G20 agenda for action on the digital gender divide

To drive positive change, G20 Ministers responsible for the digital economy could consider the following concrete actions as the basis for a shared G20 ambition to bridge the digital gender divide and build a more inclusive digital future. A possible agenda could include:

- The **design and implementation of national digital strategies** that actively aim at closing the gender digital access, adoption and use gaps, and enhancing the affordability of digital technologies at the same time as increasing online safety.

  National digital strategies should include targets (both numbers and dates) for closing the digital gender divide across at least four dimensions, namely:

  - extend networks and digital access (e.g. through satellite) to rural areas
  - promote access to and affordability and use of connected digital devices (e.g. smart phones, tablets, laptops), especially for low-income individuals
  - boost availability and promotion of e-banking and mobile money, especially to women and other disadvantaged categories
  - increase online safety.

- **Adapt national and G20 Skills Strategies to increase awareness of the digital gender divide**, help address stereotypes, target existing gender biases in education curricula, encourage greater female enrolment in STEM studies and more generally, bridge the skills gender divide in the digital era.

  Addressing the digital gender divide requires sufficient awareness and strong co-operation across stakeholders and tackling gender stereotypes is critical. In many G20 economies, the digital gender divide is particularly large in STEM education and in high-technology sectors that require STEM degrees.

  G20 economies could consider making the following commitments:

  - agree to establish (time bound) targets for women in STEM
  - create fund and grant schemes aimed at enhancing the enrolment of women in STEM education
  - establish awards and prizes enhancing the visibility of women in STEM and in high-technology sectors
  - implement awareness campaigns tackling socio-cultural norms and biases and stereotypes.

- **Facilitate the labour market participation of women**, at the same time as monitoring and ensuring job quality and the provision of support services aimed at allowing women to work and pursue while being mothers or having a family. It would also be important to pair labour market participation-related actions with actions shaping investment for better targeted life-long training.

  In 2016, the gap in labour market participation rate between men and women aged 15-64 was estimated to be around 26% for the G20 economies. OECD analysis has found that those countries with the highest shares of women working from home are also the ones that exhibit the highest employment rates and that greater work flexibility goes hand in hand with higher employment rates among mothers.

- **Foster women's entrepreneurship and engagement in innovation**, also through the promotion of diversity in entrepreneurship and within teams of researchers and inventors.

  G20 economies could take action across a number of dimensions, including:

  - promote a more gender balanced composition of financing institutions, including venture capitalists and public support agencies to private R&D

  - design prizes and incentive schemes for companies and organisations actively implementing gender-neutral policies linked to measurable targets
  - foster networking and gender inclusion in entrepreneurial and innovative activities.

- **Foster evidence-based gender-related actions** by collecting gender-disaggregated data. To this end, it would be important to add a gender dimensions to data already collected by National Statistical Offices which at present are not declined by gender (e.g. related to entrepreneurship, innovation, etc.) and to design and implement the collection and publication in periodical reports (e.g. education and employment-related reports) of gender-related statistics, also linked to the targets mentioned above. Initiatives such as the OECD Gender Portal could further help collecting the evidence available in support of policy assessment and or monitoring and benchmarking of progresses made.

- The **publication of an annual Digital Gender Equality Report** that is based on a common methodology and indicators and the periodical collection. The *Measurement Toolkit for the Digital Economy* being prepared for the G20 Digital Economy Task Force by the OECD in conjunction with the ITU and other international organisations represents a robust starting point. Monitoring progress, benchmarking initiatives and identifying best practices and high-impact measures is critical for keeping the momentum behind efforts to close the digital gender divide.

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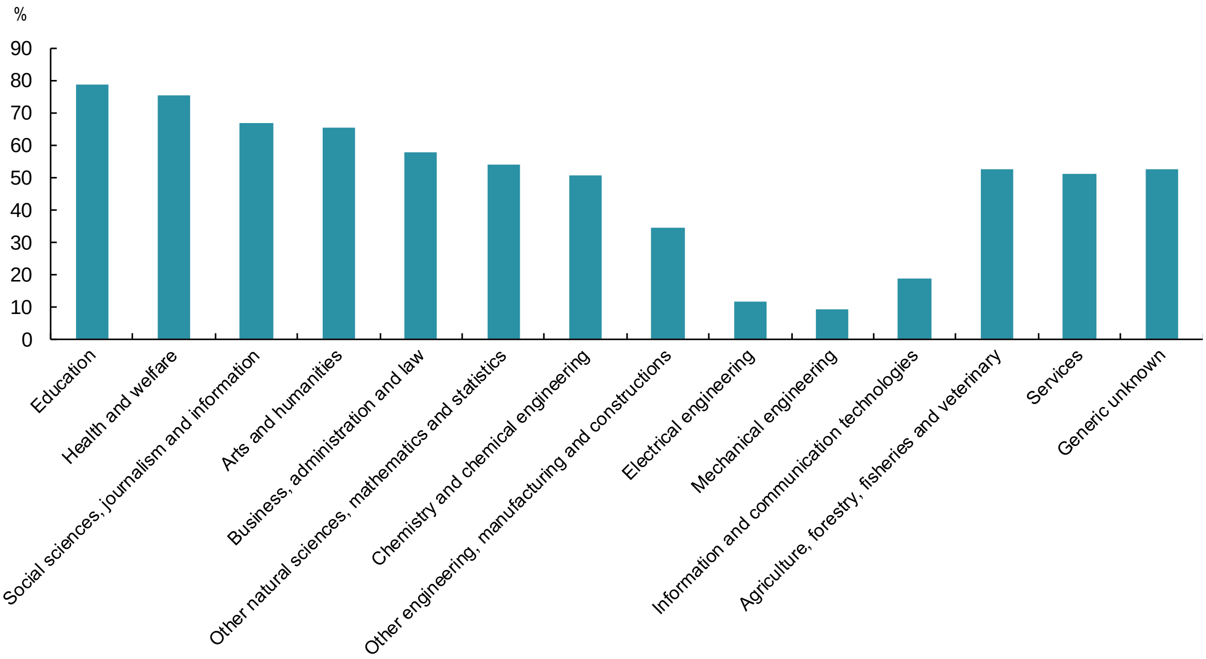
Annex of Chapter 3. Figures, tables and methodology

Figures

Figure A3.1. Share of women in tertiary graduates by field of study, 2015

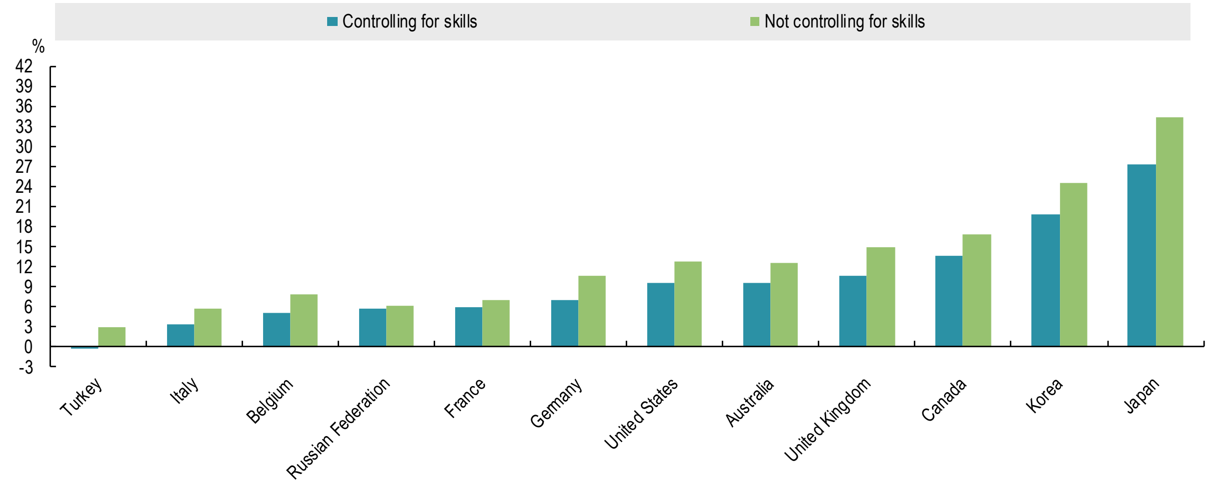
As a percentage of total tertiary graduates in that field (unweighted averages across country)



Notes: "Total Tertiary" includes all types of tertiary-level qualifications – i.e. short-cycle tertiary qualifications (International Standard Classification of Education [ISCED] 2011 Level 5), bachelor or equivalent level qualifications (ISCED 2011 Level 6), master or equivalent level qualifications (ISCED 2011 Level 7), and doctoral or equivalent level qualifications (ISCED 2011 Level 8). Fields of education are classified according to the 2013 ISCED classification of fields of education (UNESCO, 2015) then aggregated. Within each country, the number of graduates in the ad-hoc created field is calculated summing graduates in the underlying fields. The so-calculated country shares are then averaged across country. The category "Generic unknown" sums the "Field unknown" and "Generic programmes and qualifications" categories; "Electrical engineering" encompasses "Electricity and energy" and "Electronics and automation"; "Mechanical engineering" encompasses "Motor vehicles" and "Mechanics and metal trades"; "Chemistry and chemical engineering" encompasses "Chemistry" (from the "Natural sciences, math and statistics" category), "Chemical engineering" and "Environmental protection technology". Countries covered are: Austria, Belgium, Czech Republic, Denmark, Germany, Estonia, Finland, France, Hungary, India, Ireland, Israel, Italy, Korea, Lithuania, Luxembourg, Latvia, the Netherlands, Norway, Poland, Portugal, the Russian Federation, Slovak Republic, Slovenia, Spain, Switzerland and Sweden.

Source: OECD calculations based on data from OECD (2017f), *Education at a Glance 2017: OECD Indicators*, www.oecd.org/g20/OECDreport_Implementation_G20_Roadmap.pdf.

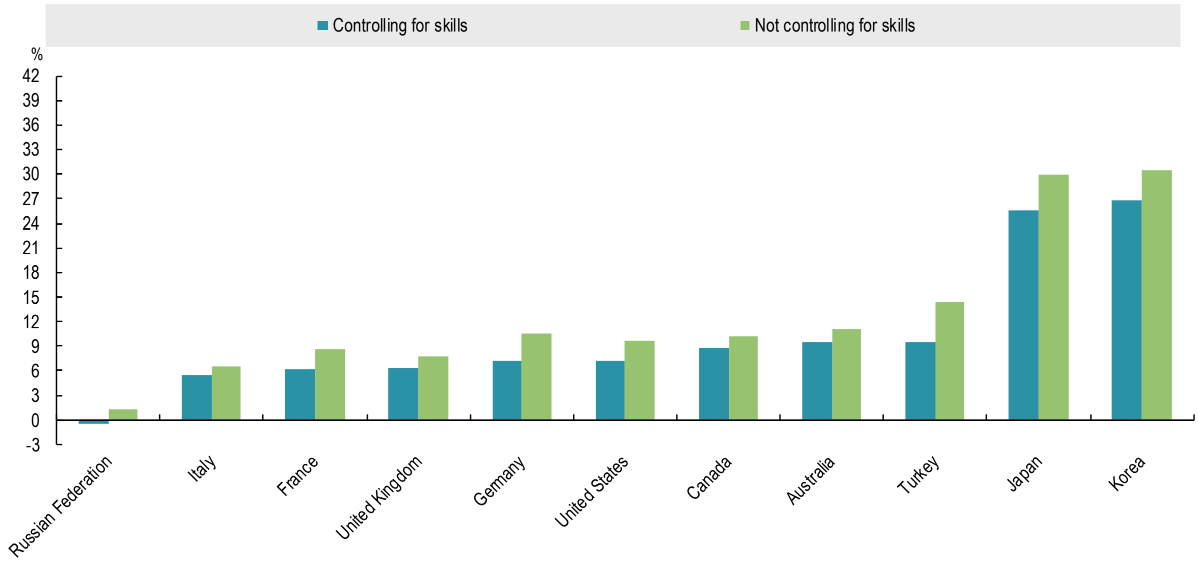
Figure A3.2. Gender wage gap by country in digital intensive industries



Notes: The figure shows the differences in hourly wages for men and women in percent for the sub-sample of employees in digital intensive industries (controlling vs. not controlling for skills). Digital intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018). The estimates for the gender wage gap are based on OLS wage regressions (Mincer equations) using data from PIAAC and control for the same covariates as in Figures 27 to 30, whereby for the gender wage gap (not controlling for skills) the skill variables were excluded from the regressions. The skill measures are based on PIAAC and are taken from Grundke et al. (2017).

Source: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Figure A3.3. Gender wage gap by country in less digital intensive industries



Notes: The figure shows the differences in hourly wages for men and women in percent for the sub-sample of employees in less digital intensive industries (controlling vs. not controlling for skills). Digital intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018). The estimates for the gender wage gap are based on OLS wage regressions (Mincer equations) using data from PIAAC and control for the same covariates as in Figures 27 to 30, whereby for the gender wage gap (not controlling for skills) the skill variables were excluded from the regressions. The skill measures are based on PIAAC and are taken from Grundke et al. (2017).

Source: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Tables

Table A3.1. Indicators of job-related task and skill requirements

Indicator of job-related skill requirements	Items included in the construction of the indicator
ICT skills	G_Q05e Frequency of excel use G_Q05g Frequency of programming language use G_Q05d Frequency of transactions through Internet (banking, selling/buying) G_Q05a Frequency of email use G_Q05c Frequency of simple Internet use G_Q05f Frequency of word use G_Q05h Frequency of real-time discussions through ICT computer G_Q01b Frequency of reading letters, emails, memos G_Q02a Frequency of writing letters, emails, memos G_Q06 Level of computer use required for the job F_Q06b Frequency of working physically over long periods
Readiness to learn and creative problem solving	I_Q04j I like to get to the bottom of difficult things I_Q04m If I don't understand something, I look for additional information to make it clearer I_Q04h When I come across something new, I try to relate it to what I already know I_Q04b When I hear or read about new ideas, I try to relate them to real life situations to which they might apply I_Q04d I like learning new things I_Q04l I like to figure out how different ideas fit together
Managing and communication	F_Q04b Frequency of negotiating with people (outside or inside the firm or organisation) F_Q03b Frequency of planning activities of others F_Q02b Frequency of instructing and teaching people F_Q02e Frequency of advising people F_Q04a Frequency of persuading or influencing others
Self-organisation	D_Q11a extent of own planning of the task sequences D_Q11b extent of own planning of style of work D_Q11c extent of own planning of speed of work D_Q11d extent of own planning of working hours
Accountancy and selling	G_Q01g Frequency of reading financial invoices, bills etc. G_Q03b Frequency of calculate prices, costs, budget G_Q03d Frequency of using calculator F_Q02d Frequency of client interaction selling a product or a service
Advanced numeracy	G_Q03f Frequency of preparing charts and tables G_Q03g Frequency of use simple algebra and formulas G_Q03h Frequency of use complex algebra and statistics

Note: Note that the labels for two of the indicators in Grundke et al. (2017) have changed. “STEM-quantitative skills” are now labelled “Advanced Numeracy skills” and “Marketing and Accounting skills” are called “Accountancy and Selling skills”.

Source: Grundke et al. (2017), “Skills and global value chains: A characterisation”, http://dx.doi.org/10.1787/cdb5de9b-en, based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Table A3.2. Classification of 36 ISIC rev.4 sectors in digital intensive vs. less digital intensive, based on 2011-12 information

ISIC rev. 4	Industry description	Digital intensity
1-3	Agriculture, forestry and fishing [A]	Less digital intensive
5-9	Mining and quarrying [B]	Less digital intensive
10-12	Food products, beverages and tobacco [CA]	Less digital intensive

13-15	Textiles, wearing apparel, leather and related products [CB]	Less digital intensive
19	Coke and refined petroleum products [CD]	Less digital intensive
20	Chemicals and chemical products [CE]	Less digital intensive
21	Basic pharmaceutical products and pharmaceutical preparations [CF]	Less digital intensive
22-23	Rubber and plastics products, and other non-metallic mineral products [CG]	Less digital intensive
24-25	Basic metals and fabricated metal products, except machinery and equipment [CH]	Less digital intensive
35	Electricity, gas, steam and air conditioning supply [D]	Less digital intensive
36-39	Water supply; sewerage, waste management and remediation activities [E]	Less digital intensive
41-43	Construction [F]	Less digital intensive
49-53	Transportation and storage [H]	Less digital intensive
55-56	Accommodation and food service activities [I]	Less digital intensive
68	Real estate activities [L]	Less digital intensive
85	Education [P]	Less digital intensive
86	Human health activities [QA]	Less digital intensive
87-88	Residential care and social work activities [QB]	Less digital intensive
16-18	Wood and paper products, and printing [CC]	Digital intensive
26	Computer, electronic and optical products [CI]	Digital intensive
27	Electrical equipment [CJ]	Digital intensive
28	Machinery and equipment [CK]	Digital intensive
29-30	Transport equipment [CL]	Digital intensive
31-33	Furniture; other manufacturing; repair and installation of machinery and equipment [CM]	Digital intensive
45-47	Wholesale and retail trade, repair of motor vehicles and motorcycles [G]	Digital intensive
58-60	Publishing, audiovisual and broadcasting activities [JA]	Digital intensive
61	Telecommunications [JB]	Digital intensive
62-63	IT and other information services [JC]	Digital intensive
64-66	Financial and insurance activities [K]	Digital intensive
69-71	Legal and accounting activities, etc. [MA]	Digital intensive
72	Scientific research and development [MB]	Digital intensive
73-75	Advertising and market research; other professional, scientific and technical activities; veterinary activities [MC]	Digital intensive
77-82	Administrative and support service activities [N]	Digital intensive
84	Public administration and defence; compulsory social security [O]	Digital intensive
90-93	Arts, entertainment and recreation [R]	Digital intensive
94-96	Other service activities [S]	Digital intensive

Note: ISIC = International Standard Industrial Classification.

Source: OECD calculations based on Annual National Accounts, the OECD Structural Analysis Database (STAN), the OECD Inter-Country Input-Output (ICIO) tables, PIAAC, International Federation of Robotics, World Bank, Eurostat Digital Economy and Society Statistics, national labour force surveys, US CPS, INTAN-Invest and other national sources. For the methodology used, see Calvino et al. (2018).

Table A3.3. Returns to skills in digital and less digital intensive industries

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Employees**	**Employees and self- employed**		**Self-employed**	**Only non-dependent self-employed**	**Only dependent self-employed**
		Including firm size	**Excluding firm size**			
Dependent variable: hourly real wages						
(Digital sector) x (ICT skills)	-0.001	-0.010	-0.015	-0.072	-0.073	-0.086
	(0.010)	(0.011)	(0.014)	(0.044)	(0.055)	(0.063)
(Digital sector) x (management and communication skills)	0.007	0.011*	0.013*	0.033	-0.023	0.058
	(0.006)	(0.006)	(0.006)	(0.048)	(0.091)	(0.064)
(Digital sector) x (accountancy and selling skills)	-0.000	0.006	0.003	0.004	0.086	-0.046
	(0.006)	(0.009)	(0.009)	(0.046)	(0.060)	(0.057)
(Digital sector) x (advanced numeracy skills)	0.017***	0.016**	0.017**	0.026	0.043	0.003
	(0.005)	(0.006)	(0.008)	(0.042)	(0.048)	(0.064)
(Digital sector) x (self-organisation skills)	0.014***	0.018***	0.018***	0.021	-0.005	0.022
	(0.005)	(0.006)	(0.006)	(0.033)	(0.072)	(0.039)
(Digital sector) x (readiness to learn)	-0.003	0.000	-0.002	-0.001	-0.004	0.025
	(0.004)	(0.006)	(0.006)	(0.026)	(0.066)	(0.047)
(Digital sector) x (literacy)	-0.000	-0.003	0.001	0.008	0.030	-0.074
	(0.007)	(0.011)	(0.013)	(0.095)	(0.148)	(0.069)
(Digital sector) x (numeracy)	0.011	0.012	0.009	0.003	-0.015	0.094
	(0.008)	(0.011)	(0.012)	(0.094)	(0.156)	(0.075)
Dummy variable for working in a digital intensive industry	0.050***	0.055***	0.050***	0.079	0.040	0.086
	(0.009)	(0.012)	(0.012)	(0.082)	(0.108)	(0.101)
ICT skills	0.089***	0.093***	0.104***	0.106***	0.139***	0.095**
	(0.009)	(0.010)	(0.010)	(0.034)	(0.043)	(0.044)
Management and communication skills	0.039***	0.039***	0.043***	0.101***	0.161***	0.065
	(0.004)	(0.004)	(0.005)	(0.036)	(0.055)	(0.045)
Accountancy and selling skills	-0.024***	-0.029***	-0.037***	0.009	0.003	0.022
	(0.005)	(0.007)	(0.007)	(0.042)	(0.064)	(0.042)
Advanced numeracy skills	0.009**	0.011**	0.013**	0.007	0.007	0.010
	(0.004)	(0.004)	(0.005)	(0.039)	(0.044)	(0.047)
Self-organisation skills	0.023***	0.021***	0.010**	-0.015	0.078	-0.046
	(0.003)	(0.004)	(0.004)	(0.028)	(0.051)	(0.030)
Readiness to learn	-0.005	-0.009**	-0.005	-0.019	-0.069	-0.005
	(0.004)	(0.004)	(0.005)	(0.024)	(0.049)	(0.034)

Literacy	0.007 (0.006)	0.008 (0.007)	0.002 (0.008)	-0.025 (0.050)	0.008 (0.094)	-0.033 (0.051)
Numeracy	0.041*** (0.009)	0.041*** (0.009)	0.051*** (0.011)	0.111* (0.056)	0.035 (0.090)	0.144** (0.058)
Age	0.038*** (0.003)	0.038*** (0.003)	0.041*** (0.003)	0.057*** (0.013)	0.055*** (0.017)	0.059*** (0.015)
Age squared	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.000** (0.000)	-0.001*** (0.000)
Years of education	0.024*** (0.003)	0.024*** (0.003)	0.026*** (0.003)	0.026*** (0.007)	0.032*** (0.009)	0.019* (0.010)
Gender (male=='1,' female==0))	0.121*** (0.012)	0.131*** (0.012)	0.139*** (0.012)	0.264*** (0.049)	0.257*** (0.054)	0.248*** (0.074)
Dummy variable for working in a medium size firm (51-250 employees)	0.067*** (0.007)	0.070*** (0.008)				
Dummy variable for working in a big firm (>250 employees)	0.151*** (0.012)	0.151*** (0.013)				
Dummy variable for good state of health of the worker	0.056*** (0.015)	0.063*** (0.015)	0.077*** (0.020)	0.214** (0.083)	0.134* (0.070)	0.258** (0.116)
Dummy variable for very good state of health of the worker	0.076*** (0.015)	0.085*** (0.016)	0.100*** (0.020)	0.248** (0.092)	0.227** (0.090)	0.257** (0.113)
Dummy variable for working part time (<=20 hours per week)	0.069*** (0.018)	0.085*** (0.021)	0.105*** (0.024)	0.516*** (0.074)	0.482*** (0.092)	0.538*** (0.084)
Dummy variable for being a dependent self-employed		-0.427*** (0.129)	-0.591*** (0.044)	-0.267*** (0.039)		
Dummy for other self-employed		-0.158** (0.059)	-0.241*** (0.055)			
Observations	104 018	108 773	117 152	12 516	5 441	7 075
R-squared	0.579	0.492	0.431	0.230	0.222	0.219
Adjusted R-squared	0.578	0.492	0.430	0.223	0.205	0.207

Notes: The dependent variable is the log of hourly wages. In addition to the shown covariates, the specification also includes fixed effects for the country, industry and occupation the individual works in. The specification in column 1 is estimated for the sample of employees, whereas the ones in columns 2 and 3 also include self-employed workers. The specification in column 4 only includes self-employed workers, whereas columns 5 and 6 include self-employed workers who are not defined as dependent and self-employed workers who are defined as dependent, respectively. Digital intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018). The skill measures are based on PIAAC and are taken from Grundke et al. (2017). The specification is estimated by weighted OLS using individual senate weights to give each country the same weight in the regression, while robust standard errors are clustered at the country level. All skill variables are standardised to mean zero and variance of one for the pooled sample using senate weights to weight observations from single countries. (*** p<0.01, ** p<0.05, * p<0.1).*Source*: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Table A3.4. Skill supply by gender (conditional on the control variables from the wage regressions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	**ICT skills**	**Management and communication skills**	**Accountancy and selling skills**	**Advanced numeracy skills**	**Self-organisation skills**	**Readiness to learn**	**Literacy**	**Numeracy**	**Problem solving**
Gender (male=='1,' female==0))	-0.032***	0.133***	-0.056***	0.152***	0.050***	0.002	-0.108***	0.143***	-0.015
	(0.009)	(0.012)	(0.010)	(0.014)	(0.011)	(0.014)	(0.007)	(0.008)	(0.012)
Age	0.014***	0.023***	-0.004*	0.010***	0.005*	-0.021***	-0.003	0.002	-0.018***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Age squared	-0.000***	-0.000***	0.000	-0.000***	-0.000	0.000***	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Years of education	0.043***	0.008***	-0.010***	0.020***	0.002	0.028***	0.010***	0.023***	-0.001
	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Dummy variable for working in a Digital intensive Industry	0.104***	-0.020	0.025**	-0.044***	0.015	-0.022**	0.005	0.008	0.016
	(0.010)	(0.012)	(0.011)	(0.011)	(0.011)	(0.009)	(0.006)	(0.006)	(0.010)
Dummy variable for working in a medium-size firm (51-250 employees)	0.076***	0.038***	-0.172***	0.082***	-0.101***	0.025**	0.014	-0.001	0.007
	(0.007)	(0.008)	(0.008)	(0.010)	(0.008)	(0.012)	(0.009)	(0.010)	(0.013)
Dummy variable for working in a big firm (>250 employees)	0.125***	0.019	-0.271***	0.140***	-0.103***	0.064***	0.014*	0.009	0.017
	(0.009)	(0.013)	(0.012)	(0.012)	(0.014)	(0.010)	(0.008)	(0.010)	(0.014)
Dummy variable for good state of health of the worker	0.028***	-0.004	-0.002	-0.033***	0.040**	0.015	-0.005	0.030**	0.018
	(0.007)	(0.012)	(0.007)	(0.010)	(0.016)	(0.017)	(0.010)	(0.011)	(0.017)
Dummy variable for very good state of health of the worker	0.042***	0.006	-0.009	-0.031**	0.081***	0.103***	0.023**	0.020*	0.037**
	(0.009)	(0.010)	(0.007)	(0.011)	(0.013)	(0.017)	(0.009)	(0.011)	(0.014)
Dummy variable for working part time (<=20 hours per week)	-0.119***	-0.174***	-0.039***	-0.003	-0.002	0.133***	0.005	0.011	0.055***
	(0.011)	(0.014)	(0.009)	(0.009)	(0.014)	(0.013)	(0.007)	(0.008)	(0.010)
ICT skills		0.189***	0.263***	0.273***	0.156***	0.083***	0.019*	0.030***	0.106***

		(0.010)	(0.011)	(0.010)	(0.009)	(0.013)	(0.009)	(0.007)	(0.007)
Management and communication skills	0.103***		0.199***	0.050***	0.139***	0.163***	0.000	-0.004	-0.003
	(0.005)		(0.006)	(0.006)	(0.008)	(0.005)	(0.005)	(0.005)	(0.007)
Accountancy and selling skills	0.178***	0.247***		0.278***	0.078***	0.005	-0.012***	0.012***	-0.008
	(0.005)	(0.007)		(0.011)	(0.006)	(0.006)	(0.004)	(0.004)	(0.007)
Advanced numeracy skills	0.145***	0.049***	0.218***		0.013**	0.082***	-0.022***	0.048***	0.010
	(0.007)	(0.006)	(0.009)		(0.006)	(0.006)	(0.005)	(0.004)	(0.006)
Self-organisation skills	0.070***	0.114***	0.051***	0.011**		0.124***	0.006	0.004	0.013**
	(0.004)	(0.006)	(0.004)	(0.005)		(0.006)	(0.004)	(0.004)	(0.005)
Readiness to learn	0.034***	0.124***	0.003	0.064***	0.115***		0.017***	0.008	0.030***
	(0.005)	(0.005)	(0.004)	(0.006)	(0.005)		(0.006)	(0.005)	(0.009)
Literacy	0.023*	0.001	-0.023***	-0.052***	0.017	0.051***		0.784***	0.512***
	(0.012)	(0.012)	(0.008)	(0.012)	(0.012)	(0.017)		(0.011)	(0.017)
Numeracy	0.040***	-0.009	0.023***	0.118***	0.012	0.025	0.811***		0.314***
	(0.010)	(0.012)	(0.008)	(0.010)	(0.011)	(0.016)	(0.006)		(0.020)
Observations	104 018	104 018	104 018	104 018	104 018	104 018	104 018	104 018	77 682
R-squared	0.705	0.461	0.548	0.450	0.312	0.282	0.759	0.766	0.675
Adjusted R-squared	0.704	0.461	0.547	0.449	0.311	0.281	0.758	0.766	0.675

Notes: The dependent variables are the standardised individual skill endowments, whereby each column represents a specification with one of the skill variables as dependent variable (denoted in the column header). For each skill variable, an OLS regression of workers skill endowments on the covariates from the wage regressions in Figure 22 is estimated (except for the interaction terms; see also Table A3.3, column 1). The skill measures are based on PIAAC and are taken from Grundke et al. (2017). The estimation sample comprises all employees who reported an hourly wage in PIAAC and are included in the specification of Table A3.3, column 1. In addition to the shown covariates, the specifications also include fixed effects for the country, industry and occupation the individual works in. The estimation sample comprises all employees who reported an hourly wage in PIAAC. The specification is estimated by weighted OLS using individual senate weights to give each country the same weight in the regression, while robust standard errors are clustered at the country level. All skill variables are standardised to mean zero and variance of one for the pooled sample using senate weights to weight observations from single countries. (*** p<0.01, ** p<0.05, * p<0.1).

Source: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Table A3.5. Skill supply by gender (including the self-employed; conditional on the control variables from the wage regressions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	**ICT skills**	**Management and communication skills**	**Accountancy and selling skills**	**Advanced numeracy skills**	**Self-organisation skills**	**Readiness to learn**	**Literacy**	**Numeracy**	**Problem solving**
Gender (male=='1,' female==0))	-0.032***	0.133***	-0.056***	0.152***	0.050***	0.002	-0.108***	0.143***	-0.015
	(0.009)	(0.012)	(0.010)	(0.014)	(0.011)	(0.014)	(0.007)	(0.008)	(0.012)
Age	0.014***	0.023***	-0.004*	0.010***	0.005*	-0.021***	-0.003	0.002	-0.018***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Age squared	-0.000***	-0.000***	0.000	-0.000***	-0.000	0.000***	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Years of education	0.043***	0.008***	-0.010***	0.020***	0.002	0.028***	0.010***	0.023***	-0.001
	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Dummy variable for working in a Digital intensive Industry	0.104***	-0.020	0.025**	-0.044***	0.015	-0.022**	0.005	0.008	0.016
	(0.010)	(0.012)	(0.011)	(0.011)	(0.011)	(0.009)	(0.006)	(0.006)	(0.010)
Dummy variable for working in a medium-size firm (51-250 employees)	0.076***	0.038***	-0.172***	0.082***	-0.101***	0.025**	0.014	-0.001	0.007
	(0.007)	(0.008)	(0.008)	(0.010)	(0.008)	(0.012)	(0.009)	(0.010)	(0.013)
Dummy variable for working in a big firm (>250 employees)	0.125***	0.019	-0.271***	0.140***	-0.103***	0.064***	0.014*	0.009	0.017
	(0.009)	(0.013)	(0.012)	(0.012)	(0.014)	(0.010)	(0.008)	(0.010)	(0.014)
Dummy variable for good state of health of the worker	0.028***	-0.004	-0.002	-0.033***	0.040**	0.015	-0.005	0.030**	0.018
	(0.007)	(0.012)	(0.007)	(0.010)	(0.016)	(0.017)	(0.010)	(0.011)	(0.017)
Dummy variable for very good state of health of the worker	0.042***	0.006	-0.009	-0.031**	0.081***	0.103***	0.023**	0.020*	0.037**
	(0.009)	(0.010)	(0.007)	(0.011)	(0.013)	(0.017)	(0.009)	(0.011)	(0.014)
Dummy variable for working part time (<=20 hours per week)	-0.119***	-0.174***	-0.039***	-0.003	-0.002	0.133***	0.005	0.011	0.055***
	(0.011)	(0.014)	(0.009)	(0.009)	(0.014)	(0.013)	(0.007)	(0.008)	(0.010)

ICT skills		0.189***	0.263***	0.273***	0.156***	0.083***	0.019*	0.030***	0.106***
		(0.010)	(0.011)	(0.010)	(0.009)	(0.013)	(0.009)	(0.007)	(0.007)
Management and communication skills	0.103***		0.199***	0.050***	0.139***	0.163***	0.000	-0.004	-0.003
	(0.005)		(0.006)	(0.006)	(0.008)	(0.005)	(0.005)	(0.005)	(0.007)
Accountancy and selling skills	0.178***	0.247***		0.278***	0.078***	0.005	-0.012***	0.012***	-0.008
	(0.005)	(0.007)		(0.011)	(0.006)	(0.006)	(0.004)	(0.004)	(0.007)
Advanced numeracy skills	0.145***	0.049***	0.218***		0.013**	0.082***	-0.022***	0.048***	0.010
	(0.007)	(0.006)	(0.009)		(0.006)	(0.006)	(0.005)	(0.004)	(0.006)
Self-organisation skills	0.070***	0.114***	0.051***	0.011**		0.124***	0.006	0.004	0.013**
	(0.004)	(0.006)	(0.004)	(0.005)		(0.006)	(0.004)	(0.004)	(0.005)
Readiness to learn	0.034***	0.124***	0.003	0.064***	0.115***		0.017***	0.008	0.030***
	(0.005)	(0.005)	(0.004)	(0.006)	(0.005)		(0.006)	(0.005)	(0.009)
Literacy	0.023*	0.001	-0.023***	-0.052***	0.017	0.051***		0.784***	0.512***
	(0.012)	(0.012)	(0.008)	(0.012)	(0.012)	(0.017)		(0.011)	(0.017)
Numeracy	0.040***	-0.009	0.023***	0.118***	0.012	0.025	0.811***		0.314***
	(0.010)	(0.012)	(0.008)	(0.010)	(0.011)	(0.016)	(0.006)		(0.020)
Observations	104 018	104 018	104 018	104 018	104 018	104 018	104 018	104 018	77 682
R-squared	0.705	0.461	0.548	0.450	0.312	0.282	0.759	0.766	0.675
Adjusted R-squared	0.704	0.461	0.547	0.449	0.311	0.281	0.758	0.766	0.675

Notes: The dependent variables are the standardised individual skill endowments, whereby each column represents a specification with one of the skill variables as dependent variable (denoted in the column header). For each skill variable, an OLS regression of workers skill endowments on the covariates from the wage regressions in Table A3.3 is estimated (except for the interaction terms; see Table A3.3, column 3). The skill measures are based on PIAAC and are taken from Grundke et al. (2017). The estimation sample comprises all employees and self-employed workers who reported an hourly wage in PIAAC and are included in the specification in Table A3.3 column 3. In addition to the shown covariates, the specifications also include fixed effects for the country, industry and occupation the individual works in. The dummy variables for firm size are not included, as over 60% of the self-employed did not report information on the firm size. The specification is estimated by weighted OLS using individual senate weights to give each country the same weight in the regression, while robust standard errors are clustered at the country level. All skill variables are standardised to mean zero and variance of one for the pooled sample using senate weights to weight observations from single countries. (*** p<0.01, ** p<0.05, * p<0.1).

Source: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Table A3.6. Differences in skill returns by gender and digital vs. less digital intensive industries

	(1)	(2)	(3)	(4)	(5)	(6)
		Employees			Employees and self-employed	
Variables	All Industries	Digital intensive industries	Less digital intensive industries	All industries	Digital intensive industries	Less digital intensive industries
			Dependent variable: hourly real wages			
(Gender) x (ICT skills)	-0.038***	-0.037***	-0.043***	-0.038***	-0.037***	-0.045***
	(0.008)	(0.007)	(0.012)	(0.010)	(0.009)	(0.014)
(Gender) x (management and communication skills)	0.012*	0.018*	0.007	0.014**	0.016*	0.014
	(0.006)	(0.009)	(0.007)	(0.007)	(0.009)	(0.009)
(Gender) x (accountancy and selling skills)	0.004	0.003	-0.001	0.004	0.002	0.002
	(0.007)	(0.007)	(0.010)	(0.007)	(0.008)	(0.011)
(Gender) x (advanced numeracy skills)	0.019***	0.023***	0.017	0.017**	0.018**	0.017
	(0.007)	(0.006)	(0.010)	(0.008)	(0.008)	(0.011)
(Gender) x (self-organisation skills)	0.008	0.003	0.012	0.011	0.007	0.015
	(0.006)	(0.007)	(0.009)	(0.007)	(0.007)	(0.010)
(Gender) x (readiness to learn)	-0.021***	-0.027**	-0.017*	-0.020**	-0.026**	-0.016
	(0.007)	(0.011)	(0.009)	(0.007)	(0.011)	(0.010)
(Gender) x (literacy)	-0.002	-0.001	-0.003	-0.003	0.006	-0.013
	(0.011)	(0.016)	(0.012)	(0.014)	(0.021)	(0.016)
(Gender) x (numeracy)	0.019	0.014	0.024	0.016	0.007	0.026
	(0.012)	(0.015)	(0.014)	(0.014)	(0.020)	(0.016)
ICT skills	0.110***	0.104***	0.115***	0.111***	0.101***	0.120***
	(0.009)	(0.008)	(0.012)	(0.010)	(0.009)	(0.014)
Management and communication skills	0.037***	0.034***	0.038***	0.037***	0.037***	0.035***
	(0.004)	(0.007)	(0.004)	(0.005)	(0.006)	(0.006)
Accountancy and selling skills	-0.026***	-0.027***	-0.022***	-0.028***	-0.031***	-0.021***
	(0.004)	(0.006)	(0.006)	(0.005)	(0.006)	(0.007)
Advanced numeracy skills	0.007	0.012**	0.001	0.009*	0.017**	0.001
	(0.005)	(0.005)	(0.007)	(0.006)	(0.006)	(0.007)
Self-organisation skills	0.025***	0.038***	0.014**	0.023***	0.036***	0.011*
	(0.004)	(0.006)	(0.005)	(0.004)	(0.006)	(0.006)
Readiness to learn	0.003	0.005	0.004	0.001	0.004	0.000
	(0.005)	(0.007)	(0.006)	(0.005)	(0.008)	(0.007)
Literacy	0.008	0.009	0.005	0.009	0.005	0.012
	(0.005)	(0.008)	(0.007)	(0.006)	(0.010)	(0.009)

Numeracy	0.036***	0.044***	0.027***	0.039***	0.051***	0.026***
	(0.008)	(0.011)	(0.008)	(0.008)	(0.011)	(0.009)
Age	0.039***	0.043***	0.034***	0.039***	0.044***	0.032***
	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)
Age squared	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Years of education	0.023***	0.023***	0.024***	0.024***	0.024***	0.024***
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)
Gender (male=='1,' female==0))	0.127***	0.131***	0.113***	0.137***	0.140***	0.125***
	(0.012)	(0.012)	(0.014)	(0.011)	(0.012)	(0.014)
Dummy variable for working in a medium size firm (51-250 employees)	0.067***	0.075***	0.062***	0.070***	0.080***	0.062***
	(0.007)	(0.008)	(0.010)	(0.008)	(0.008)	(0.010)
Dummy variable for working in a big firm (>250 employees)	0.151***	0.153***	0.149***	0.151***	0.157***	0.145***
	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)
Dummy variable for good state of health of the worker	0.056***	0.053***	0.057***	0.063***	0.062***	0.064***
	(0.015)	(0.014)	(0.018)	(0.015)	(0.016)	(0.017)
Dummy variable for very good state of health of the worker	0.076***	0.079***	0.071***	0.086***	0.092***	0.078***
	(0.014)	(0.012)	(0.019)	(0.015)	(0.018)	(0.018)
Dummy variable for working part time (<=20 hours per week)	0.071***	0.056**	0.084***	0.087***	0.075**	0.097***
	(0.019)	(0.025)	(0.016)	(0.022)	(0.028)	(0.019)
Dummy variable for being a dependent self-employed				-0.426***	-0.457	-0.427***
				(0.127)	(0.270)	(0.132)
Dummy for “other” self-employed				-0.164***	-0.096	-0.224***
				(0.059)	(0.064)	(0.069)
Observations	104 711	50 406	53 612	109 480	52 605	56 168
R-squared	0.578	0.587	0.574	0.492	0.511	0.480
Adjusted R-squared	0.577	0.586	0.574	0.492	0.510	0.479

Notes: The dependent variable is the log of hourly wages. In addition to the shown covariates, the specification also includes fixed effects for the country, industry and occupation the individual works in. Digital intensive industries are defined using a new measure for digital penetration developed by Calvino et al. (2018). The skill measures are based on PIAAC and are taken from Grundke et al. (2017). The specifications in columns 1 and 4 include workers from all industries, whereas columns 2 and 5 (3 and 6) only include workers from digital intensive industries (less digital intensive industries). Specifications in columns 1 to 3 are estimated for the sample of employees, columns 4 to 6 also include self-employed workers. The specification is estimated by weighted OLS using individual senate weights to give each country the same weight in the regression, while robust standard errors are clustered at the country level. All skill variables are standardised to mean zero and variance of one for the pooled sample using senate weights to weight observations from single countries. (*** p<0.01, ** p<0.05, * p<0.1).

Source: OECD calculations based on OECD (2017m), *Survey of Adult Skills (PIAAC)* (database), www.oecd.org/skills/piaac/.

Methodology

This analysis assesses the returns to different types of skills, i.e. cognitive as well as non-cognitive skills and personality traits, by estimating individual level wage regressions (so-called Mincer regressions) on data from PIAAC. To answer the question on what skills are needed for the digital transformation, it further investigates whether these returns to skills differ between industries that are digital intensive, as compared to those that have undergone the digital transformation to a lesser extent. Moreover, it also focuses on differences in skill returns by gender to shed light on how skills policies might help in closing the gender wage gap and preparing more disadvantaged groups of the population for the challenges posed by the digital transformation.

Differently from Hanushek et al. (2015) and Falck, Heimisch and Wiederhold (2016), the present study is the first to include measures of task-based skills from Grundke et al. (2017). This is important for two reasons, one policy-related, the other technical. On the one hand, markets reward cognitive as well as non-cognitive skills, and policy makers need information about labour market returns to non-cognitive skills to be able to design suitable education and training policies. On the other hand, the presence of an extra set of controls reduces the extent to which possible omitted variables may bias our estimates. The estimated Mincer regressions investigate whether the following skills are complementary to the digitalisation of the workplace: the cognitive skills numeracy and literacy (as well as, in robustness checks, problem solving in technology-rich environments[1]); the task-based skills ICT, managing and communication, accountancy and selling, self-organisation and advanced numeracy skills; and the personality trait readiness to learn and creative problem solving.

The empirical hypothesis underlying the analysis is that sectors that are digital intensive should reward workers' skills differently, and possibly more (assuming equal supply of skills across sectors), than sectors that have been penetrated to a lesser extent by the digital transformation (conditional on other worker-specific observable characteristics, and other controls which are specified below). Such a hypothesis has its roots in the "canonical" model of human capital in Goldin and Katz (2009), where technological progress raises the demand for skills. As some of the above-mentioned skills are easier to supply than others, the returns to skills in the whole economy are expected to vary with the type of skill considered. If one assumes that advanced numeracy skills are harder to shape than, e.g. managing and communication ones, or if they are rarer among workers, one should expect markets to offer a higher premium for advanced numeracy than for managing and communication skills.

In addition, workers with different skills may be carrying out different tasks, which in turn may have different degrees of complementarity with technology (e.g. Acemoglu and Autor, 2012). While it would be natural to expect that digital intensive sectors reward the same skill more than less digital intensive ones,[2] a task-based perspective would allow for the existence of non-linearities in the way skills are rewarded relative to the technological endowment of firms and sectors. Occupational polarisation, for example (Acemoglu and Autor, 2010), is well-known to have raised the wages of individuals, both at the top and bottom of the skill distribution, because both these types of workers carry out tasks which cannot be substituted by computers. Given all the above, the sign of the difference in skill returns between digital and less digital intensive sectors remains *ex-ante* ambiguous.

These hypotheses are tested on the pooled sample of the working population of all 31 PIAAC countries and economies,[3] based on the following empirical specification, for each individual *i*:

$$\log(wage)_i = \alpha_0 + \alpha_1 DigInd_k + DigInd_k * \boldsymbol{skills}_i\boldsymbol{\beta} + \boldsymbol{skills'}_i\boldsymbol{\gamma} + \boldsymbol{x'}_i\boldsymbol{\delta}$$

$$+\boldsymbol{\mu}_c + \boldsymbol{\sigma}_{Tiva18} + \boldsymbol{\rho}_{isco08} + \boldsymbol{u}_i \qquad (1)$$

The dependent variable is the log of the gross hourly wage in US dollars (including bonus payments).[4] The dummy variable *DigInd* indicates whether an individual *i* works in a digital intensive industry. 2-digit ISIC rev.4

industries are defined as digital intensive if they display a higher digital intensity than the median among all 36 industries (across countries,[5] see Table A3.2). The dummy variable for digital intensive industry is interacted with each of the skill variables (i.e. the vector skills), namely: numeracy, literacy, ICT, managing and communication, accountancy and selling, self-organisation, advanced numeracy skills, or readiness to learn and creative problem solving.

The coefficients of interest are captured by the vector β, which includes the coefficients of the interaction of the digital intensive industry dummy variable and all the skill variables considered. A positive and significant coefficient in the vector β indicates that individuals working in a job in a digital intensive industry are additionally rewarded by labour markets for the specific skill under consideration, compared to the same jobs being performed in less digitalised industries. This would imply that the use of digital technologies and the skill under consideration are complements in the production process and signal the need for workers to acquire those skills to cope with the increasing digitalisation of their workplaces.

The vector x includes additional covariates at the worker's level, namely: age, age squared, years of education, gender, two dummy variables for the size of the firm the individual works in (either medium-sized firm, defined as having 51-250 employees; or large firm, having more than 250 employees, the comparison group being small firms, defined as firms with up to 50 employees[6]), a dummy variable for whether the individual works less than 21 hours a week (to account for possible part time-related patterns), as well as two dummy variables for the state of health of the individual (good and very good health, the comparison group being poor health). Fixed effects for countries (μ), for 18 aggregated industries (σ) (OECD Trade in Value Added [TiVA] 18 industry list)[7] as well as for ISCO08-two digit occupations (ρ) are also included to control for unobserved wage determinants at the country, industry and occupation level.[8] All specifications are estimated by weighted OLS using individual senate weights, which are based on the population weights included in the PIAAC data set and ensure that each country is given the same weight in the regression. Standard errors are clustered at the country level. All skill variables are standardised to mean zero and variance one for the pooled sample using senate weights to weight observations from single countries.

While advancing the returns to skills discussion in many ways, the present analysis nevertheless does not treat the endogeneity of sectors explicitly, at least in this first stage. However, the high degree of consistency of results across specifications buttresses the importance of selected cognitive and non-cognitive skills for wage determination, and how these differ between digital and less digital intensive sectors.

Regarding the analysis of the returns to skills by gender, the empirical specification is the same of the one described above, but the dummy variable for working in a digital intensive industry (DigInd) is replaced by a dummy variable for being male (taking the value 1 if the individual is male and 0 if female). Accordingly, the gender variable is excluded from the vector of control variables (x). For the regressions investigating the differences of skill returns between men and women, the regressions were estimated for the sub-samples of workers in digital and less digital intensive industries, respectively.

Annex notes

1. Problem solving in technology rich environments is not included in the baseline specification as this variable is not available for France, Italy and Spain (as these countries did not participate in the test, the sample would decrease by almost 30 000 observations) and suffers from non-response problems in the other countries. In robustness checks where this cognitive skill measure is included, results do not change.
2. The higher level of technology adoption in digital intensive sectors can make individuals more productive for each level of skill endowment, and this productivity is rewarded in the form of salaries (e.g. to motivate workers). Firms in digital intensive sectors may also invest more in their internal organisation, so as to react

flexibly to changes in the production environment, and may therefore be better at matching workers with the job tasks that suit them the best. They may also be better at monitoring workers thanks to the technology embedded in production.

3. The sample covers the following 31 OECD countries and partner economies: Australia, Austria, Belgium (Flanders), Canada, Chile, the Czech Republic, Germany, Denmark, Estonia, Finland, France, Greece, Ireland, Italy, Israel, Japan, Korea, Lithuania, the Netherlands, New Zealand, Norway, Poland, the Russian Federation (excluding Moscow), Singapore, the Slovak Republic, Slovenia, Spain, Sweden, Turkey, the United Kingdom (England and Northern Ireland) and the United States.
4. In a second specification, the dependent variable log of the monthly wage is used and results do not change. Results can be obtained from the authors upon request.
5. In robustness checks, a digital intensive industry is defined as an industry with a higher digital intensity than the 75th percentile for all 36 considered industries (results can be obtained from the authors upon request).
6. The size classes are so-defined in the PIAAC dataset itself.
7. These 18 industries are aggregates of the 34 industries used in the OECD TiVA database, and include two resource extraction sectors, nine manufacturing sectors and seven services sectors.
8. In robustness checks, combined fixed effects for countries and 18 aggregated industries (TiVA 18) are included and results do not change. We also include fixed effects for 3-digit ISCO08 occupation categories and results do not change. Results can be obtained from the authors upon request.

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