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# Workforce skills and innovation diffusion: trends and policy implications



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*Research and  
Innovation*

## **Workforce skills and innovation diffusion: trends and policy implications**

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Working paper

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## POLICY MESSAGES

- With the increasing ability of machines to automate a greater number of job tasks performed by humans, automation could increase productivity and decrease the cost of production. The rise of automation and digital technologies, even if slowly, already manifests itself **through an increasing number of jobs requiring high skills and the declining demand for simple routine tasks (both cognitive and physical)**.
- **These trends may be accelerated as a result of the on-going Coronavirus outbreak.** Since its beginning, it has forced businesses as well as education and training institutions to transfer many of their activities online. Depending on how long the epidemic will last, it may further facilitate the deployment of digital technologies to mediate physical interactions, i.e. with clients. Broadening these interactions through AI applications may boost the possibilities of further replacement and automation.
- Nevertheless, these new technologies have not brought yet the expected productivity growth, rather the opposite. **The slowdown of innovation diffusion across sectors and firms has been propagated as one of the main reasons. Low absorptive capacity of firms coupled with unmet skills** needs rank as critical factors preventing the spread of such complex, close to market innovations.
- Skills are crucial to ensure that people can contribute to the development, support the broad deployment and benefit from the implementation of innovation, instead of being threatened by it. **A close interaction between skills and innovation policies is therefore needed to enable such contribution.**
- Different education and training sectors, in particular those close to the labour market, contribute to the development, deployment and diffusion of innovation:
  - A **high-quality academic education at tertiary level** equip people with strong foundational skills, knowledge and competencies enabling to pursue research or other complex cognitive activities, which remain highly demanded on the labour market. It is an essential component of vibrant innovation systems enabling the development of new, ground breaking innovations that increasingly result from the convergence between digital technologies and various scientific fields.
  - **Vocational education and training (VET)** provided across different levels of education and training systems (from lower-secondary up to professional higher education) is equally critical for supporting the adoption and diffusion of technological and organisational innovations at regional and local level, particularly among the SMEs. VET is also a key provider of digital and STEM skills in many Member States.

- **Adult learning**, firstly as an instrument for firms in preparing their workforce for the introduction of innovative technologies and processes, but also, with a more social character, providing access to up-skilling and re-skilling opportunities for those who would be willing or are forced to find new employment opportunities in emerging or growth areas.
- However, investment in both R&D and skills is persistently lagging in the EU as compared to other major developed economies. In 2018, R&D expenditure in the EU, stood at 2.2% of GDP, at par with China and behind US (2.8%) or Japan (3.3%). While there is no internationally comparable data for investment in skills, participation in adult learning (which, according to the estimates in this paper, represents around 2/3 of the total volume of investment in skills) in the US, Canada or Australia, based on OECD Survey of Adult Skills (PIAAC), was around 50% higher as compared to the EU Member States participating in that survey.
- Furthermore, **substantial skills imbalances and skills mismatches co-exist at the same time with skills gaps across many Member States**. Over-qualifications are increasing in most countries, partly due to the fact that the expansion of tertiary education is proceeding at a much more rapid pace than the expansion of high-skilled jobs. The future EU objectives in the education and skills policy domains, while aiming to ensure the availability of required skills, should also take into account the need to reduce, rather than reinforce, such imbalances.
- This calls for **improved skills intelligence**, to monitor the developments as regards both skills supply and skills demand. At the same time, **transparency and recognition of all types of skills, qualifications, and certifications** should improve so that these receive a better identification, recognition and valuation in the labour market. It is particularly relevant when these are gained outside formal educational contexts, such as through work experience, industry-based training, or self-learning.
- At the European level, Horizon Europe R&I projects could have a part of **dissemination and exploitation strategy dedicated to identification of emerging skills needs and curricula at the sectoral level**, building upon the work carried out under the 2016 Skills Agenda for Europe, such as **European sector skills alliances and blueprints for sectoral cooperation on skills**, financed by Erasmus+. **Finally, the Centres of Vocational Excellence** could strengthen technology diffusion at the local level.

## 1 Introduction

Europe's prosperity and social model depend on its ability to ride the new wave of innovation ahead of us, while ensuring a broad participation in the benefits accruing from these innovations. This ability to benefit from innovation depends on access to relevant skills, which is one of the main determinants of Europe's competitiveness and the capacity to drive innovation. The fundamental link between innovation, skills and growth makes investment in skills and proactive skills policies, aligned to the evolving industrial and technological landscape, a prerequisite for a dynamic and inclusive society.

From an economic point of view, this ability to benefit from innovation seems to be limited – testified by the decline in productivity growth rates, in particular during the last several decades in most of the developing and developed world economies (The Conference Board, 2019), despite increasing innovation activity. This is likely driven by changing demography, the maturing of latest general purpose technologies (ICT), the declining potential of educational/skills upgrading, rising inequality, declining innovation diffusion as well as measurement challenges (Gordon, 2018). A specific role is also played by structural shift of economies initially from agriculture to manufacturing and currently from manufacturing to services. Such changes may not always support productivity growth, as also observed across many EU Member States, particular if it is not favouring enough knowledge-intensive sectors (European Commission, 2020c). There are also path-dependency effects: a higher initial weight of knowledge-intensive sectors correlates with higher R&I investments and better productivity performance later-on.

Arguably, an important role in these developments is also played by the rising importance of intangible capital – R&D, skills, organisational capital (Haskel, J. and Westlake, S, 2017). The role of intangible capital can help explain some of the tendencies observed, such as increasing market concentration, declining firm dynamism, declining labour share and declining spread of innovation (Ridder, M, 2019). More generally, economic and productivity growth is driven by two aspects of intangible capital: innovation and human capital and will likely continue to be in the future (Fernald, J. and Jones, C., 2016). These are also the domains, which seem to be easier to affect by policy and could support not only economic growth, but also other key policy priorities in Europe – such as promoting faster and more equitable green and digital transitions.

The policy challenges, but also the potential in the domain of skills are clearly evident. In today's Europe, skills gaps and mismatches are striking and many people work in jobs that do not match their talents. At the same time, 40% of European employers report difficulty in finding people with the right skills. 77% of EU firms say, that lack of staff with the right skills is a barrier to investment (EIB, 2018). Persistently evolving technological developments, leading towards more autonomy, less routine, and more ICT in the workplace will likely further reduce the need to do simple routine tasks, replacing them with a demand for a broader range of skills needed to carry out ever more complex combinations of tasks. This may push current skills mismatches even further, unless there is a re-thinking of the ways we educate and train people, aligning it better towards evolving labour market needs and, ultimately, enhancing the value that skills of EU citizens can bring for themselves, for firms and for the society more broadly.



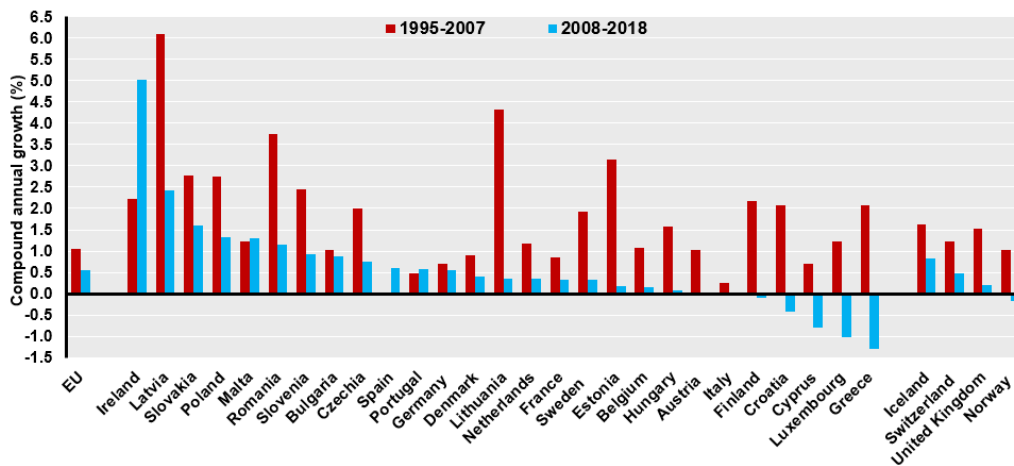
## 2 Slowdown of innovation diffusion and structural shifts reinforce inequalities

### 2.1 *The increasing concentration of innovation among small number of firms and regions slows down innovation diffusion and productivity growth*

**Despite the rise of digital technologies in the past decades promising large productivity gains, paradoxically the growth of productivity has been sluggish, holding back more robust economic growth in Europe and other advanced economies** (Figure 1). The rise of digital technologies and their convergence with the physical world, in what some have called the Fourth Industrial Revolution is transforming our economies and societies. The pace of change in consumer-driven innovation seems to have accelerated tremendously in the current era of digitalisation and increasing connectivity. Indeed, innovative consumer products are being adopted at a higher speed than in previous decades and centuries. Furthermore, a new wave of deep tech innovation is ahead of us, opening up vast new opportunities, but also significant risks that can affect disproportionately some segments of our population, if badly managed. Automation, Big Data, the Internet of Things and Artificial Intelligence are digital technologies that are coming of age, promising new and more efficient business processes and products, which could bring significant gains in productivity growth across economies, if they diffuse widely.

**Figure 1 Total factor productivity – compound annual growth, 1995-2007 and 2008-2018**

Source: DG R&I based on DG Economic and Financial Affairs



**This "Productivity Paradox" points to deep changes in innovation dynamics: the rise of a number of breakthrough innovations led by new global technological champions that create and shape entire new markets, coupled with a limited uptake of innovations across a broader range of companies, sectors or regions, suggesting that innovation diffusion mechanisms are faltering.** Despite intrinsic difficulties in properly measuring the impact of digital transformation on the economy and society (OECD, 2019), the evidence is pointing towards increased divergences in performance and productivity at the firm level. In part, this has been attributed to the

growing complexity of innovation process requiring companies to master increasingly diverse technologies and new business models as well as respond to rising network effects. This divergence of productivity growth among firms is evident since the beginning of the 2000s. Notably, a small number of leading firms (in particular platform-economy companies, Box 1) have championed strong productivity growth rates, while majority of firms have achieved only disappointing productivity growth that all together translates into low aggregate productivity growth levels. Such firm-level differences in productivity growth are found across sectors, although some intra-sectoral differences exist.

**Inequalities between firms are also driven by sectoral dynamics, with the uptake of digital technologies over the past two decades varying significantly across different sectors of the economy.**

Some sectors have benefited much more from the uptake of advanced digital technologies and adapt their products, services, and business models accordingly, than others. Such disparities could increase further with the rising applications of Artificial Intelligence (AI) that may go far beyond labour automation, transforming business models and innovation activity. The observed difference between firms with strong digital capability and well-designed AI adoption strategy could reinforce the differences in the uptake of technology, allowing these companies to further raise profit margins or increase the efficiency of their R&D operations. The potential negative implications of the growing firm-level performance differences are many, including stalling aggregate productivity growth as well as growing regional and social inequalities. An important additional effect of these technological transformation are strong and rising network effects that lead to “winner takes all” markets resulting in strong concentration of resources in a small number of firms, but also countries and regions.

### **Box 1. The rise of platform-economy companies**

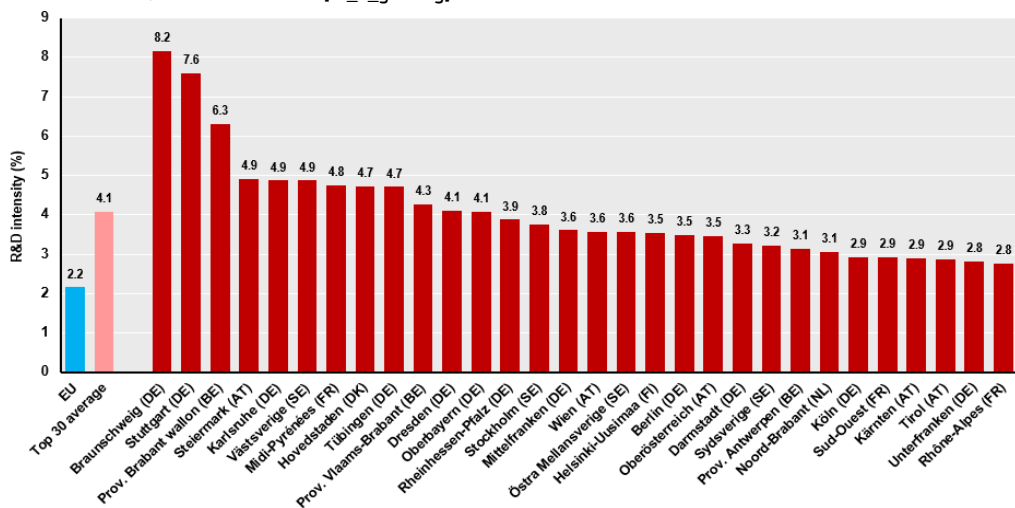
In the past several decades, digital technologies have enabled some of the most impressive breakthrough innovations that have revolutionised entire industries and markets. The so called platform-economy companies changed the way to reach firms or customers and deeply transformed how we search for things, communicate with each other, buy products, move within cities or consume entertainment. Many of these firms have been able to grow at an unprecedented pace, becoming global economic behemoths.

One of the main advantage of platforms can be characterised as enhanced capability to learn, share and profit from good ideas and information more easily and faster (OECD, 2019e). In addition, the faster and more efficient allocation of resources enabled by platforms also plays an important role. (Schwellnus, et. al., 2019).

**Lagging territories face difficulties to develop home-grown innovation and to maintain their skilled labour force.** While technology import in general helps reducing productivity gaps, given the commodification of industrial production, supply-chain perspective suggests that maintaining economic convergence increasingly requires stronger contribution from local innovation manifested e.g. by (up-stream) product design activities as well as (downs-stream) marketing and distribution services (EIB/EC, 2018). Therefore, strengthening home-grown innovation to capture more value added is a key element of the contemporary growth model for lagging territories. At the same time, increasing calls in the developed economies for the repatriation of at least some of the outsourced manufacturing capabilities, may also open up additional new opportunities to benefit from new high-tech, customisable manufacturing activities.

**Figure 2 The 30 most R&D intensive regions in EU - R&D intensity at NUTS2 level, 2017**

Source: DG R&I based on Eurostat [rd\_e\_gerdreg]



**Similarly as firm-level data, regional data also points towards increasing divergence between top-performing regions and the rest.** For example, R&D investment shows a high concentration of spending in few R&D intensive regions (Figure 2). Innovation activities are concentrated particularly in capital cities, which are the headquarters for large organisations and tend to have a relatively high concentration of well-paid and dynamic graduate jobs (Eurostat, 2019). With considerable variation of the overall intensity of R&D spending across EU regions, the highly intensive regions are almost exclusively in the west and north of Europe. Also, from the perspective of European regional innovation systems, a group of low-performing regions has barely improved, leading to a considerable slowdown of the convergence process in the EU. Even if the overall range of regions in terms of innovation performance declined between 2011 and 2019, only 45 % of regions within the modest-innovator category improved their performance, compared to 64 % among the strong-innovator and 80 % in the moderate-innovator regions pointing to a group of persistently lagging performers among the least developed regions. These weak local science and innovation systems

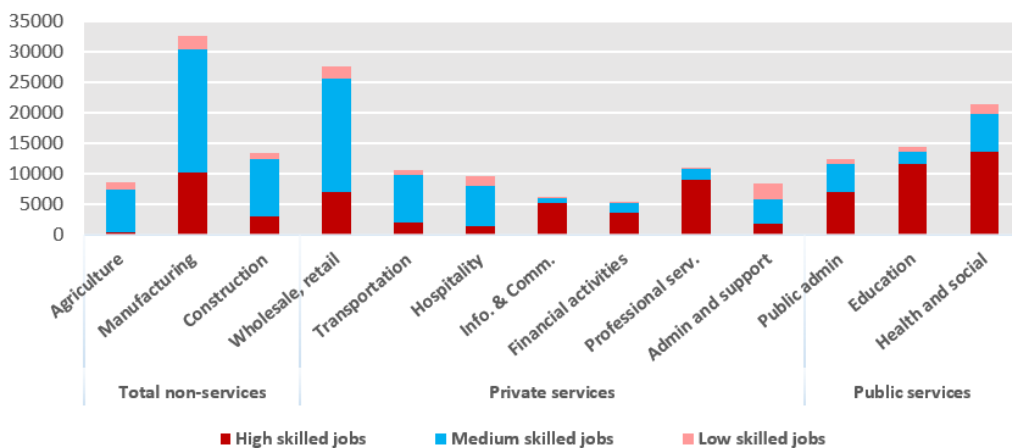
are often unable to attract investment and transform it into high quality scientific and technological outputs.

## 2.2 Long-term technological transformation changes labour and skills demand, reinforcing inequalities

**Over the long-term, Europe, like any modern economy, observed a structural shift away from mature towards new economic activities.** Taking place at different points in time and at different speeds, it started firstly with a transition from primary (agriculture and extractive) towards secondary (manufacturing) and later from secondary towards tertiary (services) sector. Nowadays, the economy of the EU is characterised by the predominance of services, representing nearly 70 % of EU employment in 2019 (Figure 3). Furthermore, companies are increasingly relying on a variety of intangible assets such as, for example, goodwill or patents, increasing the importance of intangible capital and skills. Coupled with the emerging new forms of work carried out through platforms, these changes bring a potentially far-reaching transformation of the labour market. Indeed, some recent research work highlights productivity growth differences among service sub-sectors, pointing that some of them are likely to face more automation and productivity growth (Valentinyi, A., Herrendorf, B. and Duernecker, G, 2019). All this also provides for the EU Member States opportunities to further stimulate and drive this change forward, underpinning it with adequate investment in R&D and innovation, specialising in most promising growth sectors.

**Figure 3 Sectoral composition of jobs (in thousands) by level of skills required, EU, 2019**

Source: DG EMPL based on Eurostat [lfsa\_egised]



**Given the variety of measures available to analyse skills supply and demand, there is often a risk of confusion or miss-interpretation. Two methodological considerations are of particular importance to ensure clarity and conceptual consistency of any such analysis.** The first one, as testified by the different notions

of labour market polarisation,<sup>1</sup> is the selection of the most appropriate measure (i.e. income; occupation or individual's education/skills level) for the analysis. For analysing aggregated skills demand in the labour market, it can be argued that occupational classifications (such as ISCO<sup>2</sup>) is often the most appropriate given its designed purpose to provide comparable job categories (including required skills level) across countries. Other measures, such as income or educational attainment of employees, do not represent as well in a comparable manner the features of jobs or their skills requirements. For example, wages of low-skilled jobs, apart from reflecting the skills level of such jobs, can be influenced by factors such as minimum wage regulations, wage bargaining, economic cycle or the supply of workers with skills needed for those jobs. Similarly, a job may be occupied by an individual with higher or lower qualification than would normally be required for that job, again depending on labour market conditions or skills availability.

**The second critical element, linked to the analysis of changing occupational composition of the labour market, is the attribution of occupational groups to low-skilled, medium-skilled or high-skilled occupations.**<sup>3</sup> Multiple approaches have been recently used in the literature within the automation debate to rank and group occupations in terms of their skills requirements, including tasks (i.e. routine v/s non-routine task intensity) or wages (high income v/s low income). Such efforts have often led towards attributing all or some of non-elementary services and sales workers (ISCO-5) as low-skilled, instead of medium skilled, which is the original designation in ISCO classification. Such a shift has a major impact on any conclusions, given that it is the largest occupational group among the middle-skilled occupations and the second largest overall. The treatment of this occupational group is further complicated by its diversity, large prevalence of part-time work, gender differences and sensitivity to methodological changes<sup>4</sup>. However, reviewing existing evidence related to skills requirements in this occupational group (i.e. in terms of skills use intensity and skills levels of workers, the actual level of qualification of workers or the analysis of occupational requirements) all of them<sup>5</sup> indicate a similar performance of this occupational group to the other medium

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<sup>1</sup> The concept of labour market polarisation can be measured in terms of the change of its occupational composition (i.e. high; medium and low-skilled jobs); in terms of the Income composition of jobs (high; medium and low-pay jobs); or in terms of the skills/qualifications of persons employed in those jobs (high; medium and low-skilled workers). These three concepts/measures are related but by far not identical and each of them is differently distributed across individuals, jobs, countries or regions.

<sup>2</sup> International standard classification of occupations.

<sup>3</sup> ISCO classifies jobs into different categories using skills levels and skills specialization as the main criteria. It assigns one of 4 skills levels to each of the major ISCO occupational groups: level 1 for elementary occupations (ISCO 9), level 2 for medium-skilled occupations (ISCO 4-8), level 3 to medium-high skilled occupations (ISCO 1 and 3) and level 4 to high-skilled occupations (ISCO 1 and 2). For reasons of simplicity, occupational groups are often aggregated further into three skills levels (ISCO 1-3 for high-skilled, ISCO 4-8 for medium-skilled and ISCO 9 for low-skilled).

<sup>4</sup> In the EU, this group also has showed the second largest increase in its labour market share between 2002 and 2018. However, almost all of this shift happened during a single year (2010/2011), when the occupational classification was changed in the EU LFS from ISCO 88 to ISCO 08. See Table 1 in Annex for the decomposition of changes among 1-digit ISCO occupational groups in the EU27.

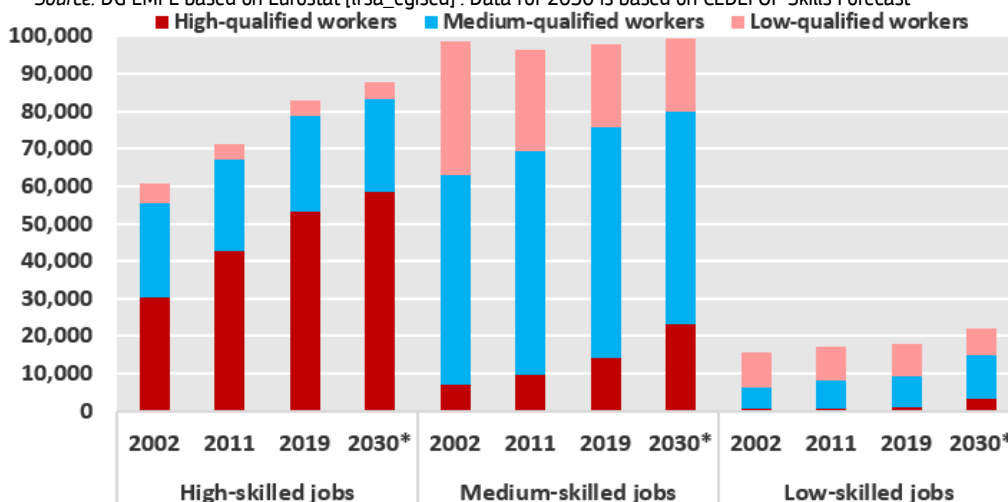
<sup>5</sup> Skills level or skills use intensity is available in PIAAC (OECD, 2013); the level of workers qualification is available from EU LFS (Eurostat, 2019); occupational requirements analysis from Cedefop, 2013.

skilled occupational groups and even better performance as compared to jobs belonging to skilled agricultural, forestry and fishery workers occupational group. Therefore, in this paper, ISCO-5 is considered as a medium-skilled occupational group.

**Like in the past, technological changes result in the transition of jobs towards sectors with better job-creation prospects and thus do not constitute an overall destruction of jobs.** Indeed, in the EU, in 2019 the employment rate (at 68.4% for 15-64 year olds<sup>6</sup>) and the total number of jobs (nearly at 200 million<sup>7</sup>) have been at the highest level ever since 2002, when first data is available. The same is observed for the EU15, for which longer time-series is available since 1995. Over the period from 2002, the two main trends observed in the labour market, from a very aggregate point of view, were a strong increase in the quantity of high-skilled jobs (by more than 35%)

**Figure 4 Number of jobs (in thousands) by skills level and the educational attainment level of workers in those jobs, EU, 2002 - 2030**

Source: DG EMPL based on Eurostat [lfsa\_egised] . Data for 2030 is based on CEDEFOP Skills Forecast



as well as a changing composition of medium-skilled jobs towards medium-qualified and high-qualified workers, at the expense of low-qualified workers (Figure 4). Overall, the total number of medium-skilled jobs remained largely the same, though their share in the labour market has declined given the growth in total employment. In terms of low-skilled jobs, they continue to play a rather marginal role in the labour market, due to their small number; their share (at around 9% of all jobs) remained stable since 2002.

**Looking through a sectoral perspective reveals much more intuitively the ongoing changes** (see Figure 5). Since 2011 around 40% of new high-skilled jobs were created in the sectors providing services of general interest (education, health); another 40% were created in private sector services (mostly information and communication sectors and professional services sectors) and around 20% in manufacturing sector. The

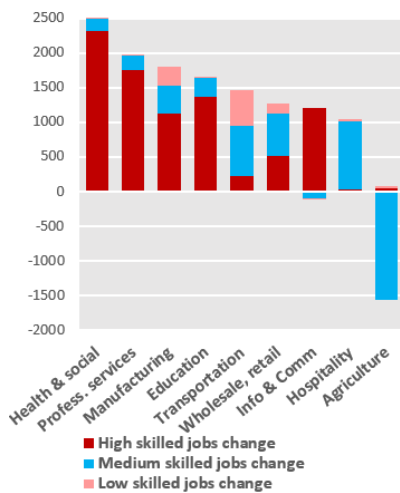
<sup>6</sup> Eurostat, Labour Force Survey, 2019, online data table [lfsa\_erqan]

<sup>7</sup> Eurostat, Labour Force Survey, 2019, online data table [lfsa\_eqan].

number of medium-skilled jobs increased mostly in private services sectors, mostly in trade, hospitality and hospitality industries while decreasing in agricultural, fisheries and forestry sector. Also such processes can be differently pronounced across EU Member States. For example, whilst most countries have experienced a fall in their employment shares in high-tech manufacturing, a few have increased their specialisation. These

**Figure 5 Sectors with highest employment changes (in thousands) between 2011 and 2019, EU**

Source: Eurostat [lfsa\_egised]



include some CESEE countries (Poland, Romania, Czechia and Latvia), together with Cyprus, Greece and Denmark. A similar scenario holds for medium high-tech manufacturing where a positive growth rate in employment shares can be observed mainly for the previously mentioned CESEE economies, including the high increase in specialisation in Estonia and Latvia (European Commission, 2020c).

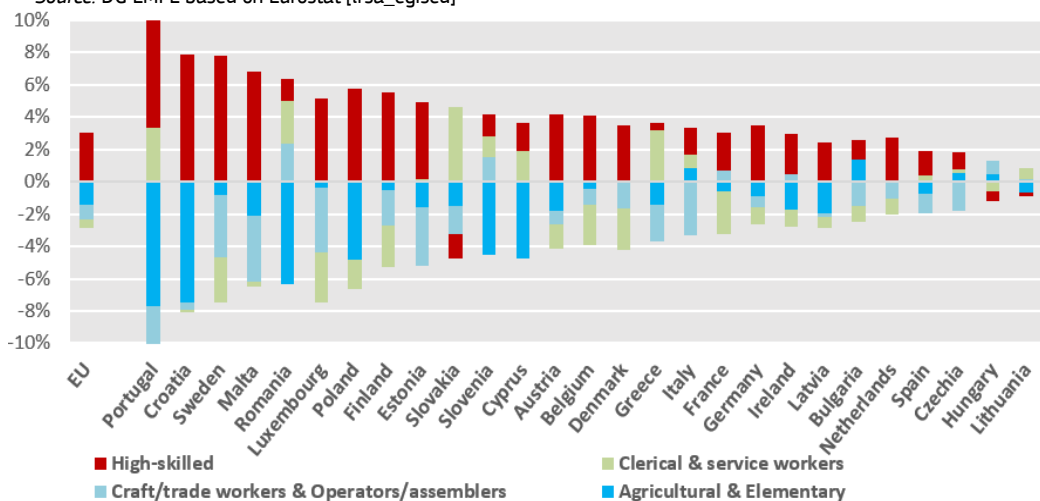
**The relationship between new technologies and the employment in different occupational groups is complex.**

This is particularly evident when the analysis is carried out at a more detailed occupational level. The relative decline in medium-skilled jobs were primarily led by falling share of skilled agricultural workers (ISCO 6) or craft and trade workers (ISCO 7). Conversely, jobs in the occupations, argued to be most routine and subject to automation, such as clerical support workers (ISCO 4) or machine operators (ISCO 8) saw less pronounced decline.<sup>8</sup>

The share of low-skilled jobs (ISCO 9) only saw a limited increase from 2002 until 2011 and has been declining since (see Table 1 in annex for more details on the changes at each individual 1-digit ISCO category). At country level, the increase in high-skilled occupations is almost universal, while the relative decline of medium-skilled jobs seems to be driven mostly by falling agricultural and elementary jobs (Figure 6). Limited occupational change (particularly the ability to create more/new high-skilled jobs) is notable for some countries between 2011 and 2019, in particular Lithuania, Hungary, but also Czechia and Spain. Moreover, in the

**Figure 6 Change in occupational composition between 2011 and 2019**

Source: DG EMPL based on Eurostat [lfsa\_egised]

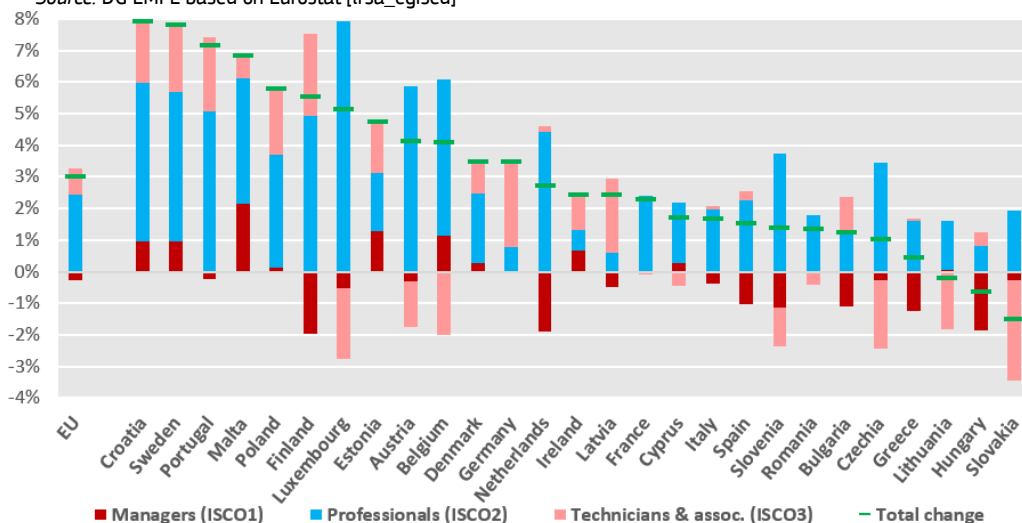


context of the current social distancing measures due to COVID-19, the potential to telework varies across occupations demonstrating that digitalisation seems to favour more the higher skilled workers (OECD, 2020)

**While the overall growth of high-skilled jobs has been nearly universal, it did not happen in a homogeneous manner.** Different tendencies emerge across countries when analysing the change of high-skilled jobs at a more detailed level (Figure 7). Notably, Slovenia, Hungary and Lithuania during the last 8 years ended up having relatively less high-skilled jobs than before. Some countries, like Austria, Czechia, Belgium and Luxembourg, created many more jobs belonging to Professionals occupational group, but retained relatively less Technicians (ISCO 3) jobs. Conversely, in Germany and Latvia the increase in high-skilled jobs was driven almost exclusively by relative increase in jobs belonging to Technicians and associate professionals.

**Figure 7 Change in occupational composition of highly skilled jobs between 2011 and 2019**

Source: DG EMPL based on Eurostat [lfsa\_egised]



**Another important aspect, when analysing in detail the composition of employment and its changes, is the prevalence of medium-qualified workers in the technicians and associate professionals occupational group (ISCO 3).** Despite being considered in many exercises as high-skilled occupational group<sup>9</sup>, the majority (51%) of jobs in this occupational group in 2019 was occupied by medium-qualified workers (see Figure 1 in the Annex for detailed country-specific data). They were even more prevalent in a broad number of European countries, like Germany, Denmark, Austria, Czechia and Italy. This specific occupational category is likely to be an important gate-keeper for the capability to deploy complex innovative technology, especially in manufacturing, but also some services sectors – for example the health sector, where in the EU nearly a third and in Germany nearly half of all workers are

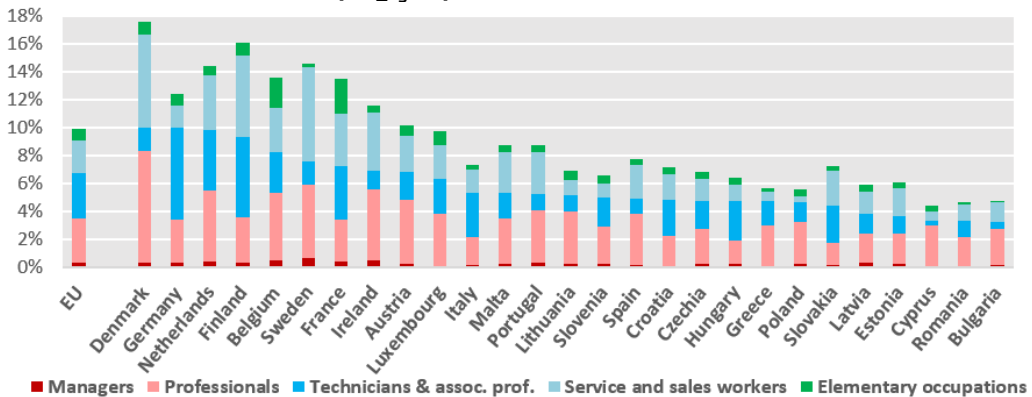
<sup>9</sup> Though based on the ISCO classification, it is attributed a medium-high skills level, in between middle-skilled and high-skilled occupations



technicians and associate professionals (Figure 8). A relatively large number of highly-skilled jobs, including those dedicated to dealing with complex technology and procedures (i.e. technicians and associate professionals), potentially help countries adopt more advanced and technology intensive processes. In the current context of COVID-19 pandemic, strong and high-skilled healthcare sector workforce may help countries manage this public health emergency.

**Figure 8 The occupational composition of healthcare sector, 2019**

Source: DG EMPL based on Eurostat [lfsa\_egised]



**This strong presence of medium-qualified workers in high-skilled jobs<sup>10</sup> is likely related to two interlinked factors – remaining presence of a significant advanced manufacturing sector and strong vocational education and training (VET) systems.** This is confirmed when looking at the composition of young (15-34 year old) medium-qualified workers. In most countries, especially where medium-qualified workers occupy a large proportion of jobs in the ISCO-3 occupational group (i.e. Germany, Austria, the Netherlands and Italy), the majority of those workers have a VET background (see Figure 3 in the Annex). A majority of these workers also believe that the education they have received is fully adequate for the jobs they carry out, reinforcing the argument of the value of high-quality VET (see Figure 4 in the Annex). On the other hand, the share of medium-qualified personnel occupying jobs in Technicians occupational group has been declining at least since 2002 (see Figure 3 in the Annex for country-specific data), with more high-qualified employees entering these jobs.<sup>11</sup> The average changes mask very different trends within the Member States. Uniquely, in Germany, most of the newly created high skilled jobs since 2011 belong to Technicians occupational group (and nearly a third of them were in the healthcare sector) and almost all of them were occupied by medium-qualified workers. In Denmark and Hungary, the number of medium-qualified workers also increased significantly in this occupational group.

<sup>10</sup> This refers in particular to ISCO-3 occupational group.

<sup>11</sup> While representing 60% in 2002, the share has declined down to 54% in 2011 and reached 51% in 2019. The absolute number of medium-skilled workers in such jobs increased between 2011 and 2019, however at a slower rate than high-qualified workers, thus resulting in a relative decline.

**Another domain, where the impact of new digital technologies in the labour market was more evident, is the platform economy.**

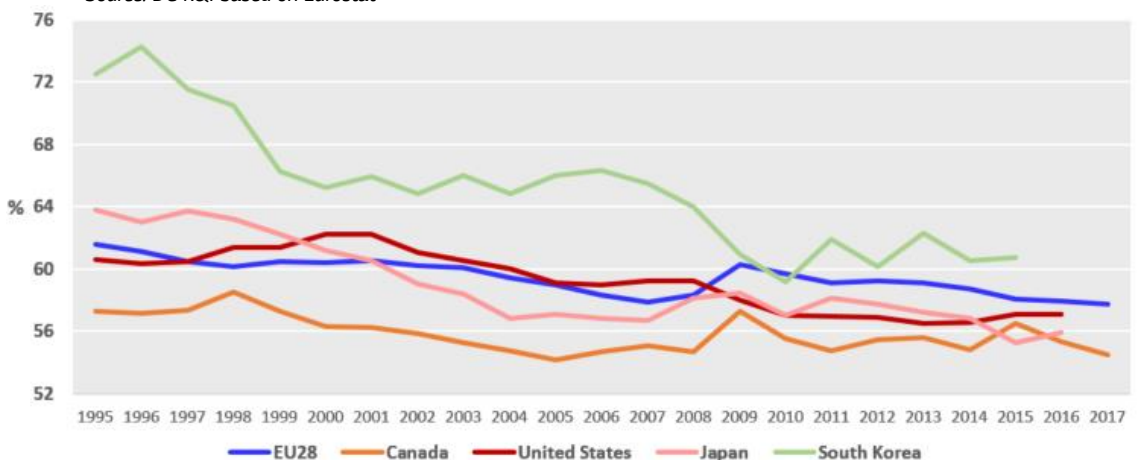
Evidence suggests that one in ten Europeans had some experience of supplying goods or services on internet platforms (World Bank, 2019). Nevertheless, it is only a minority of platform workers who make a living from platform work and only tiny shares of the population draw more than half of their income from such activity (Gonzalez Vazquez, et. al., 2019). While providing flexibility and multiple benefits, the future employee-employer relationship in platforms have to deal with challenges such as rules on working time, equal access to training, and other rights and benefits. High variety of online labour platforms with their own specific business models and worker profiles prevent a common and shared understanding of platform work. With the large amount of variety and a lack of robust evidence, many national governments are responding via policy experimentation to find new ways in securing adequate working and employment conditions (Goos et. al., 2019).

**Finally, one more key trend, influencing the labour market and likely driving inequality growth, is the declining share of income allocated to wages.**

Labour income shares, closely associated to levels of inequality in society (M. Chi Dao, et. al. 2017), have been declining in most advanced economies for decades (Figure 9). Multiple drivers seems to be behind this trend. Commodity cycles, the intangible capital, superstar firms, automation and falling labour bargaining power are identified as the key drivers, at least in the United States (Manyika et. al., 2019). This trend, combined with increasing employment levels (i.e. 68.4% in 2019 compared to 61.2% in 2002 in the EU) naturally leads to labour income stagnation at the individual level (i.e. a smaller share of labour income needs to be divided among a larger pool of wage earners). Furthermore, growing productivity gaps between businesses further reinforce growing income inequality. Wage inequality has increased both within and between firms, suggesting that increasing inequality does not only reflect the flows of economic benefits towards workers into leading firms, but also that workers at the top of the wage distribution within firms receive increasing rewards (OECD, 2019).

**Figure 9 Evolution of labour income share 1995-2017**

Source: DG R&I based on Eurostat



### *2.3 Persistent skills gaps and mismatches further inhibit diffusion and adoption of innovation*

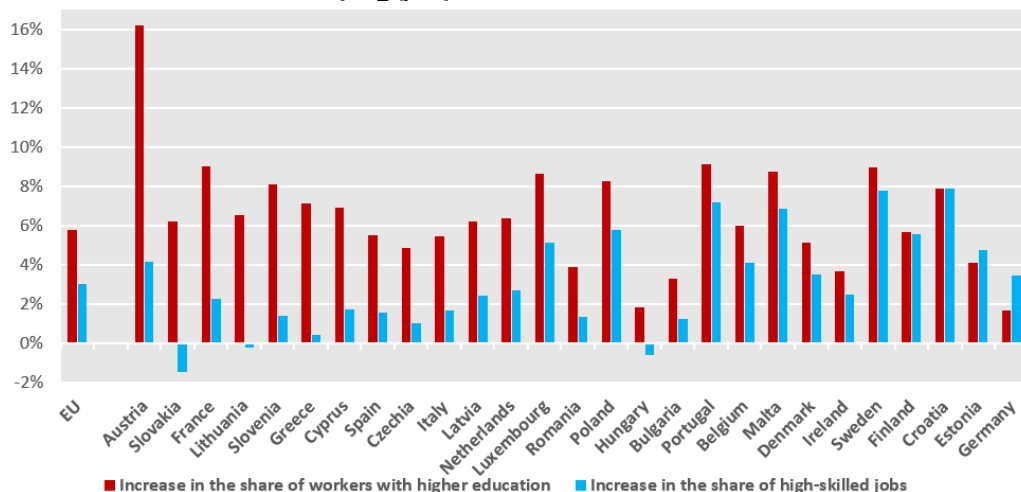
**The transition to an increasingly digital and knowledge-driven economy may bring a variety of economic and social benefits, including, for example, more sustainable production and consumption patterns or more effective healthcare systems.** However, in practice, innovation does not automatically lead to higher productivity growth across countries (rather the opposite was happening during the last decades, as discussed before). Innovation may not translate to new economic or social opportunities to the full extent possible, or even contribute to growing inequalities, due to limited or slow up-take, particularly among lagging regions, small firms or disadvantaged population groups.

**Furthermore, the predominant form of innovation in firms is incremental innovation, including both technical and organisational innovation.** This may include minor but continuous adjustments in the way firms organise their work, pursue marketing activities or adjust the features of their products or purchasing innovative technologies (such as software or new machinery) from external suppliers. The incremental nature of innovation highlights the central role that the broader workforce and its skills play in the generation, adaptation and diffusion of technical and organisational change (Toner, 2011). Therefore, innovation patterns and economic performance across countries are largely determined by their ability to ensure overall high level of standard in the initial education as well as having effective workforce skills (vocational or professional) formation systems (Toner, 2011). Recent empirical analysis carried out by the OECD confirms that firm's ability to implement productivity-improving changes is largely dependent on the availability of relevant skills (such as ICT or job-specific skills) and appropriate skills matching, both of which strongly support digital technology adoption by firms (Andrews et al., 2018).

**At the same time, on-going changes in the economy, transforming skills demand, coupled with slow reaction time in education and training systems may result in cumulating skills gaps and imbalances.** This could be particularly the case when technological changes transform skills demand faster compared to supply-side changes. It may also happen when the changes between supply and demand are not fully symmetrical. For example, imbalance may appear when the speed of up-skilling among the labour force is faster as compared to the speed of high-skilled job creation (Figure 10). On the other hand, also the differences in starting position must be taken into account. For example, if initially there is a significant gap in high-skilled labour, it could be preferable to have fast increase in high-qualified population for some time, to compensate such initial gap. Indeed, in the EU, the observed much faster growth rates in up-skilling, at least in some countries, is likely driven by the need to close the initial gaps between the share of high-skilled jobs and the number of high-qualified personnel available to perform those jobs. Earlier adopted EU-wide objectives (i.e. as part of Lisbon agenda or EU2020 strategy) may have also contributed to this trend.

**Figure 10 Change in high-skills supply and demand from 2011 to 2019**

Source: DG EMPL based on Eurostat [lfsa\_egised]



**While the existence of such skills gaps and imbalances is widely discussed and frequently commands policy attention, at the same time it is a phenomena which analytically is rather difficult to pin-point.** This difficulty in particular is driven by a shortage of easy to interpret or reliable direct measures of mismatch and the need to rely on derived or combined data from individual supply or demand measures, such as qualifications, occupations, skills, self-reporting, etc. (Eurostat, 2016).

Nevertheless, an obvious starting point for imbalance analysis is to compare the total supply of skills in an economy, as measured by qualification to the total demand for skills in an economy, as measured by occupations, revealing the extent of **vertical qualifications mismatch** (European Commission, 2015b). This approach has been used to derive the level of over-qualification in the economy (see for example Flisi, S. et al., 2014, for a review of different over-qualification measures). Eurostat skills mismatch indicator<sup>12</sup> suggests that in 2011 nearly 20% of high-qualified workers in the EU had a qualification higher than is required for their job, increasing to 22.1% in 2018, suggesting that rapid growth of tertiary graduates results in growing over-qualification<sup>13</sup>.

**However, such over-qualification indicators do not reveal the full picture of the situation.** There may actually be a corresponding large number of high-qualified jobs in the economy but not all of those jobs may be occupied by high-qualified individuals, as exemplified by the situation with ISCO-3 occupations in the previous section. Ideally, it should also differentiate the apparent mismatch (i.e. a theoretical mismatch between available workers and available jobs) and realised mismatch (i.e. actual allocation of

<sup>12</sup> Eurostat experimental statistics on skills mismatch. <https://ec.europa.eu/eurostat/web/experimental-statistics/skills>

<sup>13</sup> While the term over-qualification has a negative connotation, there may be both negative (i.e. lower job dissatisfaction or income) as well as positive (i.e. better health or higher worker productivity) effects.

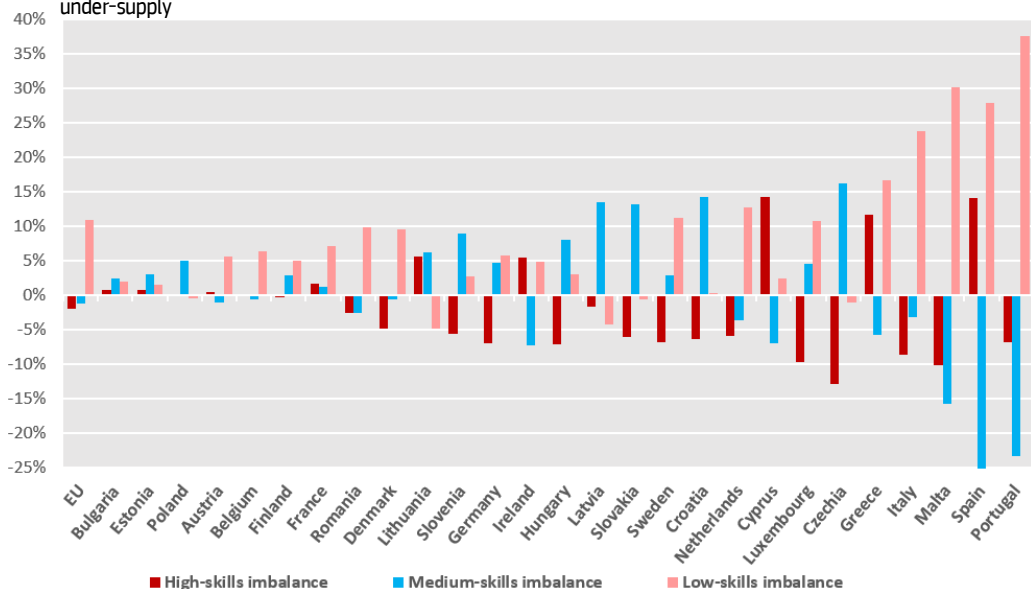
different workers in different jobs). Therefore, a number of other factors need to be taken into account to provide a more reliable picture, including the total supply and demand in the economy; available skills supply outside employment (i.e. unemployed individuals) any needed adjustments for when medium-qualifications are inferred to be adequate for some high-skilled jobs as well as an addition, to the demand side, of unfilled vacancies. An example of such assessment estimates the level of apparent structural mismatch, adjusted for availability of unemployed as well as for presence of medium-level qualifications which are adequate for high-skilled ISCO 3 jobs (see Annex for full details on the methodology). It must be noted, that in some cases also the low-qualified workers may declare to have adequate education (or at least skills) as required for their medium-skilled job. However, as in practice very few declare so, as well as due to high non-response and low reliability of data, such adjustment is not pursued here.

**This, rather experimental exercise, reveals that on average in 2019 in the EU, there was a relatively a good match between the total supply of both high- and medium-qualified workers in the labour force, compared to the total demand of high and medium-skills jobs** (Figure 11). It also reveals, that in the labour market there is also a rather consistent over-supply of low-qualified workers. But the EU average also mask very wide differences across countries and even larger differences at the regional level, though largely reflecting the performance of countries as a whole.

**Figure 11 Apparent structural mismatch between education (supply) and jobs (demand) across skill levels, 2019, adjusted for unemployment and VET qualifications in high-skilled jobs**

Source: EMPL based on Eurostat [lfsa\_egised and special data extraction from EU LFS 2016]

Note: On the vertical axis a positive imbalance value indicates over-supply; a negative value indicates under-supply



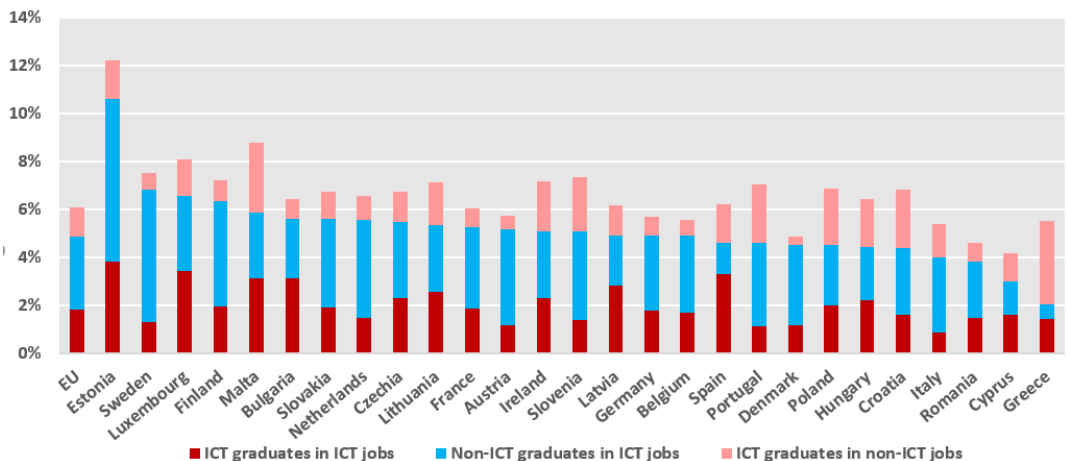
**Apart from looking at the level of education, skills gaps and mismatches may also appear in more specific dimensions.** One of the most widely reported domain potentially affected by skills gaps are STEM skills (science, technology engineering and manufacturing) and specifically ICT/digital skills. For example, it is reported that most

jobs in the EU already need at least basic digital skills (Cedefop, 2018a). But looking at the EU labour force, more than 40% of the population have only low basic digital skills or no digital skills at all<sup>14</sup>. This digital skills gap is also most pronounced among individuals with generally low level of education and skills. Although the basic level of ICT skills in the EU population seem to be slowly improving, the improvement is not sufficient given the rapidly evolving technological context and labour market needs. Furthermore, apart from basic digital skills, the shortage of IT specialists, possessing advanced digital skills, has often been highlighted by the industry. The supply of ICT professionals can be estimated as the number/share of individuals who possess a formal educational qualification in the ICT field<sup>15</sup>. The demand for ICT professionals can be estimated by identifying the number of ICT-related occupations, using the ISCO classification and methodology developed by the OECD and regularly applied by Eurostat<sup>16</sup>.

**Comparing the share of individuals having a formal qualification with the share of ICT jobs (though limited to 15-34 year old job holders) suggest that only a bit more than a third of ICT jobs are occupied by individuals with a degree in ICT.** Even in countries with a large number of ICT jobs (i.e. Estonia or Sweden) there seem to be only relatively few individuals with ICT education (Figure 12). The gravity of such imbalances, i.e. the fact that such a small proportion of all ICT jobs are occupied by individuals who possess an ICT-specific education, suggest that in this field, formal education systems play a somewhat limited role. On the other hand, it could also be argued that ICT jobs may require rather specialised, firm-specific skills, which may be difficult for formal education systems to provide. Also, it may be possible that it is preferable for firms to develop the skills of their workers themselves or relay on, i.e. industry-led training, rather than formal education.

**Figure 12 Skills mismatches in ICT, 15-34 years old workers, 2019**

Source: DG EMPL based on Eurostat (special extraction from EU LFS)



<sup>14</sup> Digital economy and society index (DESI), <https://ec.europa.eu/digital-single-market/en/desi>

<sup>15</sup> The standard international classification of education (ISCED) provides information on the field of education for vocational as well as higher education qualifications. This type of information is collected in the EU LFS, however for the moment it is restricted to 15-34 year olds.

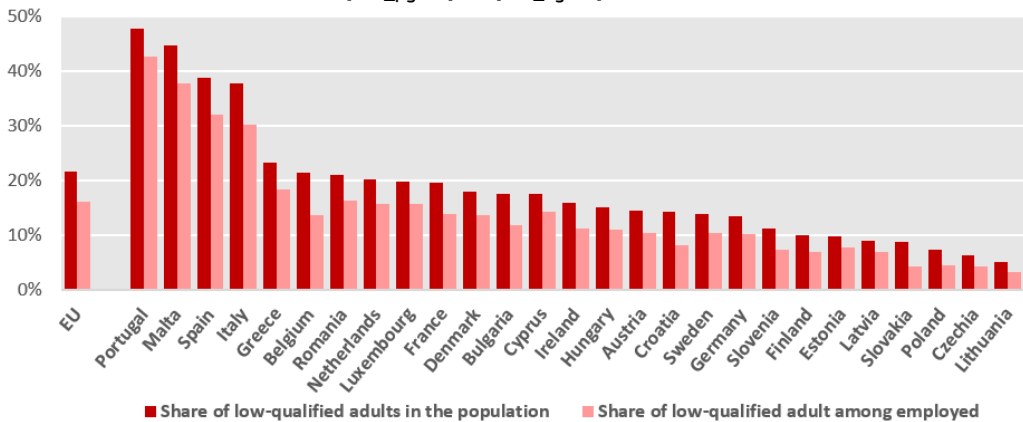
<sup>16</sup> [https://ec.europa.eu/eurostat/statistics-explained/index.php/ICT\\_specialists\\_in\\_employment](https://ec.europa.eu/eurostat/statistics-explained/index.php/ICT_specialists_in_employment)

Furthermore, gaps in digital skills are not the only challenge. Various other types of skills are also often argued to be lacking among the workforce – including healthcare, technology and lately –skills required to support the green transition. Even basic skills, such as literacy and numeracy, cannot be taken for granted. Challenges persist for large parts of the adult population, with more than a fifth (or around 51.5 million) of EU adults aged 25-64 in 2019 remaining low-qualified, i.e. having at most achieved a lower-secondary educational attainment (Figure 13). The OECD Survey of Adult Skills (PIAAC) also shows that up to 30% of the adult population in some of the participating EU countries<sup>17</sup> struggles with basic skills (literacy or numeracy).

**Figure 13 Shares of low-qualified adults in the population and employed, 2019**

*Note:* Includes only the population between 25 to 64 years old.

*Source:* DG EMPL based on Eurostat [lfsa\_pgaed] and [lfsa\_egaed]



All of this, while providing only a snapshot of the situation, suggests that multiple structural skills imbalances including both over- and under-supply are likely to be present across EU member states and skills domains. Issues with skills are also not limited to the lower parts of skills or (educational attainment) distribution. Rather, mismatches are present across countries at different skills level. All these mismatches not only inhibit the opportunities of individuals but also likely tend to slow down the generation, adaptation and diffusion of innovative solutions thus also slowing down more generally economic and social dynamism as well as the adaptation to changing technological landscape. It also may restrict the possibility for large groups of population to benefit from new technologies, including in such sensitive fields as healthcare, as has been exemplified by the on-going global Coronavirus pandemic.

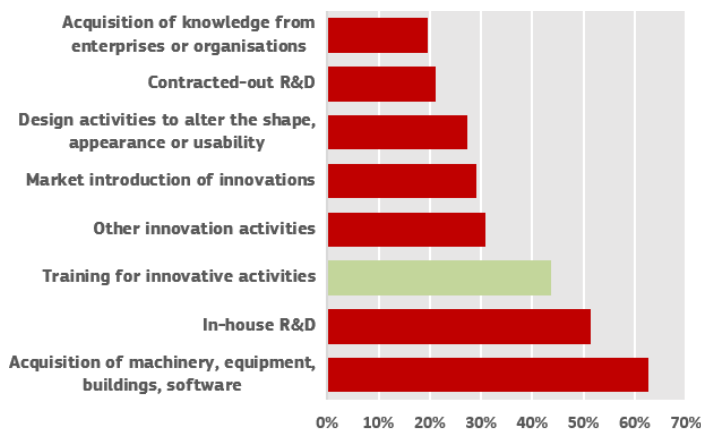
<sup>17</sup> Austria, Belgium-FL, Czech Republic, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Ireland, Italy, Lithuania, the Netherlands, Poland, Sweden, Slovenia, Slovakia, UK and Hungary.

2.4 Firm-provided training most clearly reveals interrelationships between skills development, innovation and inequalities

**The complementarity between investment in skills and investment in R&D has been well documented, particularly at the firm level** (CEDEFOP, 2012; OECD, 2013). On the one hand, skills shortages and mismatches are often cited as being among the key obstacles limiting investment and the adoption of new technologies, having a negative impact on productivity (Brunello, G. and Wruuck, P, 2019). On the other hand, investment in human capital, particularly on-the-job training, leads to more innovation at the firm level (Dostie, B. 2018) or economic growth (Dohmen, D. and Yelubayeva, G. 2019). This may relate in particular to the fact that provision of employee learning is an indication of a learning organisations, with such organisations being much more active in deploying innovation (Benhamou, S. and Lorenz, E., 2020). Also, a recent cross-country analysis by the OECD shows significant economic returns (including productivity) to individuals and firms accruing from both non-formal and informal job-related training (OECD, 2019d). Most notably, training for innovative activities is reported by firms to be one of the main innovation activities they undertake (Figure 14).

**Figure 14 Innovative enterprise by type of activity**

Source: Eurostat [inn\_cis10\_iact]



**However, many factors hamper broader participation in training and the ability to swiftly close existing skills gaps.** These in particular depend, on the one hand, on the ability and willingness of firms (in particular SME's) to provide training opportunities for their employees and on the other hand, on the interest and resources available to

individuals to take their own initiative and pursue learning opportunities. Notably, given that most adult learning is carried out in relation to one's current job and is often initiated or at least co-financed by employers (European Commission, 2020a), firms likely play a dominant role determining who and how much of training would receive.

**From the firm perspective, several observations stand out when looking at the opportunities they provided for up- and re-skilling of their workforce.** Firstly, it is the fact that SME's provide less training even if they do recognise the value of it. This is often due to much higher opportunity costs and capacity constraints (both in terms of time and expertise) to identify appropriate training opportunities and the necessary financial support, even if such support is frequently available (European Commission, 2020d). Secondly, when training is provided, it is usually provided for most-qualified



individuals<sup>18</sup>. Thirdly, the most frequent solution by firms, when skills gaps are identified, is to fill them with external recruitment, rather than training provision (European Commission, 2016). These drivers compound the inequities in access to training and strongly contributes to the entrenchment of skills imbalances.

**From an individual perspective, lack of time for and the high cost of trainings are the main two obstacles to re-skilling for those that want to train further.**

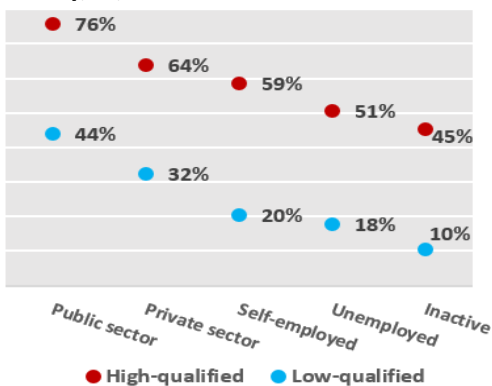
However, overall, motivation of the workforce to engage in adult learning is the major challenge, as the biggest share of those who do not undertake learning declare lack of willingness to participate at all, as testified by the results of European Adult Education Survey (European Commission, 2016; OECD, 2019f). Overall, the lack of instruments to enable individuals to take more initiative in identifying and realising their training needs is evident. It is thus one of the reasons for recent experiments in a number of countries (notably France and Singapore) to introduce universal incentive schemes – such as individual learning accounts – to stimulate the uptake of learning by individuals.

**Ultimately the workers, who are likely exposed to technological change the most, are participating in training the least. No matter if working for public or private sector, or being unemployed, adults with a low level of qualification almost always receive less training compared to those with more education**

(Figure 15). Also, workers in high-skilled jobs regularly receive more training as compared to workers in low-skilled jobs. This clearly shows, that the current system is

not inclusive enough nor fully aligned with the evolving skill needs. This is where one of the main policy challenge lies. In many countries adult learning systems lack focused policy attention and resources (EC, 2019b), putting in doubt their readiness to address future skill needs (OECD, 2019b). What makes it even more challenging is the fact that future skills needs are often very difficult to map and forecast, while at the same time some of the reported skills shortages may occur due to other distortions, rather than a genuine skills gap, such as poor hiring practices of companies (Cappelli, 2015).

**Figure 15 Participation rate of High- and Low-qualified adults in education and training by activity, EU, 2016**



<sup>18</sup> ENLIVEN – Encouraging Lifelong Learning for an Inclusive and Vibrant Europe (Horizon 2020 project No 693989), 2016-2019.

### 3 Addressing skill gaps to support uptake of innovations and reducing inequalities

#### 3.1 *Achieving the right skillset for a knowledge-led society through advanced education, training and skills strategies*

**The evolving content of work and more transitions between jobs place workers into new environment. Multiple developments such as new technologies, digitalisation, globalisation and population ageing are changing the jobs and the skill-sets they require.** To reap the benefits of these changes, skill development systems must be ready to support people in acquiring and maintaining the relevant skills needed in a changing working environments. While job- and sector-specific skills remain essential to support competitiveness and innovation, transversal skills<sup>19</sup>, including digital skills, are increasingly what determine our ability to adapt, progress and succeed in a fast-moving labour market. More frequent transitions between jobs and sectors increased a number of jobs individuals hold throughout their career (OECD, 2019c). These transitions require new knowledge, skills and mind-sets (competences), career management skills, flexibility and adaptability. It has been shown that the combination of socio-emotional skills with moderate to advanced use of ICT is linked to higher wage premium and recently, there is a rise in the returns on social skills (JRC, 2019). There is no silver bullet to acquisition of future-proof skills, but the combination of the highly demanded digital skills, accompanied by solid basis non-cognitive, socio-emotional skills, together with advanced job-specific skills is likely to be the most promising combination.

**Further efforts are needed throughout skills systems, cutting across both initial<sup>20</sup> as well as continuous education and training systems as well as measures allowing for the recognition, matching and better use of skills that are already available.** For example, given the persistent gaps in basic skills among young people and adults alike, which is a prerequisite for developing as well as exploiting the benefits of innovation, there is a need to strengthen the acquisition of key competences across all age cohorts. Ensuring universal access to compulsory education is crucial and access to high-quality early childhood education and care for all children should be the first step. Yet, early school leaving remains a major source of inequalities in some countries, since students who leave the education system early do so with low levels of skills, and tend to find great difficulties in engaging in any further form of learning or training, as well as frequently facing long spells of unemployment. In addition, the quality of compulsory education needs to improve in order to equip learners with high level of skills and effectively providing new types of skills required in the rapidly changing world.

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<sup>19</sup> Such as communication skills, team-working skills, customer handling skills, problem solving skills, learning skills and planning and organisation skills.

<sup>20</sup> Initial, in some contexts called pre-employment education and training, is usually public formal education and training provided at school or university, either with general/academic or vocational/professional orientation provided to young people before they start their working life. However, in some cases part of it (in case of Apprenticeships) or all of it (in case of private schools or universities) it also may be provided by private entities.

**Vocational Education and Training also must evolve to respond to the on-going changes.** Having a strong base of foundation and transversal skills, is a necessary, however often not sufficient factor in securing a smooth start of the working life as well

**Box 2. Formal vocational education and training (VET) in the EU**

Over 13 million learners are enrolled in a vocational pathway in any year, most of them – 8.5 million, are enrolled in programmes at upper-secondary (ISCED 3) level, representing around 50% of all students at that education level. However, VET programmes cuts across different parts of education, with significant numbers also undertaking VET programmes at post-secondary non-tertiary (1.5 million), short-cycle tertiary (1.5 million), professional bachelor (1.2 million) or professional master (0.7 million) levels.

as respond fully to the needs of more specific skills required for the economy and the labour market. Thus while majority of developed economies have set-up their Vocational Education and Training systems, so far only in a limited number of cases the full potential of such systems is realised. Too often such systems are oriented primarily towards supporting short-term skills needs or provide an alternative pathway of labour market entry (Benke, M. 2019).

However, the potential, as testified by the US Community College System (Raivio, R. unpublished), vocational and dual training systems in German-speaking countries or the Basque vocational training, applied research and innovation system, goes much beyond that, enabling valuable contribution to economic development and innovation ecosystems, particularly by addressing the needs of SMEs.

**The most widespread response to the need to equip people with higher levels of skills has been to expand access to tertiary education.** Higher share of graduates are is often associated with a considerable increase in the level of skills, especially in high-quality systems. Despite massive expansion, until recent years, the returns for university graduates in many countries have remained high. However, returns have not always met expectations in countries that have expanded access without ensuring high quality (JRC, 2019). Ensuring quality of expanded tertiary education is critical if it is to bring the individual and social benefits it promises. Looking into the future, if the expansion in the share of adults with high-level qualifications continues to exceed the speed of expansion of jobs requiring such qualifications, the prospects of tertiary graduates may deteriorate. Already now in some countries, it is seen that tertiary graduates are more frequently undertaking jobs that do not require high level of education, which also may imply income and career prospects that fall below what are the expectations for a person holding a tertiary qualification.

**Skills development does not end with initial education and training and continuous throughout life.** However, with the increased pace of change of the labour market and skills needs, in most countries existing adult learning systems are often largely inadequate to respond to the scale of re-skilling or up-skilling needs of large segments of population who have missed their chances earlier. In many, particularly less innovative countries, they are also often under-utilised as an instrument to support innovation activities. Also, across most countries SMEs face particular barriers in being able to engage their workforce in training.

**Supporting sectoral cooperation between firms could also help alleviate existing skills gaps.** Recognising the sectoral skills challenge, the Commission launched the Blueprint for Sectoral Cooperation on Skills as part of the Skills Agenda for Europe, to bring, at sectoral level, the key labour market as well as education and training stakeholders and social partners to address short and medium-term skills needs. Funded by Erasmus+, projects gather and analyse evidence of skills shortages and trends, and develops a comprehensive sectoral strategy to guide workforce adaptation, provide VET solutions and drive innovation and growth in those sectors.

**Apart from the need to develop right skills, employers and other actors must be able to easily recognise and identify the skills possessed by workers or job candidates.** However, transparency and recognition of skills, qualifications, and certifications remains a challenge. People's skills go too often unrecognised, particularly when these are gained outside formal educational, such as through industry-based training, online training or volunteering. Despite existing initiatives, such as European Qualifications Framework or the efforts to enhance skills validation and recognition systems in the EU Member States, still a lot of work remains to be done.

**Improved skills intelligence and better use of it could also bring substantial benefits in helping adjust education and training systems to changing labour market needs and better skills matching on the labour market.** A considerable body of labour market and skills intelligence is now available including both traditional labour market intelligence as well as big data analytical tools, including the analysis of real time labour market data. This enables to make more sophisticated and detailed forecasts of labour market needs, as well as improve career guidance possibilities, and employment opportunities. However, its use remains fragmented and scattered.

### *3.2 Strengthening innovation diffusion engine with the help of high-quality VET*

**Towards the end of their initial education, more than half of young people in Europe undertake vocational education and training (VET) programmes as part of their formal education.** Such programmes provide young people with labour market relevant sector- and occupation-specific skills, ensuring easier entry into the labour market, helping find their first jobs and prepare for future career. VET programmes, which have a work-based component in a company (such as apprenticeships) are particularly effective in helping young adults find good quality jobs. It is also an important pathway from economic point view, supporting the diffusion of new technologies and work-organisation practices, especially among SMEs, by preparing both new and incumbent workers to use latest technologies and providing the skills required to operate them. Therefore, EU and national policy needs to ensure that VET can provide its contribution in addressing current challenges and supporting the competitiveness and innovation of European economies. Nowadays, VET programmes go well beyond the handful of sectors traditionally associated with it, expanding to health care, arts, ICT, aerospace, robotics, communication or financial services. Even more traditional sectors - like construction, agriculture or transport, given the dynamic business environment, are also adopting new business models. They need to use new digital technologies and adjust to the demand for more sustainable business practices. Having employees well acquainted with such technologies and practices is a prerequisite for their success.

**Developing a high-quality vocational learning experience is needed to equip young people with strong foundation skills and job-specific skills high in demand in the labour market.**

This would provide access to jobs requiring middle and high levels of skills, as well as providing a durable basis for lifelong learning. Well-developed VET systems can lead to high levels of employment and the capacity to respond swiftly to changing trends in the demand for skills. However, by far not every

**Box 3. Centres of Vocational Excellence (CoVE)**

The initiative on Centres of vocational excellence (CoVE) defines a bottom-up approach to excellence where VET institutions are capable of rapidly adapting skills provision to evolving economic and social needs. They operate in a given local context, closely embedded in the local innovation ecosystems and knowledge triangles, while working with centres in other countries through international collaborative platforms. A recent mapping by the Commission revealed a variety of such centres across the EU (European Commission, 2019f).

CoVEs are intended to be world-class reference points for training in specific areas for both initial training of young people as well as for continuing up-skilling and re-skilling of adults. These centres act as catalysts for local business investment, supporting European and regional innovation and smart specialisation strategies by ensuring supply of high quality skilled workers through flexible and timely offer of training for the skills needs of companies. They also support entrepreneurial initiatives of their learners (incubators), as well as act as knowledge and innovation hubs for companies (in particular SME's).

VET system is like that and often significant reforms are needed in Member States to ensure that they can fully benefit from top-notch VET.

**Furthermore, VET could also be utilised much better in enabling easier access for companies, particularly SMEs, to latest technologies, helping to strengthen the innovation diffusion mechanism.**

This can be achieved by ensuring that VET is able to provide learners with the skills needed to manage latest technologies and pursues active collaboration with businesses (particularly SME's) through work-based learning arrangements or showcasing and sharing access to latest equipment, supporting them in deploying innovation. For example, some recent work has

clearly identified that strengthening the contribution of VET to the implementation of smart specialisation strategies to facilitate innovation diffusion and build-up absorption capacity is a key opportunity, currently well exploited only by a few highly advanced regions in Europe (Hazelkorn and Edwards, 2019; Moso-Diez, M. et. al. 2019). Recognising this opportunity, European Commission has launched an initiative for acknowledging already existing as well as promoting the development of new Centres of vocational excellence (CoVE). Such centres could act as drivers of quality vocational skills in a context of national, regional, local, sectorial or societal challenges, while supporting overall structural changes and socio-economic policies in the European Union (Moso-Diez, M. 2019).

### 3.3 Building upon STEM and STEAM workforce

**There are concerns regarding unmet demand for graduates and the need to achieve more even gender participation in the science, technology, engineering and maths (STEM) fields.** STEM skills acquired at universities and vocational schools (Figure 15) are critical to innovation and allow to gain a competitive edge in knowledge-intensive economies, but businesses in the majority of EU Member States experience labour shortages. ICT and other STEM professionals belong to occupational groups with critical shortages that have important economic implications (EESC, 2018). Women represent only about 33 % of all science, technology, engineering and mathematics higher education graduates in the EU, a share which has not changed much in recent years. In 2017, there were remarkable differences within the main STEM areas with higher share of female graduates (53%) in natural sciences, mathematics and statistics, but significantly lower share (19%) in Information and Communication Technologies. The persistence of women's underrepresentation in particular fields of STEM also contributes to reproducing economic gender inequalities, as STEM occupations represent some of the best paid and

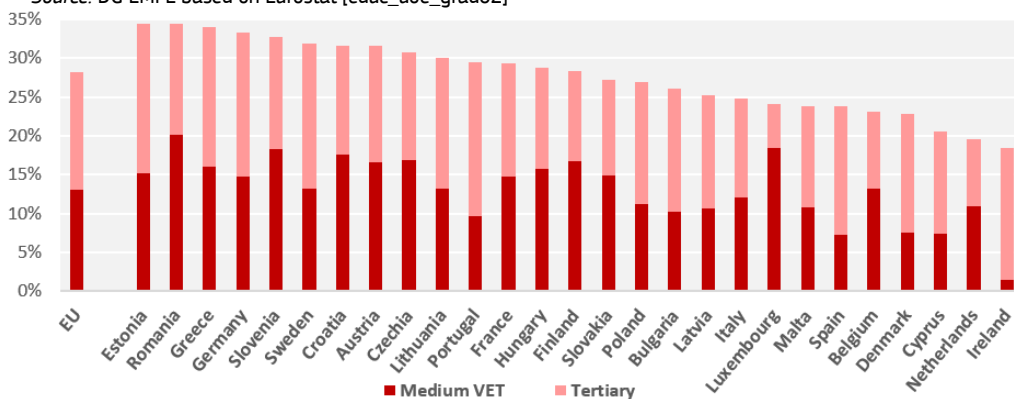
#### Box 4. European Institute of Innovation and Technology (EIT)

The EIT plays an important bridging role between the EU research and innovation framework and education policies and programmes. The institute reshapes innovative and entrepreneurial education at Master and Doctoral levels, but its initiative Skills for Future intends to rethink education programmes also at lower education level.

most prestigious jobs in the labour market (Blasko et. al., 2018). Furthermore, there is a Europe-wide shortage of teachers specialised in STEM and the outcomes of education do not always address the needs of the labour market thus hampering the transition of graduates from education to work (ECoR, 2019).

**Figure 15 Share of graduates in higher education and vocational education and training with STEM specialisation**

Source: DG EMPL based on Eurostat [educ\_uoe\_grad02]



**With the intention to apply more creative thinking in design of innovative products and in general to involve new insights and perspectives into scientific progress, the focus is shifting towards STEAM approach.**<sup>21</sup> . As STEAM grew in popularity, the Arts education in STEM currently spreads over visual arts to liberal arts and humanities, e.g. considering the ethical impact of today's technologies. The role of higher education institutions has to evolve and to educate students to be successful in a complex and interconnected world that faces rapid technological and socioeconomic changes. Universities need to better tap-in to their innovation and entrepreneurship potential to generate the ideas and new business models that can translate into start-ups and spin-offs (EC, 2018c). The European Institute of Innovation and Technology works towards breakthroughs by promoting collaboration between higher education, research, and business sectors through the establishment of Knowledge and Innovation Communities. Further initiatives as Innovative Training Networks within the Marie Skłodowska-Curie Actions and the Higher Education Innovate Initiative connect business with education and science to promote entrepreneurship and stronger knowledge flows throughout the value chain.

**Rapid technological developments, mainly in the digital field, and cultural shifts mean that occupations commonly considered as highly skilled are also in need of additional skills.** Science could better capitalise on the knowledge of researchers and students by working in multidisciplinary co-creation teams to solve specific challenges and develop de entrepreneurial spirit. Furthermore, a broad action could support the cultural shift towards open approaches in science. In particular, doctoral candidates are often either unaware of or are missing appropriate skills for open science practices. This applies mainly in the areas of Open Access publishing, data management, but also of research conduct, and of engagement with society.

### *3.4 Transforming adult learning to enhance equity and support innovation*

**Education and training does not stop with the initial education. On the contrary, the importance of continuing learning throughout whole adulthood is being increasingly recognised as a critical element of human capital formation and education and training systems.** More frequent changes of jobs during our working lives, migration from one sector to another, and changing nature of occupations ask for people to reskill and upskill continuously throughout their lives. However, current levels of participation in adult learning are considered to be low. While few comparable data is available internationally, based on data from PIAAC it would seem that adult participation in learning in the US, Canada and Australia is around 50% higher compared to European countries. In addition to that, in most countries public sector is playing a rather limited financial and/or regulatory role in adult learning, contributing primarily as a training provider for public sector employees and for unemployed or socially excluded individuals. Still, most of adult learning is initiated and financed by private sector – particularly by the employers.

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<sup>21</sup> Teaching STEM in environmental, economic and cultural contexts with the infusion of the arts, humanities and social sciences.

### **Box 5. Enhancing the governance of adult learning systems**

A key challenge is that adult learning systems are difficult to define and delineate. They consist of a range of sub-systems with different actors, objectives, inputs, activities and degrees of organisation. These range from formal basic and general education, through non-formal learning in the workplace, to leisure-oriented liberal adult education.

**Well-designed coordination and financing mechanisms** are therefore critical in order to leverage financial contributions from all involved stakeholders. Also, since governments alone cannot bear the transformation costs of the adult-learning systems, fair cost-sharing mechanism and innovative financing systems are required. With limited resources and regulatory power, public sector must strike a delicate **balance between direct intervention** in the training market, i.e. for low-skilled or unemployed adults **and indirect measures** such as incentives and support mechanisms targeted more broadly at employers (in particular SME's) and individuals.

**Thus, in most countries a paradigm shift is required that would enable the transformation of front-loaded education systems into more effective lifelong learning models.** One of possible ways how adult learning systems could evolve is by making individual entitlements/rights to training more embedded and easier to access to support labour market transitions. Such is in particular the example adopted in France through so called Individual Learning Account, allowing individuals to accumulate training credits over a number of years. Almost all EU Member States already have set-up some (limited) legal entitlements for training, most usually in the form of educational leave rights. In some cases such leave is paid, guaranteeing a level of income for the individual undertaking learning. However, the evidence on access and utilisation of such opportunities remains scarce. In some cases, it seems very few

individuals are benefiting from such rights (European Commission, 2020b).

**Apart from the more encompassing rights-based or entitlement-based approaches to support adult learning, public sector undertakes a broad range of other actions to incentivise adult learning and/or support specific target groups.** They include financial and non-financial incentives for individuals, and/or private sector employers as well as incentives, support or direct public provision for specific target groups, such as unemployed. Specifically, efforts are made to engage low-skilled and low-qualified adults in learning, who are most disadvantaged and face particular difficulties in accessing learning and work opportunities. This in particular was recognised as a key pan-European challenge, thus stimulating the launch of the Upskilling Pathways initiative in 2016<sup>22</sup>. Finally, framework conditions such as ensuring quality and relevance of training, building the evidence base on what works and adjusting the overall governance mechanisms across different parts and levels of government are also important. The diversity of actions required to stimulate adult participation in learning have been summarised into a framework of effective adult learning policies (European Commission, 2015a), which is also included in the Annex.

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<sup>22</sup> <https://ec.europa.eu/social/main.jsp?catId=1224>



### 3.5 *Contribution of technology in the time of coronavirus pandemic and beyond*

**While many of the workplace adaptations related to the global spread of coronavirus are viewed as short-term measures to enable large-scale social distancing, the rapid implementation of innovation and technologies could lead to longer-term lifestyle and productivity changes.** With the global health emergency due to COVID-19, the change in economic activity has been larger and more abrupt than anything anyone has ever experienced on a global basis (Furman, 2020). Most of firms have locked their offices, required their staff to telecommute and equipped them with the computing and video technology to do so. Moreover, there is evidence that small and informal enterprises are more vulnerable to such exogenous shocks (e.g. Fort et al. 2013), possibly due to their limited financial, managerial and information resources. These firms are also less likely to be able to respond to the crisis with technological solutions such as teleworking, (Panizza, 2020). While such negative developments could lead to disruption in supply chains, increasing gaps in productivity and, in general, reducing innovation activities, policy makers could compensate with schemes for helping enterprises to respect social distancing, protection needs for people at risk, accelerating digitisation and developing required skills. A broader diffusion and preservation of the benefits of accelerated digitalisation for the time after the pandemic could have positive implications for productivity developments.

**Enhancing student learning and worker training solutions through digital solutions, together with a wider use of technology for skills development and management could further accelerate the pace of human capital accumulation.**

Broader deployment of technology would not only reduce the gap in access to high-quality training, but also free up local resources to provide more targeted sessions or increase the variety of trainings (Shang-Jin Wei, 2020). In broader terms, the use of technology for training purposes (with support of mobile applications or augmented reality) can push learning practices to go beyond the current learning processes and allow knowledge creation and sharing right at the workplace. The smart use of technologies would make the working environment a place to learn that can at the same time encourage workers to proactively share their knowledge. Such deployment of technologies can be even brought to the next level where interaction between workers and AI agents leads to so called reciprocal apprenticeship (Daugherty and Wilson, 2018). Within this framework, on-the-job training for people takes place within AI-enhanced processes. But reciprocally, workers can also perform tasks alongside AI agents so that AI, machines can learn new skills from humans, e.g. workers can act as “role models” to the machine. Technologies and assistance systems supporting the future learning formats range from e-learning and video-based training to interactive business games and virtual reality applications. Alternative approaches aim to improve knowledge sharing practices and to re-design the work environment with pro-active use of augmented reality and geolocation (EASME, 2019). To bring these solutions to a larger scale, policy makers should consider how to effectively support the development of digital capacities and how to implement digitally enhanced learning solutions. Following these trends, the Intervention Area Social and Economic Transformations of the upcoming Horizon Europe Framework Programme should further explore use of emerging technologies such as AI, data analytics or blockchain in education and training.

**Private sector is also actively pursuing investment in developing innovative education and training (EdTech) as well as human resource management (HRTech) solutions.** Both of these sectors are vibrant markets for early stage and venture capital investment. In 2019 alone, it is estimated that globally venture capital investment in EdTech were \$7 billion<sup>23</sup>, closely followed by HR Tech investment surpassing \$5.3 billion<sup>24</sup>. New solutions, developed to enhance learning include pursuing such concepts as Cognitive Learning, AI-based learning, mixed reality learning, mobile learning, location based learning, mobile learning or even the development of educational bots. This marks a very clear on-going shift away from on-line learning concepts already considered as legacy technology (Metaari, 2020).

### *3.6 Valuing investment in skills as a part of intangible capital formation*

**Economic competencies, such as management quality, organisational structure and workforce training, are essential ingredients for reaping the full productivity benefits from investments in both tangible and other intangible assets, especially in a fast-changing world.** There are complementarities between economic competencies and other intangible and tangible assets for firm performance and productivity. These competencies relate to the resilience and agility of teams and companies to recognise and embrace the opportunities brought by new technologies. (Stehrer et al., 2019). Within the recent debates in the field of economics (see, e.g. EIB, (2016), ECB (2017), ECB (2018), European Commission (2017a), European Commission, 2017b)), it emerges that investment in intangible capital, of which training is one of key elements, has important links to productivity and economic growth. Having reliable data on the investment in job-specific skills would make it possible to isolate and assess much better its impact on these key economic performance indicators.

**Most of the data available on skills concerns non-monetary indicators – be it the availability (i.e. supply), the demand or the development of skills.** However, for taking policy action, understanding the total aggregated volume of investment across countries is an essential prerequisite for informed action, for example identifying investment gaps in a cross-country perspective. Given the segmentation of skills development systems, it is equally necessary to understand the contribution of each type of actors. Such understanding would allow identifying sectors who may need policy support; it would also allow monitoring the efficacy of policy actions to incentivise investment, given that such incentives are often sector-specific.

**However, at the European level, despite an advanced statistical system, tracking the level of investment in skills face significant barriers.** Even if multiple data sources are available, covering different parts of skills investment, due to their misalignment in terms of timing, scope and definitions used, it is very difficult to produce an aggregate estimate of such investment. Nevertheless, recent back-of-envelope calculations by the Commission (European Commission, 2019c; and further elaborated in this paper) allows drawing an initial indicative picture of what could be the

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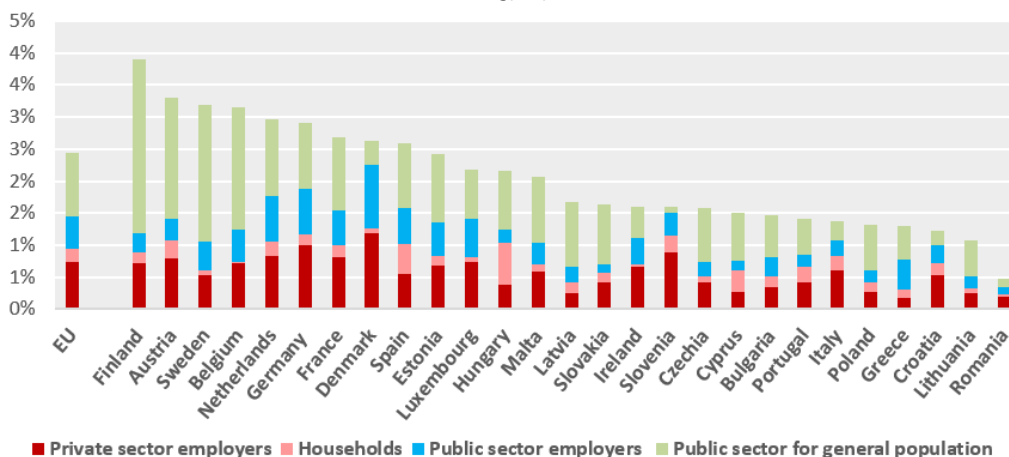
<sup>23</sup> <https://www.toptal.com/finance/market-research-analysts/edtech-trends-2020>

<sup>24</sup> <https://larocqueinc.com/2019-global-hr-tech-vc-look-back/>

total volume of such investment and its' composition (Figure 16). These calculations show, that the total investment in skills for labour market and social purposes (please see detailed description of the methodology in the Annex), having the most direct link to enterprise's skills needs and supporting innovation diffusion, in the EU27 for the reference year 2015 totalled nearly EUR 300 billion, somewhat larger but overall similar to the total investment in R&D, which reached EUR 259 billion in the same year.

**Figure 16 Investment in skills by source of financing (% of nominal GDP in 2015)**

Note: DG EMPL estimates. Source data and methodology explained in the annex.



**While such an assessment provides a relatively representative picture, several elements from the sources of financing are still missing.** The assessment covers such types of investment as public and private sector enterprises expenditure on training and apprenticeships, individuals' own expenditure on non-formal learning and households' expenditure on formal adult education as well as public expenditure for relevant education.<sup>25</sup> However still an important element missing for all countries is the expenditure on job-related skills as part of higher levels of tertiary education (i.e. bachelors and masters), particularly professional programmes or programmes with significant labour market preparation content (including work-based learning).<sup>26</sup>

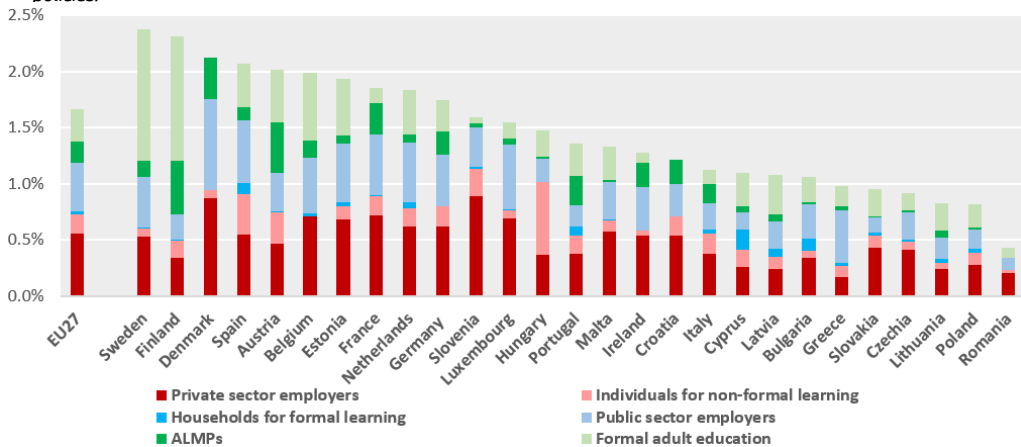
<sup>25</sup> This includes formal VET and ISCED levels 3 (upper-secondary), 4 (post-secondary non-tertiary) and 5 (short-cycle tertiary) as well as estimates of expenditure on formal adult education.

<sup>26</sup> Also, investment data on publicly financed non-formal education and training programmes for adults outside active labour market policies (ALMPs) is also not available. Furthermore, there are also gaps in some data categories for specific countries that would likely also have an impact on the overall estimated expenditure levels.

These estimates also suggest that two-thirds of investment in skills development are oriented towards adult learning (Figure 17), as opposed to around one third dedicated for initial skills formation as part of initial vocational education and training<sup>27</sup>. This ratio, however, is likely to be more balanced, given that a significant amount of investment towards vocational/professional skills development is also dedicated at tertiary level (bachelors’ and master’s, as mentioned above). However, at this stage it is not possible to isolate such investment. Furthermore, it should also be noted, that estimates of employer investment in training includes opportunity costs (i.e. foregone salaries), which represented around 50% of total investment. If this part of investment would be excluded, the estimate of total expenditure for adult learning in the EU would likely be smaller by 0.5% of GDP.

**Figure 17 Investment in adult learning by source of financing (% of nominal GDP in 2015)**

Note: DG EMPL estimates. Source data and methodology explained in the annex. ALMPs – active labour market policies.



### 3.7 Realising synergies between investment in R&D and investment in skills

**Overcoming the gaps in economic dynamism and innovation performance requires, among others, policies to improve the conditions to speed up knowledge creation and diffusion via increased investments in intangible assets and skills.** These should be further accompanied by strengthening innovation ecosystems, engaging SME’s and leveraging the networks of vocational education and training institutions to support uptake of innovation. Innovation-friendly regulation that supports transformative technological change across sectors is also important.

**However, challenges persist in aligning the role and actions of public sector actors to the actions of the private sector.** This is sufficiently difficult even in a single sector – as testified by challenges faced in aligning public investment priorities and fundamental research with the needs and applied research carried out by the private

<sup>27</sup> Adult learning investment estimates exclude firms’ expenditure on apprenticeships as well as household and public expenditure for participation in formal programmes at ISCED levels 0-5 for those, who are younger than 25, as well as at ISCED level 6 or above for those, who are younger than 30.

sector. Similarly in skills systems, aligning the provision of education and training with labour market and social needs is a persistent challenge. All these difficulties are further multiplied, if better alignment is sought between, rather than only within, such policy domains. In most countries such effort is still in early stages. Nevertheless, in some countries – like in Singapore, which has started to work in this direction already since early 2010s, trying to align innovation, skills, industrial and trade policy domains, or in the US, through advanced manufacturing institutes<sup>28</sup>, show promising initial results (Sekmokas, M./IAL, 2019).

**More support is needed for cross-border and cross-region collaborations across European and international value chains. Institutional capacity at regional and local level also needs to be strengthened to support reforms of innovation systems and help develop the new skills needed.** European Structural and Investment Funds backed by solid Smart specialisation strategies have the potential to enable stronger interregional innovation links. Synergies with Horizon Europe, European Social Fund (ESF+), and Erasmus+ Programme would ensure a good matching of the EU funds to the key European and national policy challenges. For example, the ESF+ could mainstream and scale up Erasmus and Horizon Europe funded innovative curricula that would equip people with the skills and competences needed for the jobs of the future (EC, 2018d). Horizon 2020 R&I projects are already identifying skill needs and curricula. However, effectively deploying them will require interaction and collaboration with different actors, including the European Social Fund (ESF+). Although these instruments can provide appropriate financial resources and funding mechanisms, the timeline of such initiatives should not be primarily driven by access to EU funds and tied in with their planning periods, but rather organised in a sustainable and market oriented fashion.

#### 4 Conclusion

**Skills are crucial to ensure that people contribute to and benefit from innovation.** As in earlier economic transformations, technological change and skills development need to go hand in hand in order to guarantee rising levels of prosperity in society. When this relationship is not synchronised, periods of social pain and tensions caused by rising inequality are likely to arise. Against this backdrop and to ensure inclusive growth, European and national policies need to be agile to react to the scale and speed of the changes that the on-going social and economic transformations are bringing about. In particular, while providing the conditions and support for the development of breakthrough innovations, they should also take further action to facilitate the diffusion of such innovations across firms and regions, steering technological development towards being complementary and amplifying to human labour, rather than eliminatory.

**A critical factor hampering innovation diffusion are the persistent skills gaps and mismatches across and within EU countries and regions.** This is in part caused by the difficulty of projecting medium and long-term skills needs that inhibits a more strategic steering of education and training systems in line with evolving societal

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<sup>28</sup> <https://www.manufacturingusa.com/institutes>

demands. Furthermore, any adjustments of skills supply after initial education and training is difficult given the slow-moving nature of initial education and training systems as well as the inadequacy of adult learning systems. The intangible nature of skills makes it also very hard (or at least very expensive) to showcase and verify which are the skills possessed by a particular individual or how such skills are distributed across populations.

**Mitigation of skills shortages and mismatches likely will be a critical lever in any policy mix designed to address the dual challenge of stalling innovation diffusion and growing inequalities.** Such mitigation can only be achieved by acting across the existing skills ecosystems. This includes alleviating the inequities in initial education and training systems, ensuring their stronger contribution to innovation adoption, and enhancing the governance and accessibility of adult learning systems. Major challenges remain as regards the overall efficacy of skills development systems and skills markets. In particular, further work on skills intelligence and more strategic skills management approaches are required when it comes to the way skills are developed, the matching of their supply and demand on the labour market as well as the recognition and reward of their deployment at work.

**Figure 18 Importance of synergies between Research & Innovation and skills policies**

Source: DG R&I



**Furthermore, achieving a more consistent monitoring of investment in skills would mean a significant progress for the assessment of the gaps and returns of such investment.** More importantly, it would help to understand better the role of skills investments as part of the portfolio of intangible assets, the complementarity and relationship between these various intangible assets (R&D, skills, economic competences) as well as their economic and other benefits at the micro and macro-levels.

**Finally, exploring how to better align innovation and skills policy, as well as other policy domains, is important.** Some initial efforts have been pursued already at the EU level by the Commission, for example through the Skills Agenda, Sectoral Skills Alliances and Blueprint projects for sectoral cooperation on skills and actions to increase the pool of digital skills, such as the Digital Coalition for Skills and Jobs and now, more recently, through the Vocational Excellence initiative. In addition, an important ingredient to align better innovation and skills policy is improved skills intelligence, mentioned above. One of the three work strands of the Skills agenda focuses on improving skills intelligence with better data on skills needs and trends. This includes big data techniques to scrape on-line job vacancies as well as reinforcing the evidence of needs across sectors to produce more precise and real-time information (the EU "Skills Panorama").

**On the research side, the Horizon 2020 programme and its successor, Horizon Europe, foster the creation and diffusion of the skills that, alongside high-quality new knowledge and technologies, also provide solutions to global challenges.** Notably, to reinforce the Union's scientific leadership, the Marie Skłodowska-Curie Actions equip researchers with new skills via mobility and training, while the European Institute of Innovation and Technology develops entrepreneurial and innovation skills in priority areas through its Knowledge and Innovation Communities. However, policies that support innovation, skills and other domains, both at the EU and national levels, require further strengthening and alignment to enable achieving stronger impact on social inequalities, innovation and economic growth, that the economic and social transformations are calling for.

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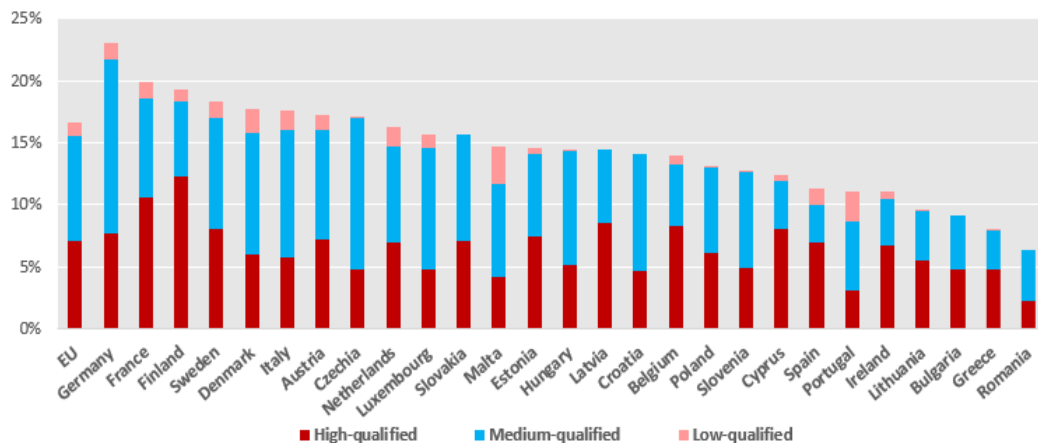
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## 6 Annex – Additional tables and figures

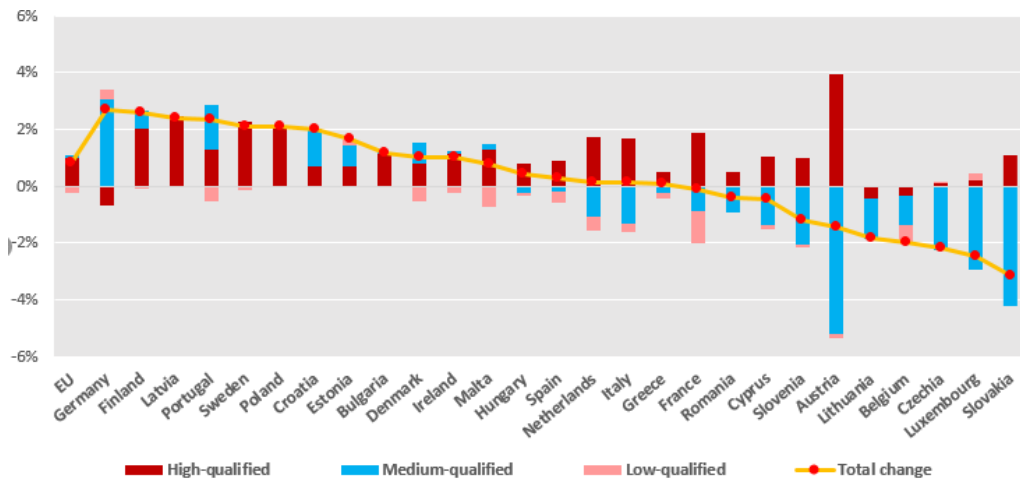
**Figure 1 Share of jobs in technicians and associate professionals occupational group (ISCO 3), out of total jobs in the economy and their composition by employee educational attainment, 2019**

Source: DG EMPL based on Eurostat [lfsa\_egised]



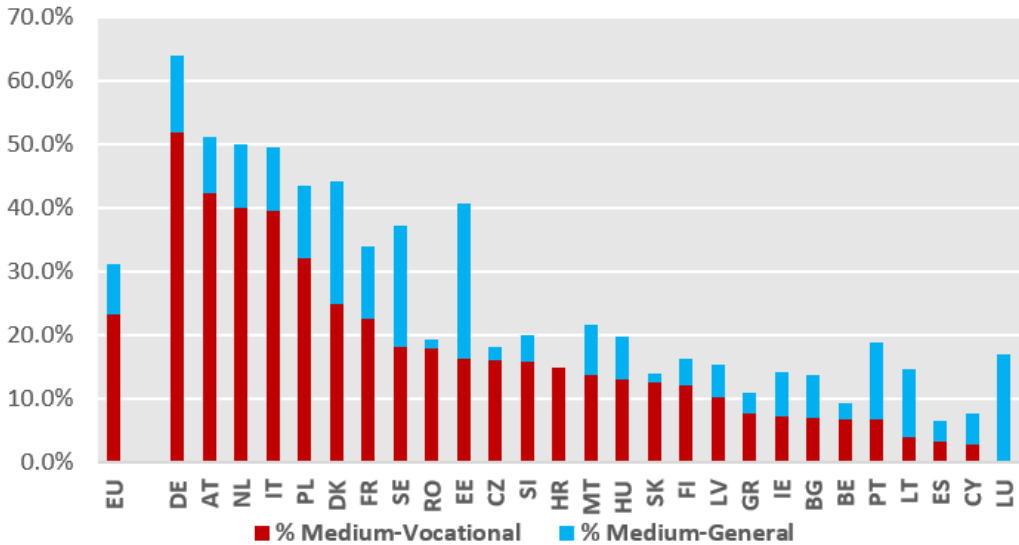
**Figure 2 Change in employee share in ISCO 3 jobs by educational attainment, 2011-2019**

Source: DG EMPL based on Eurostat [lfsa\_egised]



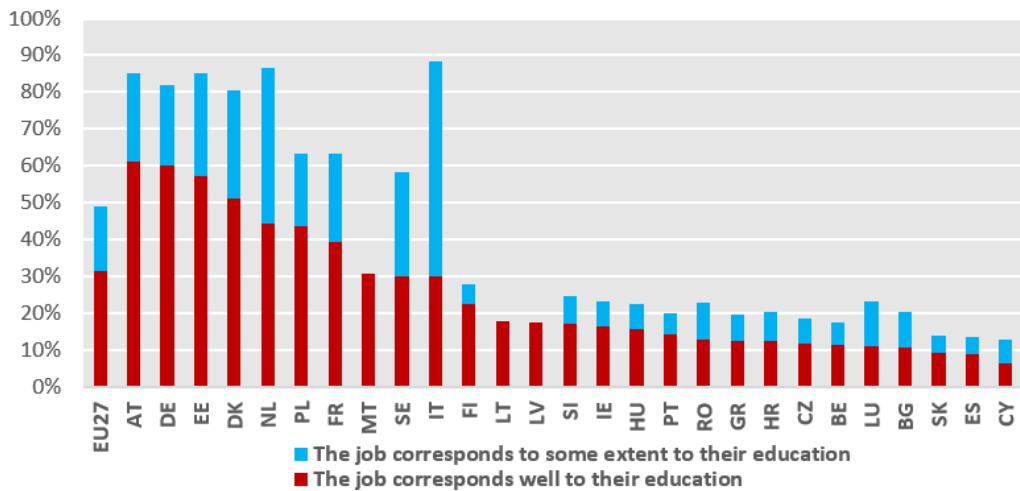
**Figure 3 Share of medium-qualified workers in ISCO3 and orientation of their education (15-34)**

Source: DG EMPL based on Eurostat (special extraction from EU LFS 2016)



**Figure 4 Self-reported fit between education and job of medium-qualified ISCO 3 workers (15-34)**

Source: DG EMPL based on Eurostat (special extraction from EU LFS 2016)



**Table 1 Changing occupational composition, EU**

Source: DG EMPL based on Eurostat [lfsa\_egised]

Major occupational groups	2002 - 2010	2010 - 2011	2011 - 2019	Total
Managers (ISCO 1)	0.7%	-1.8%	-0.3%	-1.4%
Professionals (ISCO 2)	2.4%	<b>2.3%</b>	2.0%	6.7%
Technicians and associate professionals (ISCO 3)	1.5%	-1.2%	0.8%	1.0%
<b>Total high</b>	<b>4.6%</b>	<b>-0.7%</b>	<b>2.4%</b>	<b>6.3%</b>
Clerical support workers (ISCO 4)	-0.8%	-0.5%	-0.3%	-1.6%
Service and sales workers (ISCO 5)	0.5%	<b>3.2%</b>	-0.1%	3.6%
Skilled agricultural, forestry and fishery workers (ISCO 6)	-1.8%	-0.2%	-1.0%	-3.0%
Craft and related trades workers (ISCO 7)	-2.3%	-0.8%	-0.7%	-3.8%
Plant and machine operators and assemblers (ISCO 8)	-0.8%	-0.6%	0.0%	-1.4%
<b>Total medium</b>	<b>-5.2%</b>	<b>1.1%</b>	<b>-2.1%</b>	<b>-6.1%</b>
Elementary occupations (ISCO 9)	0.8%	-0.3%	-0.2%	0.2%
<b>Total low</b>	<b>0.8%</b>	<b>-0.3%</b>	<b>-0.2%</b>	<b>0.2%</b>

**Table 2 Composition of employment by ISCO group and sector (2019)**

Source: DG EMPL based on Eurostat [lfsa\_egised]

	Total	Total ISCO 1-3	ISCO 1	ISCO 2	ISCO 3	Total ISCO 4,5,7,8	ISCO 4	ISCO 5	ISCO 7	ISCO 8	ISCO 9
<b>Total</b>	<b>198,263</b>	<b>41.5%</b>	<b>5.2%</b>	<b>19.4%</b>	<b>16.8%</b>	<b>46.0%</b>	<b>9.5%</b>	<b>16.7%</b>	<b>11.9%</b>	<b>7.8%</b>	<b>9.0%</b>
<b>Manufacturing</b>	<b>16.4%</b>	<b>5.1%</b>	<b>0.9%</b>	<b>1.6%</b>	<b>2.7%</b>	<b>10.1%</b>	<b>1.3%</b>	<b>0.5%</b>	<b>5.1%</b>	<b>3.3%</b>	<b>1.1%</b>
<b>Electricity, gas, steam, air condit.</b>	<b>0.7%</b>	<b>0.4%</b>	<b>0.0%</b>	<b>0.2%</b>	<b>0.2%</b>	<b>0.3%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.0%</b>
<b>Water supply; sewerage, waste</b>	<b>0.8%</b>	<b>0.2%</b>	<b>0.0%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.4%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.1%</b>	<b>0.2%</b>	<b>0.2%</b>
<b>Construction</b>	<b>6.8%</b>	<b>1.6%</b>	<b>0.4%</b>	<b>0.3%</b>	<b>0.8%</b>	<b>4.7%</b>	<b>0.4%</b>	<b>0.1%</b>	<b>3.8%</b>	<b>0.4%</b>	<b>0.5%</b>
<b>Wholesale and retail trade; repair</b>	<b>13.9%</b>	<b>3.5%</b>	<b>0.9%</b>	<b>0.9%</b>	<b>1.7%</b>	<b>9.4%</b>	<b>1.3%</b>	<b>6.2%</b>	<b>1.4%</b>	<b>0.6%</b>	<b>1.0%</b>
<b>Transportation and storage</b>	<b>5.4%</b>	<b>1.0%</b>	<b>0.2%</b>	<b>0.2%</b>	<b>0.5%</b>	<b>4.0%</b>	<b>1.1%</b>	<b>0.3%</b>	<b>0.2%</b>	<b>2.4%</b>	<b>0.4%</b>
<b>Accommodation and food service</b>	<b>4.8%</b>	<b>0.7%</b>	<b>0.5%</b>	<b>0.1%</b>	<b>0.2%</b>	<b>3.2%</b>	<b>0.3%</b>	<b>2.8%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.8%</b>
<b>Information and communication</b>	<b>3.1%</b>	<b>2.6%</b>	<b>0.3%</b>	<b>1.7%</b>	<b>0.7%</b>	<b>0.4%</b>	<b>0.3%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.1%</b>
<b>Financial and insurance activities</b>	<b>2.7%</b>	<b>1.8%</b>	<b>0.3%</b>	<b>0.7%</b>	<b>0.8%</b>	<b>0.9%</b>	<b>0.8%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.0%</b>
<b>Real estate activities</b>	<b>0.8%</b>	<b>0.5%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.4%</b>	<b>0.2%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.1%</b>
<b>Professional, scientific and techn.</b>	<b>5.5%</b>	<b>4.5%</b>	<b>0.3%</b>	<b>2.9%</b>	<b>1.4%</b>	<b>0.9%</b>	<b>0.7%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.1%</b>
<b>Administrative and support service</b>	<b>4.2%</b>	<b>0.9%</b>	<b>0.2%</b>	<b>0.3%</b>	<b>0.5%</b>	<b>1.8%</b>	<b>0.6%</b>	<b>0.8%</b>	<b>0.2%</b>	<b>0.1%</b>	<b>1.3%</b>
<b>Public administration and defence</b>	<b>6.2%</b>	<b>3.5%</b>	<b>0.3%</b>	<b>1.3%</b>	<b>1.8%</b>	<b>2.3%</b>	<b>1.1%</b>	<b>0.9%</b>	<b>0.2%</b>	<b>0.1%</b>	<b>0.4%</b>
<b>Education</b>	<b>7.3%</b>	<b>5.8%</b>	<b>0.2%</b>	<b>4.8%</b>	<b>0.7%</b>	<b>1.1%</b>	<b>0.3%</b>	<b>0.7%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.4%</b>
<b>Human health and social work</b>	<b>10.8%</b>	<b>6.8%</b>	<b>0.3%</b>	<b>3.2%</b>	<b>3.3%</b>	<b>3.1%</b>	<b>0.5%</b>	<b>2.4%</b>	<b>0.1%</b>	<b>0.1%</b>	<b>0.8%</b>
<b>Arts, entertainment and recreation</b>	<b>1.7%</b>	<b>1.0%</b>	<b>0.1%</b>	<b>0.5%</b>	<b>0.5%</b>	<b>0.5%</b>	<b>0.2%</b>	<b>0.2%</b>	<b>0.1%</b>	<b>0.0%</b>	<b>0.1%</b>
<b>Other service activities</b>	<b>2.4%</b>	<b>0.7%</b>	<b>0.1%</b>	<b>0.3%</b>	<b>0.3%</b>	<b>1.5%</b>	<b>0.2%</b>	<b>1.1%</b>	<b>0.2%</b>	<b>0.1%</b>	<b>0.2%</b>
<b>Activities of households</b>	<b>1.1%</b>	<b>0.0%</b>		<b>0.0%</b>	<b>0.0%</b>	<b>0.4%</b>		<b>0.4%</b>	<b>0.0%</b>		<b>0.7%</b>

**Table 3 Private investment in skills in Europe (estimated)**

Source: DG EMPL calculations, see methodological annex for details

Private expenditure on skills (million EUR; see methodological annex for details)								
	Employee training, >10 employees	Employee training >10 employees	Apprentices' labour costs	Individuals' non-formal learning	Individuals' formal adult education	Total private	Nominal GDP, 2015	% of GDP
<b>EU</b>	<b>55,451</b>	<b>12,295</b>	<b>22,241</b>	<b>21,314</b>	<b>3,169</b>	<b>114,471</b>	<b>12,213,173</b>	<b>0.94%</b>
AT	1,324	279	1,100	944	52	3,700	344,269	1.07%
BE	2,580	367	49	n/a	108	3,105	416,701	0.75%
BG	129	25	n/a	28	51	233	45,676	0.51%
CY	46	n/a	2	26	32	106	17,827	0.60%
CZ	610	76	3	135	29	853	168,473	0.51%
DE	15,416	3,394	11,379	5,431	n/a	35,621	3,030,070	1.18%
DK	2,105	276	865	186	n/a	3,432	273,018	1.26%
EE	100	43	n/a	24	7	174	20,782	0.84%
EL	296	n/a	17	170	49	532	177,258	0.30%
ES	4,135	1,702	181	3,942	1,075	11,035	1,077,590	1.02%
FI	578	135	797	330	15	1,855	211,385	0.88%
FR	13,321	2,510	2,034	3,601	353	21,819	2,198,432	0.99%
HR	168	72	n/a	77	n/a	317	44,616	0.71%
HU	346	68	23	726	n/a	1,162	112,210	1.04%
IE	1,201	217	325	109	6	1,858	262,833	0.71%
IT	4,514	1,634	3,886	3,025	612	13,672	1,655,355	0.83%
LT	79	11	n/a	19	13	123	37,322	0.33%
LU	316	45	28	37	2	427	52,066	0.82%
LV	45	14	n/a	26	19	104	24,426	0.42%
MT	45	10	2	9	1	68	9,659	0.70%
NL	3,753	530	1,460	1,124	380	7,246	690,008	1.05%
PL	1,000	172	16	467	176	1,830	430,258	0.43%
PT	503	164	74	307	143	1,190	179,713	0.66%
RO	289	31	1	46	1	368	160,298	0.23%
SE	2,020	370	n/a	339	17	2,746	454,184	0.60%
SI	282	64	n/a	94	6	446	38,853	1.15%
SK	251	88	1	90	21	450	79,758	0.56%



**Table 4 Public investment in skills in Europe (estimated)**

Source: DG EMPL calculations, see methodological annex for details

<b>Public expenditure on skills (million EUR, see methodological annex for details)</b>									
	Public employe e training	Public apprentices ' labour costs	ALMPs	Formal Mediu m VET	Formal ISCED- S VET	Formal adult educatio n	Total public	Nominal GDP, 2015	% of GDP
<b>EU</b>	<b>52,088</b>	<b>9,770</b>	<b>23,101</b>	<b>53,963</b>	<b>9,737</b>	<b>35,661</b>	<b>184,320</b>	<b>12,213,173</b>	<b>1.51%</b>
AT	1,174	n/a	1,559	2,326	966	1,615	7,640	344,269	2.22%
BE	2,079	n/a	642	4,654	158	2,513	10,045	416,701	2.41%
BG	142	n/a	7	188	n/a	103	440	45,676	0.96%
CY	28	0	9	59	11	54	160	17,827	0.90%
CZ	401	0	38	1,091	8	256	1,794	168,473	1.06%
DE	13,902	7,451	6,180	16,275	2	8,465	52,276	3,030,070	1.73%
DK	2,210	511	1,014	n/a	n/a	n/a	3,735	273,018	1.37%
EE	108	n/a	16	103	n/a	105	331	20,782	1.59%
EL	833	n/a	67	541	n/a	326	1,766	177,258	1.00%
ES	5,981	54	1,231	3,513	1,825	4,172	16,775	1,077,590	1.56%
FI	473	188	1,005	2,375	n/a	2,351	6,392	211,385	3.02%
FR	11,841	106	6,144	9,983	6,241	2,888	37,204	2,198,432	1.69%
HR	128	n/a	97	n/a	n/a	n/a	225	44,616	0.50%
HU	226	7	28	722	14	262	1,258	112,210	1.12%
IE	1,005	81	577	446	n/a	242	2,351	262,833	0.89%
IT	3,888	130	2,761	n/a	19	2,156	8,955	1,655,355	0.54%
LT	70	n/a	25	96	n/a	90	281	37,322	0.75%
LU	303	n/a	27	291	16	73	710	52,066	1.36%
LV	59	n/a	15	105	41	87	306	24,426	1.25%
M T	32	0	2	42	26	29	131	9,659	1.36%
NL	3,654	1,227	451	5,057	34	2,778	13,200	690,008	1.91%
PL	738	2	51	2,160	14	907	3,872	430,258	0.90%
PT	330	13	480	n/a	n/a	507	1,330	179,713	0.74%
RO	170	0	2	82	n/a	146	400	160,298	0.25%
SE	2,067	n/a	652	3,326	353	5,322	11,720	454,184	2.58%
SI	136	n/a	16	n/a	n/a	20	172	38,853	0.44%
SK	110	0	8	529	10	193	849	79,758	1.07%

## 7 Annex – Methodological note on skills imbalance indicator

The indicator has been constructed in the following way. For the demand-side, the starting point is the number of total jobs in the economy, segmented by 1-digit ISCO occupational groups into high (ISCO 1-3), medium (ISCO 4-8) and low-skilled (ISCO 9) jobs. Ideally, the demand-side should be adjusted (i.e. increased) by the number of vacancies, but this data is not available. For the supply-side, the starting point is the number of employees in the economy, segmented using ISCED classification into high (ISCED 5-8), medium (ISCED 3-4) and low-skills (ISCED 0-2). The supply measure is then adjusted twice.

The first adjustment is done for countries, which have a large proportion of ISCO-3 jobs occupied by medium-qualified workers (see Figure 1 in the Annex), mostly VET graduates (see Figure 3 in the Annex) and where they declare a good fit between their education and the job (see Figure 4 in the Annex). The adjustment is made by reducing the supply of medium-qualified and increasing the supply of high-qualified workers by a factor calculated as the share of medium-qualified workers in ISCO 3 jobs who report the best match between their job and their education (based on the data from EU LFS ad-hoc module from 2016). This adjustment is only done for Austria, Germany, Estonia, Denmark, Netherlands, Poland, France, Malta, Sweden, Italy and Finland (countries where well-matched medium-qualified workers in ISCO 3 represent more than 20% of all ISCO 3 workers). This adjustment is conservative as such adjustment is not done for any other country; it also does not adjust in any way for workers who respond to be partially matched for their job.

The second adjustment is done based on the number of unemployed individuals in each country by their qualification level using ISCED classification (the same operationalisation as for workers), by adding the number of unemployed individuals to the total supply. The two numbers – demand (as the number of jobs) and adjusted supply (number of available workers) are then compared. In case the supply is larger, the imbalance has a positive sign, when the supply is smaller, it has a negative sign.

## 8 Annex – Methodological note on skills investment estimates

### Sources and estimations of data on investment in job-specific skills

The evolving statistical infrastructure at the European level since early 2010s allows moving towards a more comprehensive picture of the investment in human capital. The coverage of investment into the initial education system overall is well represented through such data sources as COFOG<sup>29</sup> (for government expenditure on education) or the UOE<sup>30</sup> (for an integrated finance framework on formal education). However, estimating investment in job-related skills, especially taking place after initial education, still faces major difficulties, as testified by earlier efforts in 2013 (Dohmen, D. 2013), due to the fragmentation of adult learning system and equally fragmented statistical infrastructure. In addition, job-related skills development as part of initial education and training, taking place through vocational education and training (VET) programmes has been defined more precisely in the UOE framework as of 2014, due to the implementation of new ISCED-2011 classification<sup>31</sup>. This development, together with coincidental data collections at the European level in 2015/2016 on labour market, adult learning and continuing vocational training, provides an opportunity to develop a more comprehensive estimate of the investment and its sources on job-related skills. This note details the key sources of data used to compile the total volume and composition of investment in job-specific skills in the Member States of the European Union (UK included).

Importantly, it must also be noted, that given the fact that the data has been compiled from different data sources, for some countries there are certain data gaps and in some instances the data has been estimated, the level of precision of the total estimates at country level or for specific source of investment is likely to suffer. However, this exercise did not aim at providing a very precise measure of investment for cross-country comparison, but to provide an indicative estimate as well as to highlight the possibilities for aggregating such data utilising existing data sources. As such, it also cannot be interpreted as an official statistical estimate.

Finally, apart several country-specific cases, more universal gaps in data remains. This in particular concerns to areas of skills/continuing education and training. Firstly, it is difficult to cover job-specific investment carried out as part of tertiary education, given lack of statistical definitions at international level (though they do exist at national level in a number of cases) on differentiating or measuring job-specific (vocational; professional) programmes at ISCED level 6 (bachelor) and above. The only exception is ISCED 5 (short-cycle tertiary programmes) where such a definition was agreed and data is being collected. Secondly, there is an overall lack

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<sup>29</sup> Government expenditure by function. More details here: [https://ec.europa.eu/eurostat/statistics-explained/index.php/Government\\_expenditure\\_by\\_function\\_%E2%80%93\\_COFOG](https://ec.europa.eu/eurostat/statistics-explained/index.php/Government_expenditure_by_function_%E2%80%93_COFOG)

<sup>30</sup> Unesco-OECD-Eurostat joint data collection on education statistics. More details here: [https://ec.europa.eu/eurostat/statistics-explained/index.php/UNESCO\\_OECD\\_Eurostat\\_\(UOE\)\\_joint\\_data\\_collection\\_%E2%80%93\\_methodology](https://ec.europa.eu/eurostat/statistics-explained/index.php/UNESCO_OECD_Eurostat_(UOE)_joint_data_collection_%E2%80%93_methodology)

<sup>31</sup> International Standard classification of Education. More details here: [https://ec.europa.eu/eurostat/statistics-explained/index.php/International\\_Standard\\_Classification\\_of\\_Education\\_\(ISCED\)](https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_(ISCED))

of data on the volume of investment into publicly financed non-formal adult learning programmes, provided outside active Labour Market Policy domain.

### **Sources of data on private<sup>32</sup> expenditure on skills**

- Expenditure on employee training incurred by private firms with 10 or more employees. Source: Eurostat, [Continuing Vocational Training Survey](#), reference year 2015, special data extraction for DG EMPL. Data includes both direct as well as opportunity costs (i.e. salaries of employees for the duration of their training activities) of employer sponsored training. Data issues: data reliability concerns for several countries, including Greece and Cyprus (due to very high estimate cost per participant) and Germany (due to low response rate).
- Expenditure on employee training incurred by private firms with less than 10 employees. The data was estimated using average per-employee training per country from the CVTS for firms with more than 10 employees) as well as data on participation in firm-sponsored training of workers in the business economy sector from the Adult Education Survey (see below). Data issues: some precision is likely lost due to possible over-estimation caused by the differences of average cost per training participant in micro-firms as compared larger firms as well as under-estimation of the total number of participants given that AES only covers population 25-64, thus excluding any possible participants below the age of 25 or above the age of 64.
- Apprentices' total labour costs incurred by firms in the private economy with 10 or more employees. Source: Eurostat, [Labour Cost Survey](#), reference year 2016, online data code [[lc\\_nstruc\\_r2](#)]. Data issues: under-coverage of firms with less than 10 employees.
- Individuals' expenditure for non-formal adult learning. Source: Eurostat, [Adult Education Survey](#), reference year 2016, special data extraction for DG EMPL. Data issues: possible-under-coverage, as only age group 25-64 is covered by the survey; also, some issues with data precision possible for several countries due to high non-response rate. Possible over-coverage as this data does not exclude learning activities declared by individuals as non-job related (on average around 1/5<sup>th</sup> of all non-formal learning activities were declared to be non-job related).
- Households' expenditure on formal adult education. Source: estimations by DG EMPL based on data from Eurostat, [UOE data collection](#), reference year 2015, online data tables [[educ\\_uoe\\_enra02](#)] and [[educ\\_uoe\\_fine03](#)]. Estimation is based on the number of enrolled learners by age, calculating the share of adult learners (aged 25 or above for ISCED levels 1-5; aged 30 or above for ISCED levels 6-8) of all learners at each level of education. Based on the proportion of adult learners, the proportion of household investment towards adult education is then estimated. ISCED levels 6

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<sup>32</sup> Including firms, who are reported to belong to private-sector economy based on the [classification of sectors of economic activity \(NACE\)](#) and individuals/households

to 8 grouped together due to lack of further disaggregation of finance data. Data issues: the cut-off age is somewhat arbitrary; data includes both labour-market related and general/academic programmes.

- For share of GDP calculations, country-specific nominal GDP was used. Source: Eurostat, Annual National Accounts, reference year 2015, online data table: [[nama\\_10\\_gdp](#)].

### **Sources of data on public<sup>33</sup> expenditure on skills**

- Public employer expenditure on employee training. The data was estimated using average per-employee training per country from the CVTS for firms with more than 10 employees) as well as data on participation in firm-sponsored training of workers in the public economy sector (NACE sectors O-S) from the Adult Education Survey (see above). Data issues: some precision is likely lost due to possible under-estimation caused by the differences of average cost per training participant in public firms as compared private firms (particularly due to different opportunity costs driven by wage differences). Also, under-estimation of the total number of participants is likely given that AES only covers population 25-64, thus excluding any possible participants below the age of 25 or above the age of 64.
- Apprentices' total labour costs incurred by public employers (NACE sectors O-S) with 10 or more employees. Source: Eurostat, [Labour Cost Survey](#), reference year 2016, online data code [[lc\\_nstruc\\_r2](#)]. Data issues: under-coverage of firms with less than 10 employees.
- Expenditure on training as part of Active Labour Market Policies. Source: DG EMPL, [Labour Market Policies \(LMP\) database](#), reference year 2015. Data issues: precision of ALMP data by expenditure type has been criticised as possibly lacking in reliability due to difficulties to differentiate different expenditure types as ALMP services are increasingly integrating different types of activities offered to the same person. Data for Italy refers to reference year 2014.
- Public expenditure on medium-level (ISCED levels 3 and 4) vocational education and training (VET). Source: Eurostat, [UOE data collection](#), reference year 2015, online data table [[educ\\_uae\\_fine02](#)].
- Public expenditure on higher (ISCED level 5) vocational education and training (VET). Source: Eurostat, [UOE data collection](#), reference year 2015, online data table [[educ\\_uae\\_fine02](#)].

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<sup>33</sup> This includes expenditure of public employers for training of their employees or apprentices costs as well as provision or financing of training by the public sectors as service of general interest accessible by the general population.

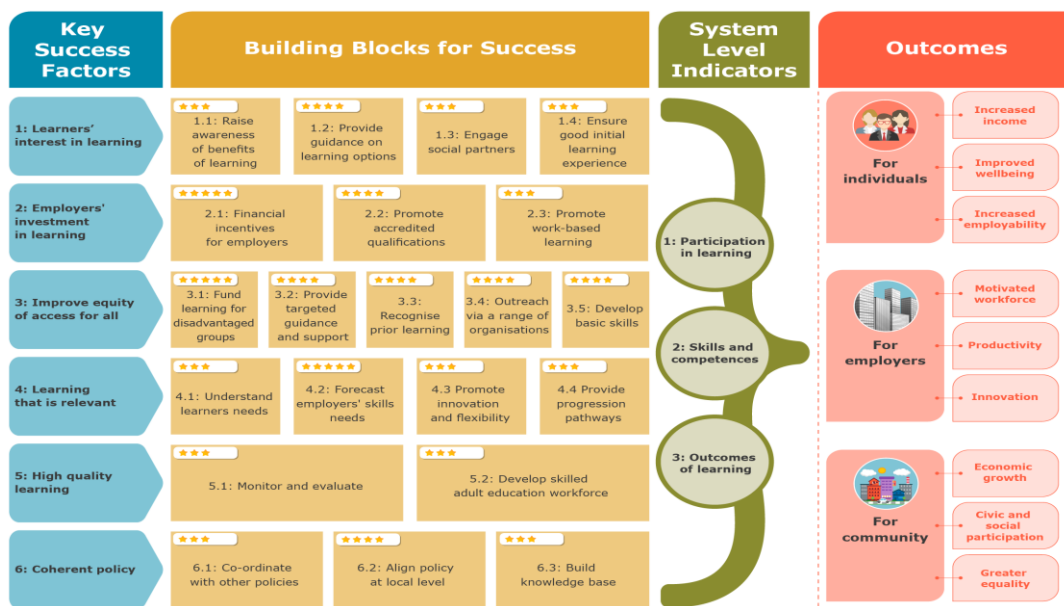
- Public expenditure on formal adult education. Source: estimations by DG EMPL based on data from Eurostat, [UOE data collection](#), reference year 2015, online data tables [[educ\\_uae\\_enra02](#)] and [[educ\\_uae\\_fine02](#)]. Estimation is based on the number of enrolled learners by age, calculating the share of adult learners (aged 25 or above for ISCED levels 1-5; aged 30 or above for ISCED levels 6-8) of all learners at each level of education. Based on the proportion of adult learners, the proportion of household investment towards adult education is then estimated. ISCED levels 6 to 8 grouped together due to lack of further disaggregation of finance data. Data issues: the cut-off age is somewhat arbitrary; data includes both labour-market related and general/academic programmes. Some (though limited) double counting is possible with adults participating in vocational education and training programmes covered in points 4 and 5 above.
- For share of GDP calculations, country-specific nominal GDP was used. Source: Eurostat, Annual National Accounts, reference year 2015, online data table: [[nama\\_10\\_gdp](#)].

## 9 Annex - Summary table of data sources on expenditure on skills and sources of financing

Different data sources for different types of education and training for skills development can be summarised in the following table, grouping them based on the key institutional sectors of the economy – employers; households and the public sector.

DATA SOURCES / DATA COVERAGE				
Source of financing (institutional sectors)	Formal E&T	Non-Formal related E&T	Job	Non-Formal non-job related E&T
Private – employers for their employees (including opportunity costs – wages)	CVTS and UOE, in practice negligible. SES for apprenticeships.	CVTS, including public subsidies		Negligible, prevalence can be estimated from AES
Private – individuals /households	UOE, including subsidies	potentially public	AES, treatment of public subsidies unknown. Limited own contribution by individuals – can be estimated from AES.	AES, treatment of public subsidies unknown. The biggest part of individuals' own investment in non-formal learning
Public – employers for their employees (including opportunity costs – wages)	CVTS and UOE estimates, in practice negligible. SES for apprenticeships.		Estimation using CVTS and AES	Negligible, prevalence can be estimated from AES
Public – financing for the general population	UOE		LMP – reports training both for unemployed as well as employed when linked to active labour market policy.	Not covered, prevalence can be estimated from the AES

## 10 Annex – Framework for effective adult learning policy



**Source:** European Commission (2015): An in-depth analysis of adult learning policies and their effectiveness in Europe, available at:

<http://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=7851>



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Europe's prosperity and social model depend on its ability to ride the new wave of innovation ahead of us, while ensuring a broad participation in the benefits accruing from these innovations. This ability to benefit from innovation depends on access to relevant skills, which is one of the main determinants of Europe's competitiveness and the capacity to drive innovation. The fundamental link between innovation, skills and growth makes investment in skills and proactive skills policies, aligned to the evolving industrial and technological landscape, a prerequisite for a dynamic and inclusive society.

This paper looks in particular at the potential of education and training for skills upgrading, innovation adoption and thus, in a long-term, increasing economic growth and reducing inequalities. The analysis takes into account wide range of issues, such as the structural change of economies, developments of productivity and innovation as well as employment shifts in labour markets, while considering also the effects of policies and investments.

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