CHAPTER 4.1

INNOVATION, THE FUTURE OF WORK AND INEQUALITY

KEY FIGURES

11.1%
adult participation in learning

73%
of platform workers are men

1 in 5
jobs created in 2017 were part-time

133 million
new work roles may emerge worldwide until 2022

What can we learn?

- Digitalisation, automation, and robotisation risk creating **job displacement and further shrinking the labour share of income**, which could have consequences for inequality, particularly income inequality and inequality in opportunities.
- **Changing skills demand may lead to high job polarisation** in the labour market and is hollowing out the middle-skilled jobs.
- Even if technologies and business models may produce a sufficient number of new jobs to keep unemployment low, **they may contribute to a decline in overall job quality and employment standards**.
- While there is a lack of evidence on **massive disruption across sectors**, technological transformation will not be friction free and individuals or whole sectors need to **capitalise on the benefits** of new technologies in the workplace.
- The emergence of digital technologies **does not help to close the gender gap**, as observed by the lower participation of women in ICT-related fields and platform work.

What does it mean for policy?

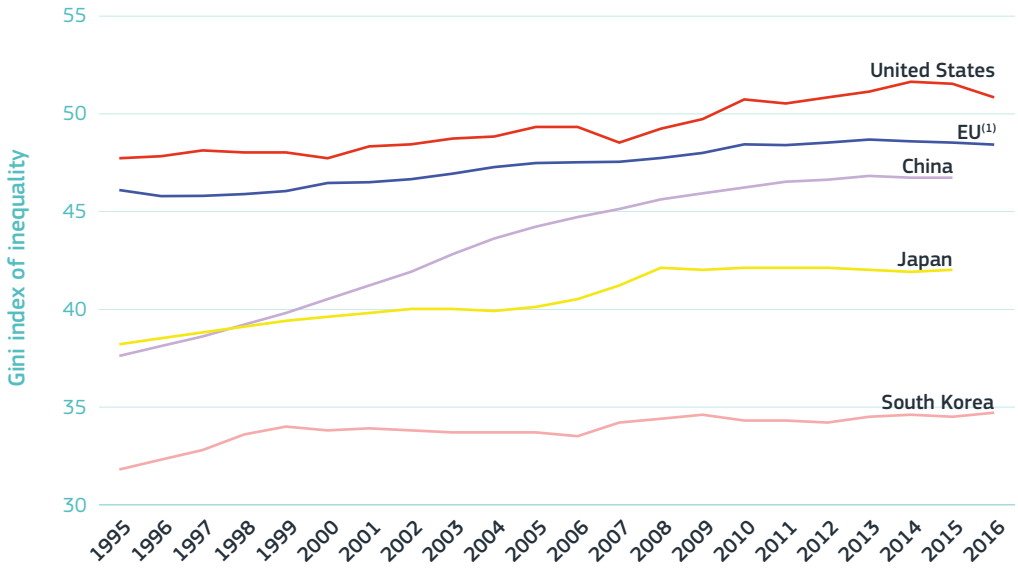
- With very limited growth in the share of adults participating in education and training, it is important to increase **adult participation in learning**, in particular for those in most need of access to learning.
- Improved **skills intelligence, labour-market relevant skills provision, transparency and recognition** of all types of skills remain a challenge. Increased synergies among programmes such as Horizon Europe, the European Social Fund (ESF) and Erasmus+ could address these challenges at different stages. Furthermore, policymakers need better **intelligence to act** (shorter forecasts, scenario planning and simulations in forecasting models) and **policy design that allows for a quick response**.
- Uptake of new technologies and industries has not helped reduce gender gaps; policies to **support the participation of women in specialised ICT-related positions** should be maintained and where possible reinforced to make further progress.

1. Rise in inequality and its perception related to technological developments

Inequality has been growing in most advanced economies in recent years, as indicated by the Gini coefficient of market income inequality (Figure 4.1-1). The index shows that inequality in market income has grown with the EU currently facing similar levels of market income inequality as in the United States. Nevertheless, Europe remains a more equal place to live compared to other countries because the national tax and welfare systems reduce the relatively high market income inequality. Although a substantial mitigation of a general rise in income inequality can be observed in Europe, there are certain age groups or places of residence that face increased income inequality (OECD, 2019). Furthermore, phenomena such as youth unemployment and inequality of opportunity can have long-lasting effects on young people in many European regions.

While fiscal policy has a direct impact on disposable income (i.e. after taxes and social benefits), **other policies enhancing productivity and real wages, or upgrading skills and providing equal opportunities can be equally important. Technological change ranks among the most important factors**[1] **affecting income distribution** as an increase in the demand for high-skilled employees leads to increases in their wage premiums and amplifies wage dispersion (EC, 2017).

Figure 4.1-1 Gini index of inequality - household market income (pre-tax, pre-transfer), 1995-2016



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat data

Note: (1)EU is the weighted average of the values for the EU Member States.

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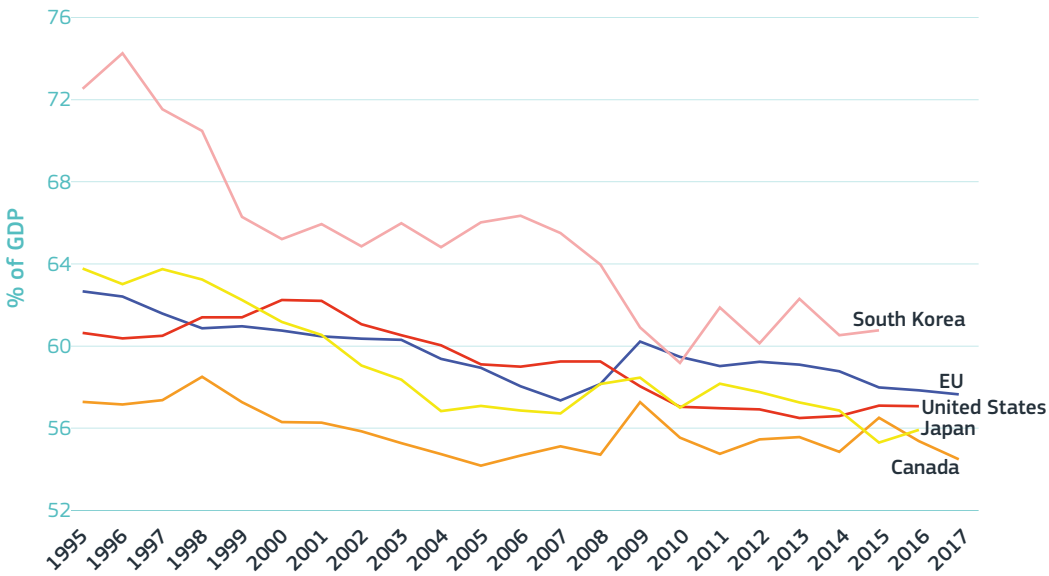
1 Globalisation, demographic developments and household composition rank among other factors.

This growing inequality is closely related to technological change that has affected the distribution of production factors towards higher shares of capital and technology (Figure 4.1-2). With the increasing ability of machines – potentially reinforced with contributions from artificial intelligence – to automate a greater number of job tasks performed by humans, the distributional implications increase inequality. As automation increases productivity and decreases the cost of production, it can lead to deeper automation – i.e. further improvements to existing machinery in tasks that have already been automated.

Although both effects further increase demand for labour, automation contributes to a higher increase in outputs per worker than their wages and therefore the labour share in national income could shrink. This would mean that the rise in real incomes[2] resulting from automation is skewed towards a narrow segment of the population with much lower marginal propensity to consume than those losing incomes and possibly their jobs (Acemoglu and Restrepo, 2018). Such a technologically accelerated substitution of labour with capital could introduce productivity gains while also reducing the labour share of income and contributing to future inequalities affecting mostly lower-skilled workers. Companies are

Figure 4.1-2 Evolution of labour income(1) share (as % of GDP), 1995-2017



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat, OECD and DG Economic and Financial Affairs (AMECO database)

Note: (1)Labour income is calculated by multiplying compensation of employees by hours worked by all those employed (total employment domestic concept) and divided by the hours worked by employees.

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2 Evolution of the labour income share in the EU28 reveals a declining trend from 72 % in 1995 to around 60 % in 2015.

increasingly relying on a variety of intangible assets such as, for example, goodwill or patents, and it is increasingly the low-skilled workers who suffer the negative consequences brought about by technological change and new types of capital assets. A closer look at the intangibles within the distribution of income is crucial to understand the decline in labour shares over past decades.

More unequal distributions of income and wealth have increased attention to tax shifts towards capital. As there is a gap between capital income and labour income taxation, higher labour taxation could dampen employment levels and contribute to higher capital accumulation. Therefore, the suggestion is that shifting taxes away from labour towards capital could increase the labour share and lead to stronger overall productivity growth (JRC, 2019a). Important policy questions relate to how and where to tax capital income and what might be the broader economic effects of such taxation (Mathé et. al., 2015).

2. Broad technological uptake would have repercussions for the quantity and quality of jobs

While employment rates are at record high numbers since the crisis in many European countries and in the United States[3], polarisation has appeared in the job market with a significant shrinking of medium-skilled routine jobs and an increase in high- and low-skilled jobs. With almost 236 million people in employment in 2017, EU employment is at an all-time high and means an increase of 19.5 million since 2002 (EC, 2018). This is mainly due to a strong increase in female employment as well as a higher employment rate among older workers. As labour market conditions have continued to improve, many countries have reached values above their pre-crisis level (Figure 4.1-3). The same applies to unemployment rates which have continued to fall across the EU. In April 2019, the unemployment rate had dropped to 6.8% in the EU, which is the lowest level since 2008[4].

Available evidence concerning the impact of new technological development on the labour market is inconclusive[5]. A high level of uncertainty accompanies different estimates, as they are highly sensitive to the choice of data sources and the methods used to categorise tasks. Implications for the net displacement of jobs will depend on the new models of work organisation and management of workplaces, including platform work and new unconventional working arrangements. Figure 4.1-4 shows various assessments of automatable job shares, but also more balanced employment effects when job-creation effects are included (Wolter et al. 2015; Arntz et al. 2018).

While estimates identified a broad range of job shares with routine tasks, it seems that automation and digitalisation are less likely to destroy large numbers of jobs in the short term. A greater

3 Employment rate (age range 15-64) in OECD countries rose from 66% in 2010 to 69.5% in 2017; in the EU from 64.1 % to 67.7% and the United States from 66.7% to 70.1%.

4 EU (from 2019) value; Eurostat. Unemployment – monthly average.

5 See European Commission (2018) Chapter 2, World Bank (2016), Frey and Osborne (2013; 2017), Nedelkoska and Quintini (2018).

Figure 4.1-3 Labour force participation rate, 15-64 year-olds, as % in same age group, 2006 and 2018

Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: lfsi_emp_a) and OECD data

Note: Employment by activity - total active population as percentage of total population. The economically active population is the sum of employed and unemployed people. Inactive people are those who, during the reference week, were neither employed nor unemployed. (1)EU estimated by DG Research and Innovation.

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degree of automation and data exchange in manufacturing technologies will inevitably affect firms' strategic approaches and organisational models in their production and innovation systems. Low-qualified and low-skilled workers are likely to bear the burden of the adjustment costs as trends in the labour market seem to work against them. Therefore, the likely challenge for the future lies in coping with rising inequality and ensuring sufficient training, especially for low-qualified workers. To understand the magnitude of the challenge, various attempts have been made to assess the share of automatable jobs (Figure 4.1-4). A full understanding of broader impacts and reskilling needs demands factoring in issues such as adjustments in learning systems, individual motivation, and financing schemes, which represent additional layers of complexity.

While many of the current jobs will become obsolete through technology, many others will change the set of performed tasks and new jobs will be created. The changing task content of occupations introduced by technological innovations ranges from generally reducing the importance of physical tasks to higher safety standards and better-quality jobs (see Box 4.1-1).

Figure 4.1-4 Share of highly automatable jobs and net effects on employment

Source	Share of automatable jobs	Time horizon	Remarks
Frey and Osborne (2013)	47 %	10–20 years	USA, all sectors
Bowles (2014)	47 % to 60 %	10–20 years	EU Member States, following the approach of Frey and Osborne (2013)
Bonin et al. (2015)	12 %		DE, all sectors
Arntz et al. (2016)	9 %		21 OECD countries, following the approach of Bonin et al. 2015
World Bank (2016)	50 % to 60 %	coming decades	USA and Europe, real effects moderated by lower wages and slower technology adoption
Nedelkoska and Quintini (2018)	14 %	10–20 years	32 developed, mostly OECD countries, following the approach of Arntz et al. (2016)
Source	**Automatable jobs and job creation**	**Time horizon**	**Remarks**
Wolter et al. (2015)	- 1 %	25 years	DE, manufacturing, incl. economy-wide compensation effects
Arntz et al. (2018)	+1.8 %	5 years	DE, incl. job-creation effects, baseline

Source: DG Research and Innovation

Note: See the references for full citations. Conclusions simplifed for presentation purposes.

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BOX 4.1-1 Current jobs with new tasks

Innovations in **production techno-logies and work organisation** reduce **workplace risks** and increase the **overall quality of jobs**. In recent decades, automation technologies have helped to significantly improve health and safety across industries. The quality of jobs can be broadly understood as a measure of the richness of work and creative human activity. It is improved by more intellectual tasks which increase the variety and stimulation. a shift to more work in teams along assembly lines helps to boost social interaction in the workplace (Eurofound, 2019).

New jobs are not centred on the automation process with humans plainly assisting machines or algorithms in the production process. Although many new occupations will be enabled through technology, they will not be technology- or machine-specific. New jobs will respond to human needs and societal challenges, such as global warming or food production[6]. The downside of this is that educators are often tasked with tackling the problems of preparing people during education for jobs that do not yet exist, eventually using technologies that have not yet been invented and solving problems that we have yet to define clearly (Penaluna and Rae, 2018). Any forecasts about the number of newly created jobs or predictions on the net destruction of jobs must be taken with caution (Chapter 11 - The consequences of AI-based technologies for jobs). Replacing labour with technology is accompanied by countervailing mechanisms that are difficult to quantify. Dedicated studies, such as that by Bruegel on the impact of industrial robots on employment conclude with displacement effects, particularly significant for medium-skilled workers, for example[7]. A later study by Autor and Salomons (2018) shows that although automation leads to job displacement in industries, it facilitates indirect employment gains in customer industries and contributes increasing aggregate demand, ultimately leading to net employment growth. Given the human imagination and ingenuity, other estimations are oriented towards more qualitative approaches categorising new roles and jobs according to their technological proximity, time horizon or emerging sectors of the economy (Figure 4.1-5).

The effects of an increasingly digital economy, including many jobs created through the platform economy and new unconventional working arrangements, start to emerge for a growing number of workers. Permanent full-time employment constitutes the largest share of employment by far, although a growing incidence of less standard forms of employment may bring structural change. Contractual stability and employment quality still greatly depend on industrial relations and coverage by collective agreements. The evidence shows that one in ten adults have some experience of supplying goods or services on internet platforms (Figure 4.1-6). The majority of platform workers provide professional services (such as software development, translation services, or writing) which demand high skill levels (Gonzalez Vazquez et al., 2019).

New technologies could provide workers with greater job satisfaction, but they can also demand more flexibility, creating new jobs that are less stable. New ways of working emerge on digital platforms and in the collaborative economy, with more part-time and freelance work and self-employment. The new features, such as higher degree of flexibility, a better work-life balance, and supplementary income inevitably bring the traditional employer-employee relationship into question. Online platforms acting as intermediaries between service users and providers revoke the temporary work agency model. Service providers working for the platforms are considered self-employed by the platform, even though the relationship between them often has features of an employment relationship based largely on subordination[8].

6 Experts list jobs such as 'vertical farm consultant' or 'tidewater architect'; Cognizant (2018). 42 Jobs: The Road to 2028-2029.

7 The study examined the impact of industrial robots on employment and wages in six EU countries that account for 85.5 % of the EU market for industrial robots. The assessment was that one additional robot per thousand workers would reduce the employment rate by 0.16-0.20 percentage points. The study also found a particularly strong displacement effect for medium-skilled workers and for young cohorts. Chiacchio, F., Petropoulos, G. and Pichler, D. (2018), The Impact of Industrial Robots on EU Employment and Wages: a Local Labour Market Approach, Bruegel Working Papers, Issue 2.

8 More details in the Commission report 'The Future of Work? Work of the Future!', a report by Michel Servoz.

Figure 4.1-5 Jobs of the future along expected time horizon and tech-centricity

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Source: Cognizant forecast based on the report 21 More Jobs of the Future (2018)

Note: Cognizant presented 21 jobs of the future in the order they expect them to appear. A more detailed description of each job is available in the report.

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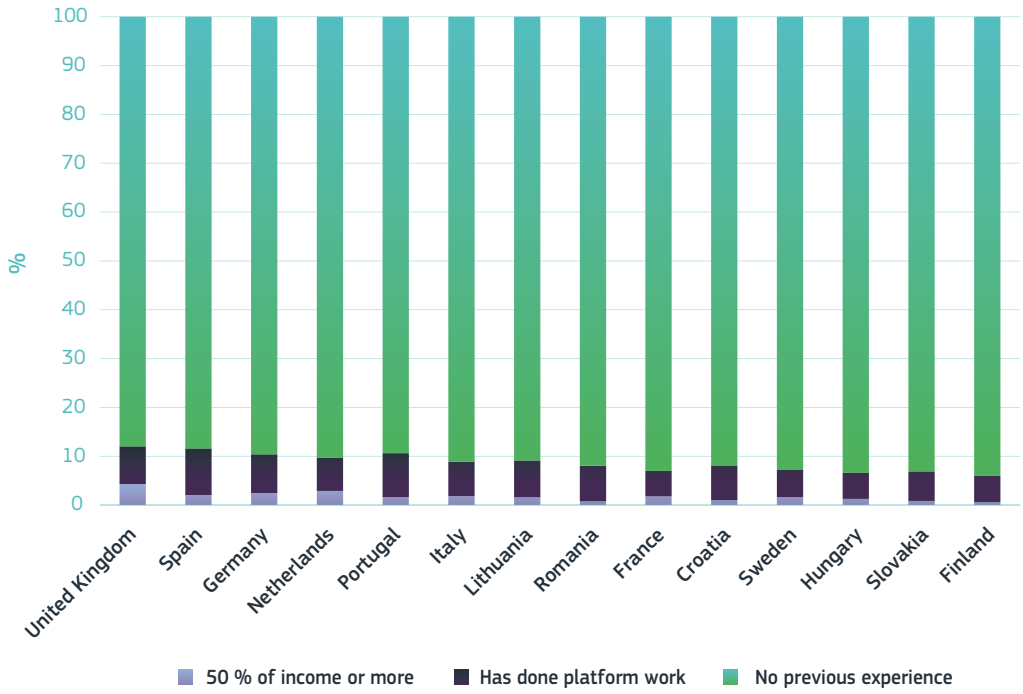
While embracing the benefits of flexibility enabled by technologies, the future employee-employer relationship will have to deal with challenges such as rules on working time, equal access to training, and other benefits. Due to the slowly evolving nature of these challenges and a lack of robust evidence sometimes, many national governments are responding via policy experimentation. The Dutch government proposed to regulate self-employment with a minimum hourly rate for self-employed people, while French independent workers enjoy full rights to set up or participate in trade unions (JRC, 2019a; SZW, 2019).

Figure 4.1-6 Adult population involved in platform work (%), 2017



Science, research and innovation performance of the EU 2020

Source: European Commision, DG Employment, Social Affairs & Inclusion calculations based on COLLEEM survey 2017

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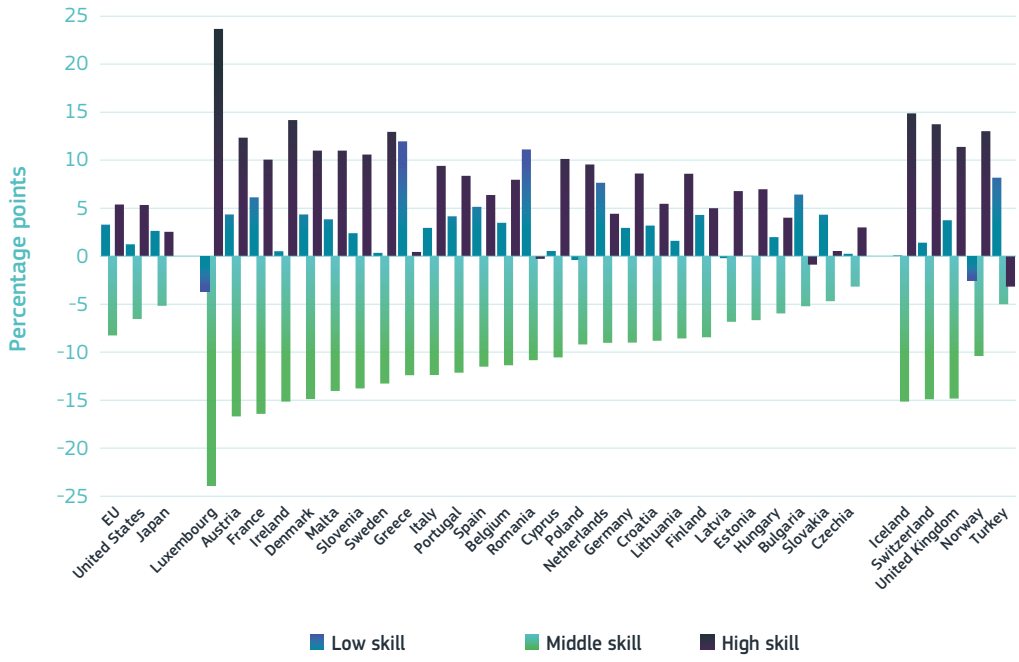
3. Changes in the labour market require new skills

Although we observe only mild symptoms of unemployment, further progress in ground-breaking digital transformation that has brought more efficient production and business processes can have a disruptive impact on workers. In particular, the rise of automation and digital technologies is already affecting labour markets, with **high rates of job polarisation and a hollowing of medium-routine tasks jobs**. This trend is expected to accelerate as digital technologies become more pervasive. At the same time, the quality of jobs done by the least skilled is likely to decline, as is their income share. This trend appears less pronounced in many of the new Member States where labour costs are relatively low and the incentives for automation are supposedly lower (OECD, 2017).

Figure 4.1-7 Percentage point change among shares of occupational groups[1], 1995-2018[2]



Science, research and innovation performance of the EU 2020

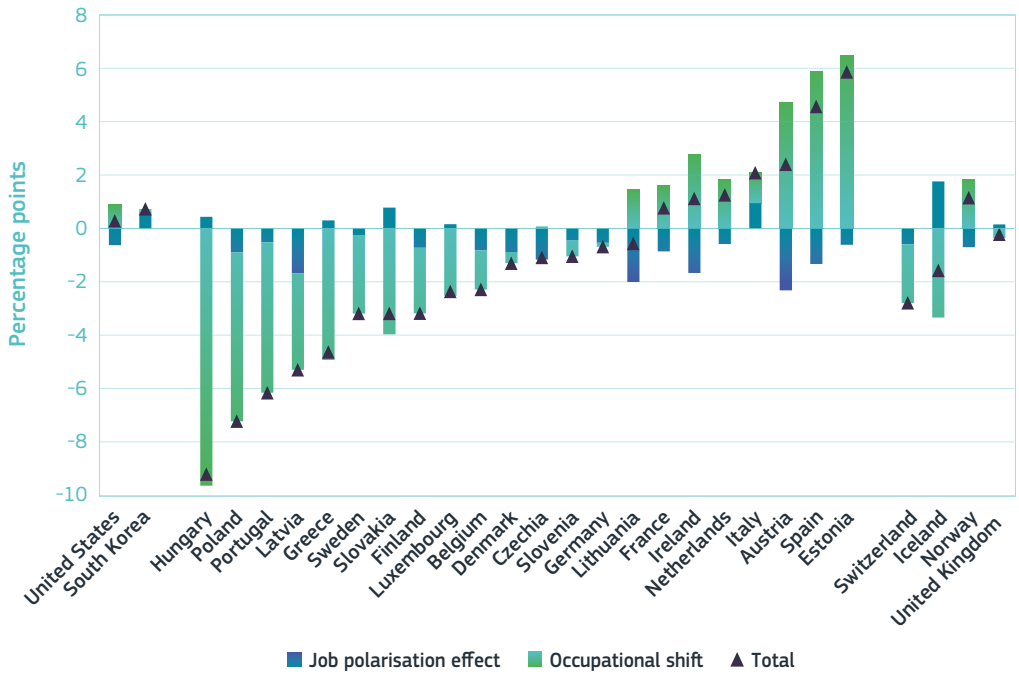
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: lfsa_egised) and OECD data

Note: [1]High-skilled occupations include jobs classified under the ISCO-88 major groups 1, 2, and 3. Middle-skilled occupations include jobs classified under the major groups 4, 7, 8, and low-skilled occupations include jobs classified under the groups 5 and 9. [2]US: 1995-2015; JP: 1995-2010; SI, NO, CH: 1996-2018; CZ, EE, HU, PL, RO, FI, SE: 1997-2018; LV, LT, SK: 1998-2018; CY: 1999-2018; BG, MT: 2000-2018; EU, HR: 2002-2018; TR: 2006-2018.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-7.xlsx

The borders between different skills and earning levels become fluid as some jobs demanding a high level of skills tend to no longer provide high incomes. This development seems to be primarily driven by very low wage growth among workers in high-skilled occupations in last decade or so (OECD, 2019). The overall effect on income distribution is still uncertain a priori since the emergence of new tasks and jobs may reward workers differently across the skills spectrum. Further evidence suggests that workers with less than tertiary education have shifted towards low-skill occupations, including mid-skilled workers, and face a higher risk of unemployment. The share of low-paid jobs is declining due to job polarisation and occupational shift. Job polarisation explains why the number of highly skilled occupations grew faster than other occupations, while the rest of the shift is explained by occupational shift whereby several occupations tend to pay lower wages. The overall trend in rising skill needs at lower levels creates further questions about changing mid-level occupations and future skills defining these occupations (Chatzichristou, 2018).

Figure 4.1-8 Percentage point changes in the share of low-paid[(1)] jobs by type of effect, 2006-2016[(2)]



Source: OECD Employment Outlook 2019

Notes: [(1)]Low-paid jobs are those paying less than two thirds of the median wage, while high-paid jobs are those paying more than 1.5 times the median wage. [(2)]Different time periods coverage for KR (2006-14), EL, LV, PT (2007-16), IT (2007-15), CH (2008-15), IE and LU (2006-15), and IS (2006-13).

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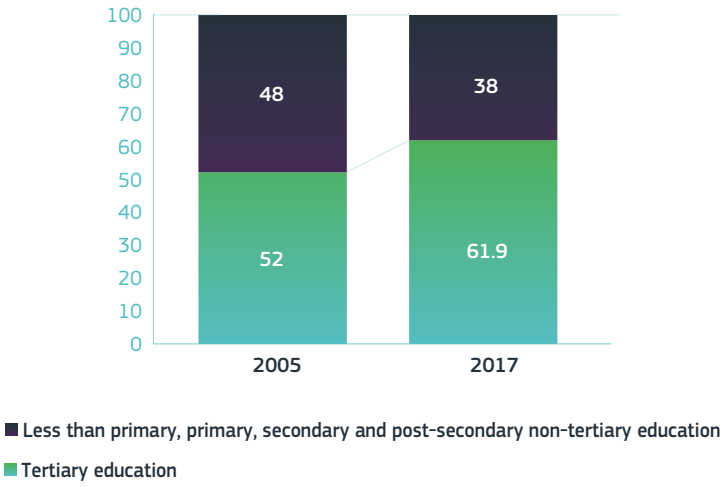
At the level of labour-market entrants, education is the solution to equip people with better skills which will increase both their employability outlook and earnings. Tertiary education is often associated with a considerable increase in the level of skills, especially in high-quality systems. Until recently, and despite massive expansion, in many countries the returns for university graduates remained high. Education belongs at the core of the inequality debate as differences in educational attainment and status are important markers of inequalities. In turn, unequal educational opportunities have repercussions on social cohesion and mobility (EC, 2017a).

While ICT skills seem to be slowly improving among the EU population, there is a growing need for highly skilled IT professionals. The best-known skills gap is perhaps the digital one where the lack of IT specialists is growing (according to IDC and Empirica, the shortage is expected to reach over 749 000 by 2020). Most jobs in the EU already require at least basic digital skills (Cedefop, 2018) and there is growing share of individuals with tertiary education working as ICT specialists in the EU labour market (Figure 4.1-9). On the other hand, 35 % within the overall EU labour force do not have at least basic digital skills (Eurostat, 2019).

Figure 4.1-9 Share of employed ICT specialists by educational attainment level (%), EU



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: isoc_sks_itspe)

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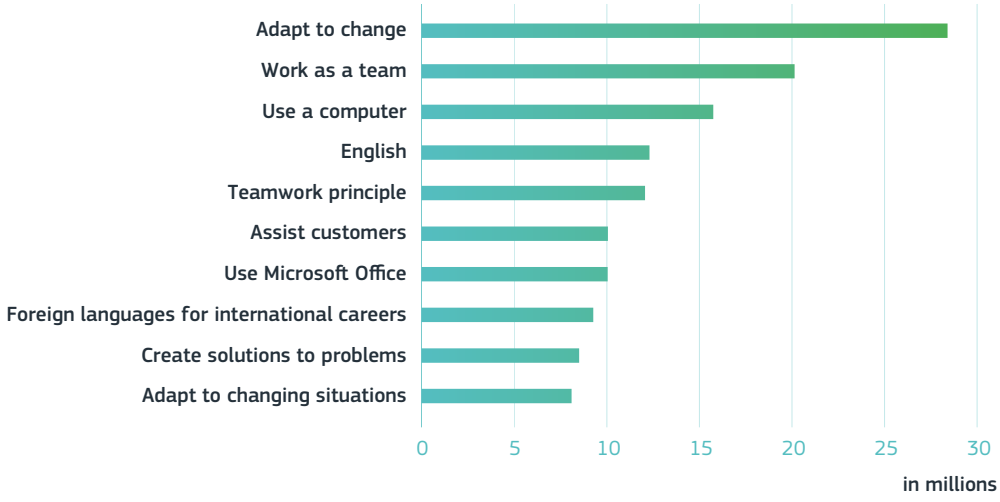
The changing content and nature of jobs require new knowledge, skills and mind-sets. Soft skills[9] are increasingly important for all types of jobs, including those in the digital sector. While job- and sector-specific skills remain essential to support competitiveness and innovation, transversal skills[10], including digital skills, are increasingly determining our ability to adapt, progress and succeed in a fast-moving labour market. The latest evidence suggests a broader set of skills being demanded for the digital age, including not just digital skills but softer ones such as adaptability, entrepreneurship and multidisciplinarity (EPSC, 2019). This points to a solid base of social skills facilitating interaction and communication with others as a favourable complementary asset for employees in the future.

Moreover, the EU labour market is already demanding more soft and digital skills, and specifically a combination of both. The JRC report (Gonzalez Vazquez et al., 2019) showed that the vast majority of occupations which have expanded in recent years are in the groups of professionals or service and commercial managers who require a combination of ICT use and soft skills, e.g. to deal with customers and teams.

9 Personal skills not thought to be measured by IQ or achievement tests. Their attributes receive various labels in the literature, including non-cognitive, personality traits, non-cognitive abilities, etc.

10 In general, skills which have been learned in one context or to master a special situation/problem and can be transferred to another context are relevant to jobs and occupations other than those they currently have or have recently had (as broadly defined by Cedefop).

Figure 4.1-10 Most-sought-after skills 2018-2019



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Source: Cedefop's Skills-OVATE 2019

Note: Based on analysis of online job-vacancy data in 18 EU Member States.

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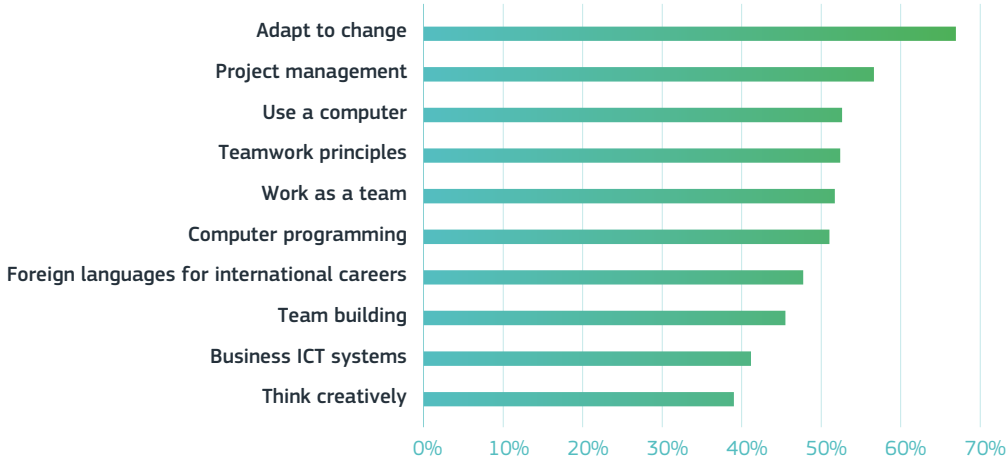
Figure 4.1-11 Share of most-sought-after skills, 2018-2019, for ICT professionals(1)



Science, research and innovation performance of the EU 2020

Source: Cedefop's Skills-OVATE 2019

Note: (1)Shares for skills when mentioned in vacancies at the 2 digit ISCO occupation for ICT professionals.

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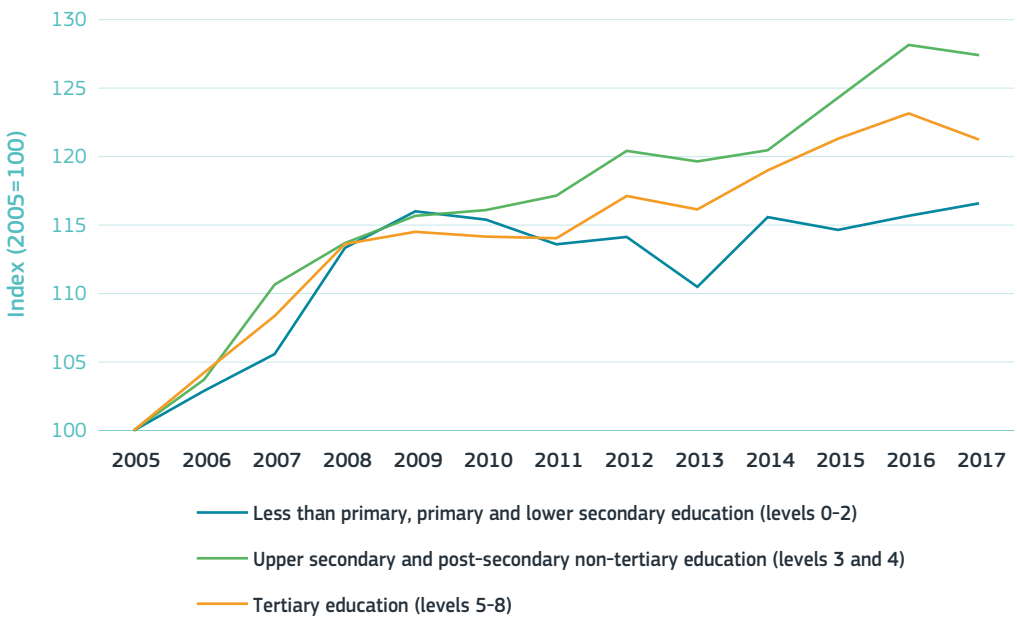
4. Skill-relevant policies need to be inclusive

Returns on investment in education have not always met expectations in countries that have expanded access to tertiary education without ensuring high quality since, in such cases, tertiary education does not lead to a substantial improvement in skills. Furthermore, the latest data suggests that tertiary wage premium is starting to decline, driven primarily by very low wage growth among workers in high-skilled occupations (Figure 4.1-12)[11]. If the expansion in the share of adults with high-level qualifications continues to exceed the speed of expansion in jobs requiring such qualifications, tertiary graduates' prospects may deteriorate. In some countries, it is already evident that tertiary graduates are more frequently undertaking jobs that do not require a high level of education, which also implies income and career prospects that fall below the expectations for someone holding a tertiary qualification and, on an aggregated level, leads to skill mismatch. In that context, the high numbers of highly educated people among platform workers (more than 50% of European platform workers have tertiary education) are remarkable given that the tasks performed by platform workers often do not require a high level of education (EC, 2018).

Figure 4.1-12 Evolution of median equivalised net income by educational attainment, EU[(1)(2)], 2005-2017



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: ilc_di08)

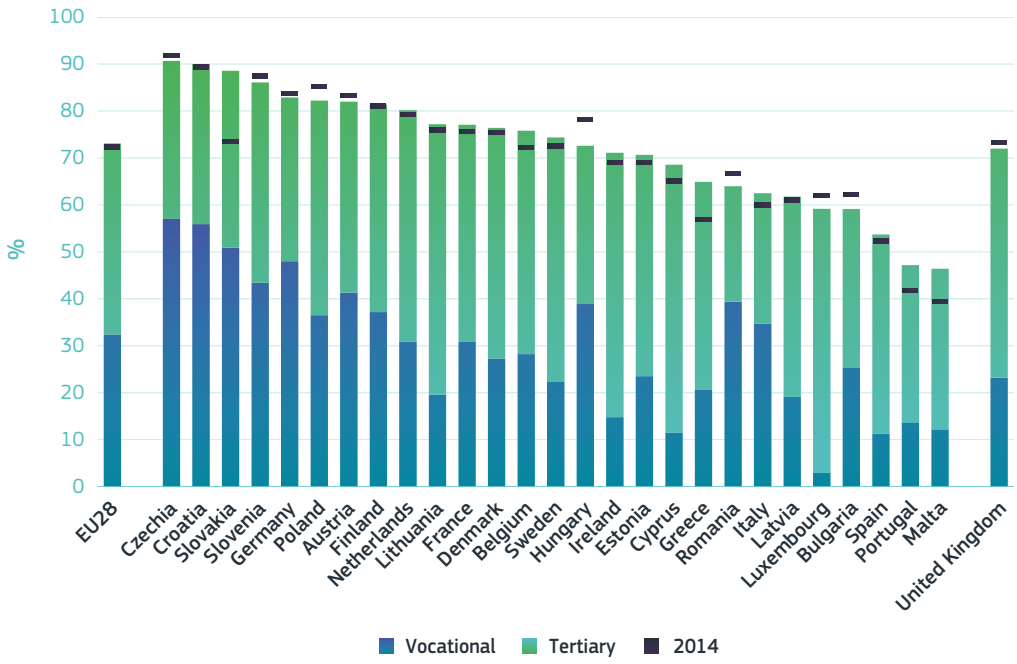
Notes: (1)The calculation is based on the EU 2007-2013 composition with the UK before accession of Croatia. (2)The calculation includes incomes of workers from 18 to 64 years.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-12.xlsx

11 Additional evidence at: OECD (2019) The future of work. OECD Employment outlook 2019.

When properly designed, vocational education and training systems can offer high levels of employability and access to high-quality jobs, including in emerging sectors such as the digital economy. After compulsory education, around half the young people in Europe enrol in vocational education and training (VET) programmes. Traditionally, VET systems were concentrated in the initial education systems and targeted low-performing students to help them acquire the skills required to work in sectors with a predominance of manual or low-skilled tasks. Nowadays, to a large extent, economies do not rely on these sectors where a high proportion of the population could be employed with a lower level of skills. **Therefore, developing a high-quality vocational learning experience is necessary to equip young people with strong foundation skills and job-specific skills which are in high demand in the labour market**. This would provide access to jobs requiring middle and high levels of skills, as well as creating a sustainable base for lifelong learning. As shown in Figure 4.1-13, both types of educational path allow young adults to enter the labour market. The challenge is to preserve such a balance through a well-developed VET system that leads to high levels of employment and has the capacity to respond swiftly to changing trends in the demand for skills.

Figure 4.1-13 Share of young adults holding a vocational or tertiary education qualification(1) (%), 2014 and 2018



Science, research and innovation performance of the EU 2020

Source: Eurostat (online data code: edat_lfs_9914)

Note: (1)Shares of young adults aged 30-34. Vocational education attainment includes qualifications at ISCED levels 3-4 with a vocational orientation; tertiary educational attainment includes qualifications at ISCED levels 5-8.

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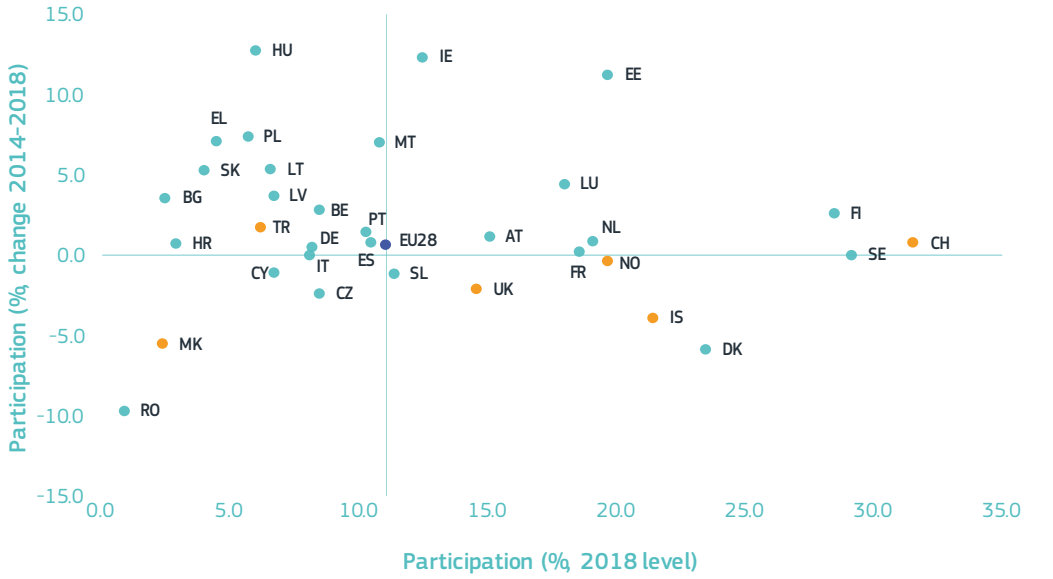
The importance of learning during adulthood is also increasing for all workers. A paradigm shift is taking place that requires the transformation of traditionally more front-loaded education systems delivering general and specialised skills at an early age into effective lifelong-learning models. Adult learning is perhaps the stage that requires the development of new models in most countries in order to learn and train workers during their lifetime, combining formal, non-formal and informal ways of gaining new knowledge. Broad participation in training remains a challenge for all EU Member States as currently only 10.9% of European adults are participating in training and the participation rates are not improving with time (Figure 4.1-14).

Figure 4.1-14 Participation rate in adult training (%)



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: trng_lfse_01)

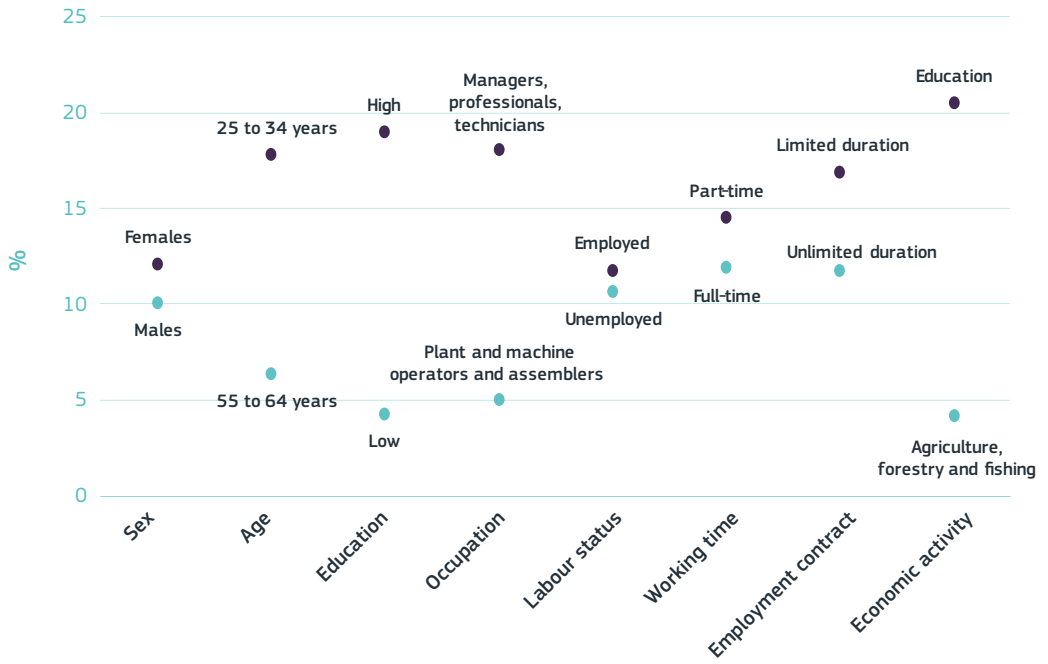
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-14.xlsx

Those individuals likely to be the most affected by changes in the world of work are under-represented in training. There are large participation gaps between adults with low skills and their more-skilled peers, between those earning low wages compared to those on medium-high wages, and between different sectors of economy. Overall, there are broad opportunities for improving the general coverage of adult-learning systems to engage the adult population in learning (OECD, 2019a). The latest data reveal that 61 million adults aged 25-64, many of them in employment, are still low qualified[12]. Furthermore, the employment rates among the low qualified are already much lower than for medium and

12 Low-qualified people include lower secondary education at most. Among the 61 million low-qualified adults, aged 25 to 64, more than 34 million are in employment, over 21 million are inactive and less than 6 million are unemployed (EU, LFS, 2017).

higher qualified – around 55 % for low qualified compared to 75 % for medium qualified and 85 % for high-qualified people. **It is important that adult-learning systems are inclusive and aligned with skills needs in order to reach out to workers at most risk of job loss or displacement**. More can be done in this area as workers with jobs at significant risk of automation show lower participation rates in training (especially non-formal training) compared to workers at low risk of automation (Figure 4.1-15). These gaps in training participation and demands of the future labour market demand coordinated policy actions.

Figure 4.1-15 Highest and lowest shares of job-related adult learners by groups (%) in EU28, 2018



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (data from Labour Force Survey)

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-15.xlsx

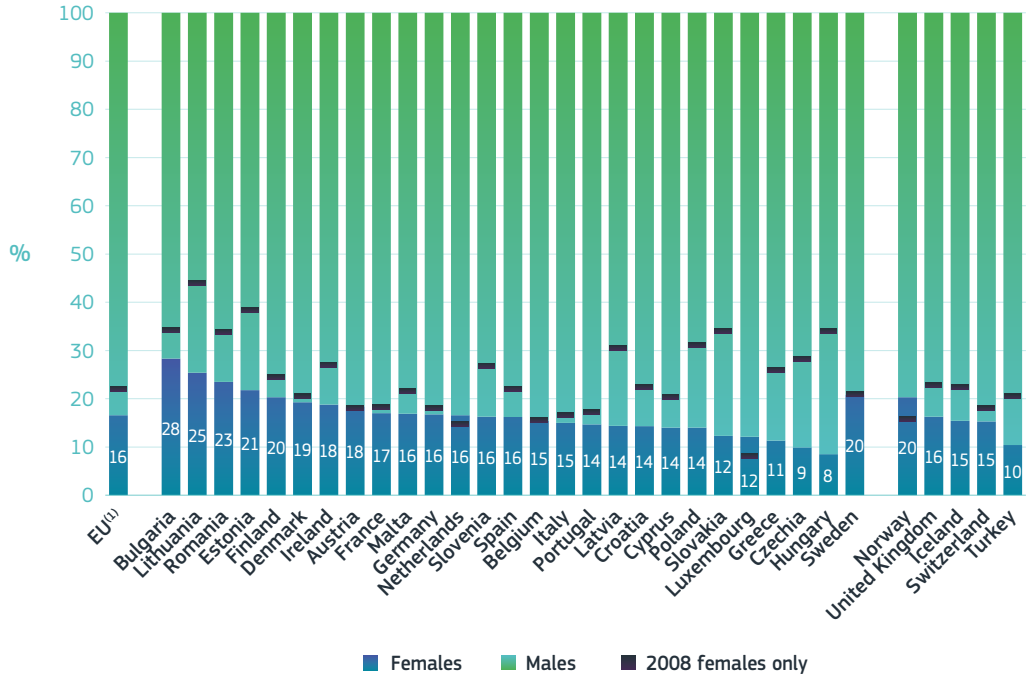
5. Gender gap in employment and entrepreneurship has new drivers

Although the EU has witnessed a significant increase in female employment over the last two decades, women's participation in the digital field is lagging behind in several areas, with varying participation rates across the Member States. Those Member States leading in digital competitiveness are also leaders in female participation in the digital sector. The gender gap is largest in the area of ICT specialist skills and employment:

82% for ICT specialists and 65% for science, technology, engineering, mathematics and ICT graduates (Figure 4.1-16).

Women account for 52% of the European population but only around 17% of women work in ICT-related jobs. Women's participation in the development and deployment of AI technology, such as machine-learning researchers, and in platform work is unbalanced. a review of participants attending AI academic conferences reveals an under-representation of women in academia (19% of conference authors) as well as industry researchers (16% of conference authors; Mantha and Kiser, 2019). OECD came to the same conclusion that software development is male dominated, especially in companies (OECD, 2018a). As regards platform work in Europe, these jobs are mainly dominated by men and the gender gap widens with the importance of platform work relative to total income (Figure 4.1-17). Irrespective of the concerns about job quality, more work flexibility can boost employment and help parents combine work with family life. The flexibility to choose where and when to work is one of the major advantages of digital platforms and offers women the possibility to better combine motherhood with pursuing a career (OECD, 2018a). These initially positive expectations of technological developments on female employment seem not to have materialised.

Figure 4.1-16 Share of ICT specialists by sex (%), 2008 and 2018



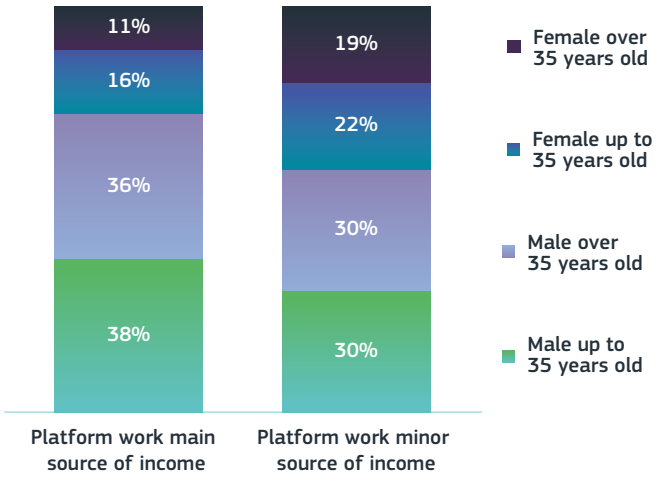
Science, research and innovation performance of the EU 2020

Source: Eurostat (online data code: isoc_sks_itsps)

Note: (1)EU average estimated by DG Research and Innovation.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-16.xlsx

Figure 4.1-17 Share of platform workers by age and sex (%)



Science, research and innovation performance of the EU 2020

Source: European Commission, Joint Research Centre based on COLLEEM Survey 2017

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-17.xlsx

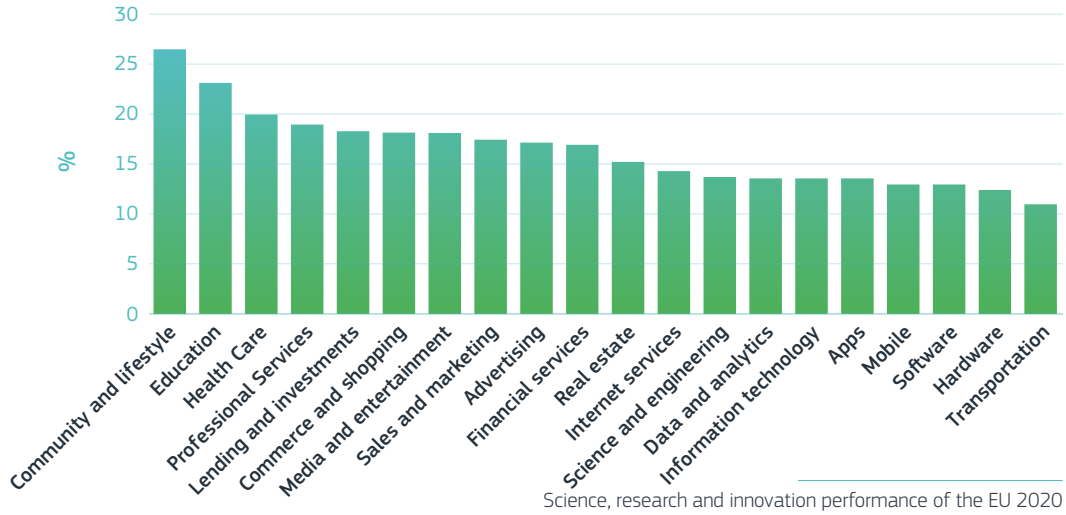
Female entrepreneurship and funding opportunities for high-potential startups are characterised by a significant gender gap. For example, in the EU, the proportion of women in self-employment is under 10% compared to 17% for men[13]. Recent studies of high-growth start-up activity find that only a marginal share of start-ups are founded by women while start-ups with at least one woman in the founding team are often less likely to receive funding than start-ups founded by men only[14]. (For more information, see Start-up gender gap section in Chapter 3.3 - Business Dynamics and its contribution to structural change and productivity growth and in Chapter 8 - Framework conditions). There seems to be a division between 'STEM-related' industries that are more dominated by male-founded companies and female-led start-ups, meaning that at least one founder is a woman (Figure 4.1-18). These tend to be in areas generally perceived as less high-tech, such as lifestyle, education, and fashion rather than ICT technologies. Given the preference of venture capital providers to invest in sectors which typically generate big returns on small initial investments, such as information and communications technology or life sciences, women's starting position could improve by expanding into these areas. **Thus, a substantial part of the gender gap can be attributed to the origins of gender gap in education and later career paths (e.g. gap in STEM education)**. Policies to close the participation gap of women would need to address upstream factors related to education and training. Policy interventions focused on education policy, women's participation in STEM entrepreneurship and various accompanying business supporting schemes could potentially reduce these divisions.

To find out more, see Chapter 11 - The consequences of AI-based technologies for jobs.

13 Eurostat. Employment and Self-employment by sex, 2018: 20.5 million self-employed men compared to 9.9 million self-employed women in the EU28.

14 Only 10-15% of startups have been founded by women in the United States (Brush et al., 2014). Start-ups with at least one woman in the team of founders are 10% less likely to receive funding compared to start-ups founded by men only. OECD (2019): Levelling the Playing Field: Dissecting the Gender Gap in the Funding of Innovative Start-Ups Using Crunchbase.

Figure 4.1-18 Female-founded startups across different sectors - share of companies with at least one female founder (%)



Source: OECD estimates based on Lassébie et al. (2019) and computed from Crunchbase data

Note: Sample limited to firms created between 2000 and 2017, located in OECD, Colombia, and BRICS countries. Graph restricted to the top 20 technological fields in terms of number of firms in the sector.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-18.xlsx

Summary of Peter Cappelli - The consequences of AI-based technologies for jobs

This contribution follows the recent public debate on the changes across industrial countries that stem from information technology, including notions of artificial intelligence and its implications for how work is performed. While acknowledging the size and pervasiveness of these discussions, **the article discusses the core argument related to the impact of information technology on the way businesses and organisations operate, how these changes could translate to the labour market**, and other potential outcomes such as lower wages or unemployment.

The argument begins with an introduction to the two ways in which people tend to anticipate future developments. This either happens through estimates based on prior experience (commonly known as forecasting) or through a belief in a real uncertainty of future developments and reliance on other kinds of evidence besides traditional forecasts. The article maps the projected impact of technological uptake on the labour markets and reviews the empirical evidence. It touches upon many of the above-discussed trends, such as skill-biased technological change or routine-biased technological change and their implications for skills

demand. With an historic perspective, the article argues that predictions based on the past may be less relevant in the current context. Although new equipment and practices could eliminate certain jobs, on balance they do not necessarily destroy jobs because their overall effects on improving productivity and overall wealth create jobs elsewhere.

To understand why assumptions claiming that the future is like the past are not correct and extrapolations from prior experiences are unlikely to be accurate predictors of the future, read Chapter 11 - The consequences of AI-based technologies for jobs.

6. Conclusions

Technological developments accompanied by growing computing power and the greater availability of big data are shifting the boundaries of what can be automated by machines and could further reduce the costs of automation, in particular of so-called routine tasks. Although employment levels have not declined, other trends, such as the **polarisation of labour markets with a declining share of medium-skilled occupations**, have emerged across advanced economies. This suggests that the technological potential should not be equated with the actual impact on employment as this depends on specific circumstances. For example, a wider diffusion of technology is a necessary precondition for any broader occurrence of technology-driven employment effects. Furthermore, the evolving set of tasks within occupations can reshuffle the existing pool of jobs and the expected job-creation effects are currently difficult to quantify. In general, many of the developments in employment between occupations or whole industries introduced by cutting-edge technologies **are related to structural change within economies towards more productive and innovative activities**.

The various challenges in the field of education and training require actions from multiple stakeholders. **Better labour market intelligence that helps anticipate change and promotes innovation, new angles to lifelong learning and adult education that emphasise inclusiveness, or contributions by technologies to the training process** rank among the priorities. More focused training and qualification measures may help workers to target expanding occupations in a technology-rich environment and reduce the potential losses of those working in shrinking occupations, although this will depend on the accuracy and level (sectoral or company specific) of forecasts.

Exploring how to better align innovation and skills policy is increasingly relevant and some initial efforts have taken place, for example through the Skills Agenda, Sectoral Skills Alliances projects and, more recently, through the Vocational Excellence initiative. The **definition and diffusion of skills, along with new high-quality knowledge and technologies**, could support structural change and provide solutions to global challenges. However, this would require that policies supporting innovation and skills, both at the EU and national level, become increasingly more synergetic.

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