

# DIGITALIZATION, JOBS, AND CONVERGENCE IN EUROPE: STRATEGIES FOR CLOSING THE SKILLS GAP



Thor Berger<sup>1</sup>, Carl Benedikt Frey<sup>2</sup>

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<sup>1</sup> Department of Economic History, School of Economics and Management, Lund University & Oxford Martin Programme on Technology and Employment, Oxford Martin School, University of Oxford.

<sup>2</sup> Oxford Martin Citi Fellow and Co-Director at the Oxford Martin Programme on Technology and Employment, Oxford Martin School, University of Oxford.

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# 1. Introduction

Since the digital revolution, the pace of technological change has arguably been faster than ever before. In particular, technology adoption lags have shortened considerably over the past two centuries—a trend that has recently accelerated.<sup>4</sup> A recent report published by Citigroup and the Oxford Martin School estimates that while the telephone needed 75 years to reach 50 million subscribers, it has taken Facebook 3.5 years, and Angry Birds just 35 days to reach the same number of users.<sup>5</sup>

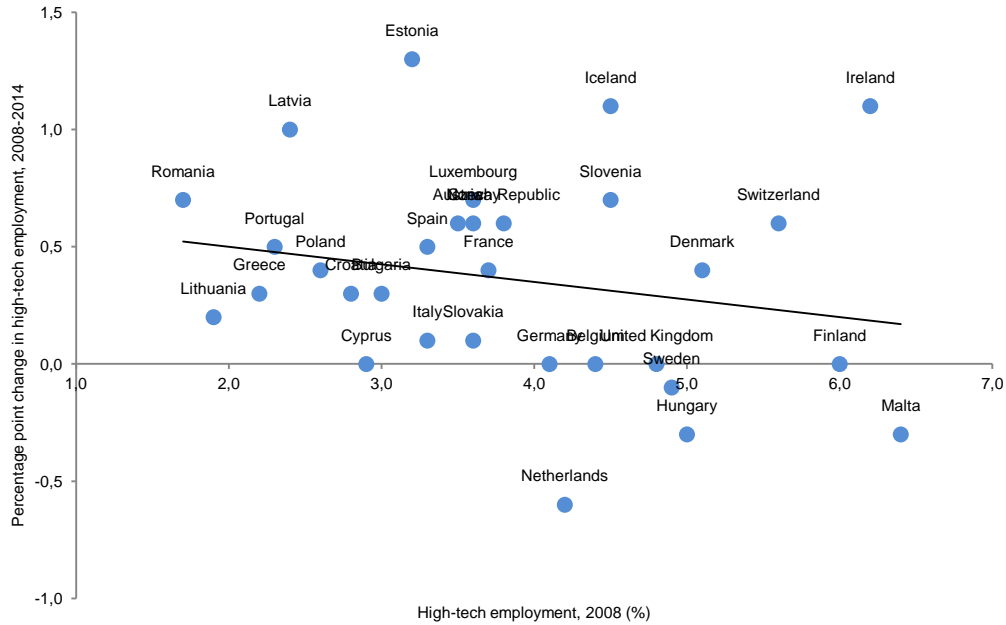
An empirical puzzle is that while studies suggest that new technologies are diffusing at a faster pace, the benefits of these technologies have seemingly not been widely shared: recent aggregate productivity growth has been sluggish compared to the early stages of the digital revolution (Gordon, 2012; Fernald, 2014; Fernald and Jones 2014), median wages have decoupled from productivity growth (Frey and Osborne, 2015), and income convergence has faltered. In a seminal study, Comin and Mestieri (2014) asks the question: if technology has arrived everywhere, why has income diverged? Doing so, they show that although technology adoption lags across countries have declined significantly over the past two centuries, the degree to which new technologies diffuse across the population, after their initial adoption, has widened over the same period. In other words, while lagging economies have become better at adopting new technologies, they are getting worse at putting them into widespread use.

One explanation for this tendency is that new technologies increasingly are benefiting skilled workers, and thus countries with a relative abundance of skills. O’Rourke et al. (2013), for example, has argued that the skill-biased technological change (SBTC) has contributed to the increase in income differences across countries, as Western countries benefited relatively more from them. The same pattern of SBTC can also account for much of the widening wage gap within countries, as well as the high concentration of economic activity to skilled cities. A recent empirical counterpart to this prediction is provided by Berger and Frey (2015a), showing that new technology industries, emerging in the twenty-first century, overwhelmingly employ highly skilled workers, while locating in skilled locations that is contributing to a “Great Divergence” in human capital levels across space (Moretti, 2012). Thus, relative to technological breakthroughs such as the railroad, the automobile, and the telephone, which created vast employment opportunities for relatively unskilled workers, recent developments in digital technology has mainly benefited a small share of highly skilled workers clustering in skilled locations such as London, Munich, and Stockholm.

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<sup>4</sup> For example, while it took on average 119 years for the spindle to diffuse outside Europe, the Internet has spread across the globe in only seven years (Comin and Hobijn, 2010).

<sup>5</sup> See Frey and Osborne (2015).



Notes: This figure shows the slow convergence in high-tech employment across European countries. Data is obtained from Eurostat and the high-tech sector is defined as high-technology manufacturing and knowledge-intensive high-technology services. Also shown is a fitted OLS regression line.

**Figure 1.1 High-tech Employment in Europe, 2008-2014.**

In this paper, we argue that digital technologies are likely to contribute to a surge in productivity over the forthcoming decades, while raising concerns that associated benefits are unlikely to be widely shared unless substantial investments are made to upskill the European workforce. Importantly, there is growing evidence that the slow convergence in high-tech employment within the European Union reflects the slow diffusion of skills across Member States (see Figure 1.1). For example, work by Goos et al. (2015) point at human capital as one of the key obstacles to job creation in technology industries in lagging European regions. Filippetti and Peyrache (2015) further argue in contrast to investments in fixed capital, which are subject to diminishing returns, investments in technology and human capital is pivotal for lagging regions to catch-up, and for the European Union to achieve sustained convergence. Thus, over the long run, job creation and shared economic prosperity across the European Union hinges on its ability to facilitate the diffusion of skills.

The remainder of this paper is structured as follows. We begin by showing that since the computer revolution of the 1980s, new technologies and production methods have mainly favored skilled workers, contributing to a widening difference in the returns to skill in many European countries (Hanushek et al., 2015). At the same time, European labor markets have seen a wide range of middle-income routine jobs disappear, as computer technologies have substituted for workers in clerical and production tasks, in turn explaining recent job polarization (Autor et al., 2003). Although there are competing explanations for the decline of middle-skill jobs—particularly emphasizing the role of offshoring—a large body of work

documents that technology is the main factor to understand the striking job polarization evident in nearly every European country (Goos et al., 2009; 2014).

Second, we proceed to showing that the potential scope of automation recently has expanded beyond routine work as technological advances in Machine Learning (ML) and Mobile Robotics (MR) have brought a wider range of more complex tasks into the domains of computers (Frey and Osborne, 2013). Against this background, we discuss how technological advances may affect job creation and skill demands in Europe over the next decades. According to some estimates, as many as 54 percent of current jobs in the EU27 could be computerized as a result; including many low-skill jobs in construction, logistics, and services (Bowles, 2014). The implications of these trends are also already being widely perceived by firms: for the fourth survey in a row, the perceived importance of automating and/or improving business processes had increased in the McKinsey Global Survey—in the most recent wave, more than half of respondents cite it as a top-three priority for their organization.<sup>6</sup>

We next turn to examining the effects of digital technologies on job creation. Although technological change is rapidly destroying jobs and transforming others, it also creates entirely novel types of jobs and industries; app development, big data analysis and software design are all examples of new work created in the wake of the digital revolution. A growing body of work, however, suggests that the pace of new job creation has slowed since the Computer Revolution of the 1980s. Estimates by Lin (2011), for example, show that while 8.2 percent of the US workforce shifted into new jobs in the 1980s, that share had fallen to 4.4 percent in the 1990s. A recent study by Berger and Frey (2015a) similarly shows that a meager 0.5 percent of US workers are employed in technology-related industries—such as audio streaming and online auctions—that have been created in the twenty-first century.<sup>7</sup> Although the data is not available to repeat these exercises for European countries, these estimates suggest that the digital revolution has not created new employment opportunities to the same extent as technological revolutions of the past—as aptly summarized by Bart van Ark (2014, p.11): “while they may be cool places to work, ICT producers are still not net job creators in Europe.”

While new technologies have not created many new jobs directly, the arrival of new technologies is, however, significantly changing the demand for skills beyond the technology sector: across occupations and industries new job tasks are emerging as technologies are being implemented. As digital technology continues to transform work practices in a wide range of jobs, there will be an increasing need for European workers to develop, refine, and update their skillsets over the course of their careers. In particular, we find that technological advances rapidly are outdated many skills: according to the European Skills and Jobs (ESJ) survey, some 47 percent of European workers have seen new technologies used on the job

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<sup>6</sup> McKinsey (2015a).

<sup>7</sup> It shall be noted that these figures are not directly comparable, and that estimating the share of new jobs resulting from the emergence of new technologies is associated with some measurement problems. Nevertheless, they remain suggestive of a downward trend in new job creation.

since they started their employment and 21 percent of workers believe their skills will be outdated over the next five years.<sup>8</sup> Digital transformation is also becoming a key priority for most companies: more than half of the respondents in the most recent McKinsey Global Survey stated that their CEOs are typically leaders of the organization's digital agenda, while at the same time personally sponsoring digital initiatives.<sup>9</sup>

As a result of these trends, the vast majority of workers will be required to have (at least) basic digital skills. Yet, some 10 percent of European workers—as many as one in four in countries such as Poland—lack fundamental skills such as using a mouse or navigating a web browser. Meanwhile, forecasts suggest that there will be a shortfall of digital professionals, which may lead to as many as 756,000 unfilled vacancies in ICT jobs by 2020, of which around 226,000 are at management level, though such estimates have a wide margin of error.<sup>10</sup> Among managers, especially advanced analytics skills are in shortage: some 73 percent of respondents to a recent survey conducted by the Harvard Business Review stated that data analytics was extremely important to their business, while only one in five managers rated their skills as “high” in this area.<sup>11</sup>

In the light of these findings, we argue that the key challenge for the European Union going forward is to devise policy responses to accelerate productivity at the frontier while supporting convergence among its regions and Member States. This, in turn, rests upon establishing models to facilitate the diffusion of skills across locations. To tackle the shortage of basic digital skills in lagging regions, we propose that digital competence centers are established in each region, to provide basic training, help workers to obtain and refine their digital skills, and facilitate and support the adoption of digital technology in firms across the productivity spectrum. Second, we argue that e-learning needs to play a larger role in supporting the diffusion of advanced digital skills, by allowing for modularized educational offerings, that does not require workers to complete an extensive academic programme to update their skills. Nevertheless, while e-learning provides a promising way of facilitating the diffusion of technical skills, interactive skills are also becoming increasingly important. We therefore argue that e-learning needs to be combined with tutorial style teaching that foster creative and social skills—skills that computers are unlikely to make redundant in the foreseeable future. Lastly, to anticipate skill shortages and maintain an up to date view of skill gaps and mismatches, the creation of a unified European digital job portal is an attractive option to reduce skills mismatch, offering a standardized means of certification and validation

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<sup>8</sup> The ESJ is the first pan-European survey to examine the extent of skills mismatch in Europe, drawing on information from about 49,000 workers, aged 24-65, in all 28 Member States. See <http://www.cedefop.europa.eu/en/publications-and-resources/publications/8088> for more information and a summary of the key findings from the ESJ.

<sup>9</sup> McKinsey (2015a).

<sup>10</sup> Tobias Hüsing, Werner B. Korte, Eriona Dashja: e-Skills in Europe - Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020). empirica Working Paper, November 2015.

<sup>11</sup> Harvard Business Review (2015).

of digital skills and competencies across Member Countries.<sup>12</sup> As policy is often guided by forecasts, which are inevitably subject to substantial uncertainty, real-time information on skill demand that could be provided by a digital job portal, would also improve policy making as such. Taken together, these initiatives would serve to narrow the digital divide across countries and regions, while at the same time boosting productivity in the European Union as a whole.

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<sup>12</sup> This could build on European activities like the Skills Panorama of Cedefop (<http://skillspanorama.cedefop.europa.eu/en>) dealing with skills demand and supply issues and those of EURES – the European Job Mobility Portal set up in 1993 as a co-operation network between the European Commission and the Public Employment Services of the EEA Member States to provide information, advice and recruitment/placement (job-matching) services for the benefit of workers and employers as well as any citizen wishing to benefit from the principle of the free movement of persons (<https://ec.europa.eu/eures/public/homepage>).



## 2. The changing composition of European labour markets

The economic consequences of the digital revolution are subject of intense debate. While some have argued that the digital technologies have failed to deliver the rapid growth and shared prosperity provided by technological revolutions of the past, and that future growth will be stagnant as a result (e.g. Gordon, 2012), others have suggested that the pace of technological progress today is faster than even before (e.g. Brynjolfsson and McAfee, 2014). In this section, we show that while European labour markets have experienced rapid change over recent decades, associated benefits have not been widely shared. In particular, we examine two key trends that have significantly shaped the trajectories of European labour markets since the computer revolution of the 1980s. First, we document how the adoption of computer technology has increased the demand for college-educated workers, explaining the growing wage gap between skilled and unskilled workers. Second, we show how computers have substituted for labour in a wide range of routine job tasks, contributing to the hollowing-out of middle-income jobs and growing wage polarization. Finally, we document how the potential scope of computer-for-labour substitution has recently expanded beyond routine job tasks, potentially constituting a watershed for European labour markets over the forthcoming decades.

### 2.1 Wage inequality in Europe

Technological change does not benefit all workers equally. In the canonical model outlined by Acemoglu and Autor (2011), for example, technology is assumed to take a factor-augmenting form, complementing either high- or low-skill workers. If technological change is skill-biased, it tends to increase the relative wages between skill groups, as it increases the demand for skills. Consistent with the SBTC hypothesis, returns to skill have increased in most countries over recent decades, making education increasingly valuable for the individual worker.<sup>13</sup> In particular, workers in technology-intensive sectors have had more favorable labor market outcomes in Europe, with lower unemployment rates, and considerably higher wages, reflecting a growing demand for workers whose skills are complementary to new technologies.<sup>14</sup> Meanwhile, median wages have stagnated in nearly half of all OECD countries. In the UK, for example, each percentage of GDP growth has historically been associated with a 0.9 percent increase in the median wage, while the contribution to median wages has fallen to some 0.4 percent since the early 2000s.<sup>15</sup> Thus, although technology has benefited relatively more skilled workers, ordinary workers have not equally shared associated gains in productivity.

The recent surge in wage inequality has its origins in the 1980s, when computer technology started to spread in the workplace. Several studies have indeed documented that computer technology is mainly used by skilled workers on the job, contributing to an increase in their relative wages: data from the OECD's PIAAC survey, for example, shows that while a

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<sup>13</sup> Acemoglu (1998).

<sup>14</sup> Goos et al. (2013).

<sup>15</sup> Pessoa and Van Reenen (2013).

meager 4 percent of adults with a higher education had no experience using computers, some 60 percent of those with less than an upper secondary education lacked such experience.<sup>16</sup> Moreover, both computer use and ICT skills are much more prevalent among workers in skilled occupations, particularly among workers that perform analytical or interactive tasks.<sup>17</sup> Studies have shown that using a computer on the job raises a worker's wage by some 10-15 percent and that as firms gain access to broadband Internet the productivity of skilled workers increase.<sup>18</sup> In addition, there is evidence suggesting that this largely reflects a growing importance of cognitive skills rather than higher education per se, consistent with technological advances favoring workers performing analytical or problem-solving tasks.<sup>19</sup>

Nevertheless, although the return to skill has increased in many countries, there is also substantial cross-country variation. While evidence from the OECD's PIAAC survey shows that a one unit increase in numeracy skills leads to an 18 percent increase in wages on average across 22 countries, these returns range from some 12-15 percent in Scandinavia to 28 percent in the United States.<sup>20</sup> Such cross-country differences in the returns to skill are seemingly associated with differences in labor market policies: countries with larger public sectors (higher taxes), higher union density, and strict employment protection have lower returns than other countries.<sup>21</sup> Thus, while market forces are important to understand increases in wage inequality driven by increasing returns to education, considerable country-level differences in the returns to skill also imply that there are ways of combating wage inequality.<sup>22</sup>

## **2.2 Job polarization in Europe**

Although SBTC has favored skilled workers relative to less skilled workers, the SBTC framework falls short in explaining the most distinct feature of European labor markets—that of job polarization. Importantly, since the early 1980s, European labor markets have also experienced routine-biased technological change (RBTC) as computer technologies have substituted for labour in a wide range of routine tasks, which are repetitive in nature and follow rule-based procedures that can easily be specified in computer code (Autor et al. 2003). Indeed, as new computer technologies have emerged, routine tasks performed by assembly workers, office clerks, and machine operators have gradually been automated away. As shown by Goos et al. (2014), an important characteristic of jobs that are intensive in routine tasks is that they typically cluster at the middle of the skill and income distribution. Consistent with this argument, nearly all European labor markets have experienced polarization, reflecting the disappearance of middle-skill routine work (Figure 2.1).<sup>23</sup>

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<sup>16</sup> OECD (2013).

<sup>17</sup> Berger and Frey (2015).

<sup>18</sup> See Krueger (1993) and Akerman et al. (2015).

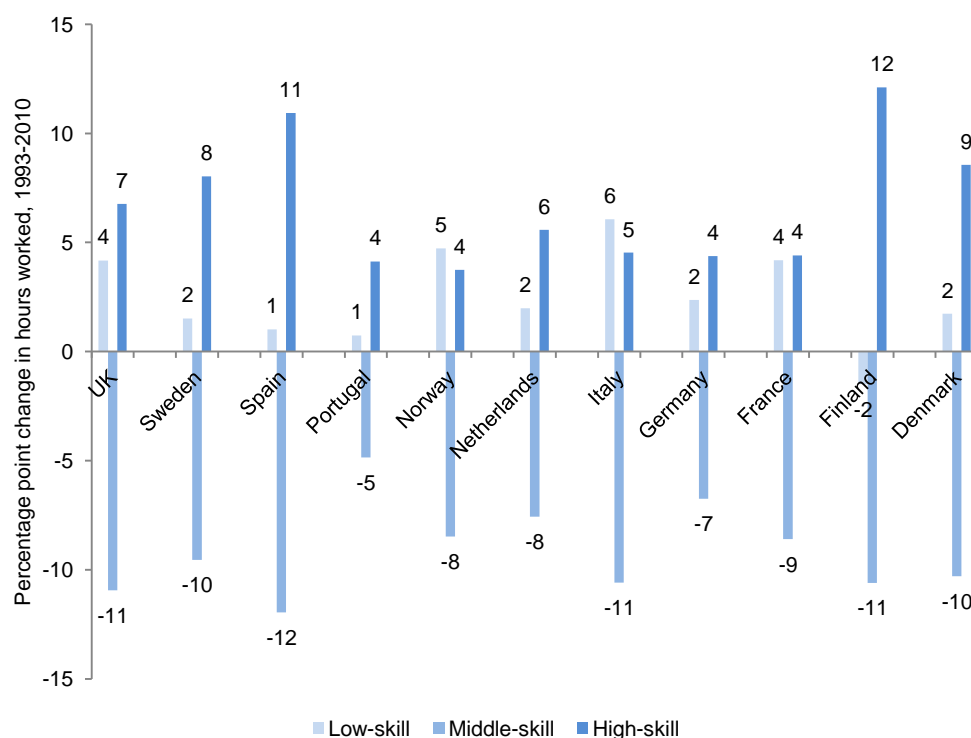
<sup>19</sup> Ingram and Neuman (2006).

<sup>20</sup> Hanushek et al. (2015).

<sup>21</sup> Hanushek et al. (2015).

<sup>22</sup> Autor (2014).

<sup>23</sup> Autor et al. (2003).



Notes: This figure shows percentage point employment changes in low-skill, middle-skill, and high-skill jobs in selected European countries between 1993-2010, based on data in Goos et al. (2014).

**Figure 2.1 Job Polarization in Europe, 1993-2010.**

At the same time, consistent with the SBTC framework, most European countries have experienced rapid employment growth at the upper end of the skill distribution, as computer technology has diffused across the workplace, reflecting the complementarity between digital technology and abstract tasks. Jobs at the top end of the skill distribution—such as managerial, professional, and technical occupations—often entail workers performing analytical or problem-solving tasks such as financial analysis or programming. ICT complements such work because it lowers the cost of acquiring and analyzing information, enabling workers to spend more time on applying and interpreting it.<sup>24</sup> Moreover, since the demand for services such as finance or health care is relatively income elastic, employment in these jobs has grown as a result. At the same time, because acquiring the education and knowledge needed to perform such jobs is time consuming, a sluggish inflow of workers into these occupations have further contributed to growing wages at the top of the income distribution.<sup>25</sup>

At the bottom end of the income distribution, employment growth has mainly been confined to low-skill manual occupations that require physical flexibility or social interaction, such as a wide range of sales and services jobs. Robots are still unable to emulate human perception and manipulation, meaning that they have a comparative disadvantage in related tasks.

<sup>24</sup> Autor (2015).

<sup>25</sup> Autor (2015).

Similarly, jobs that involve human interaction have historically been challenging to automate, due to the complexities of even simple social interactions. An additional channel through which the demand for jobs at the lower end of the skill spectrum increases is through the multiplier effects of job creation at the top of the income distribution: as high-income jobs are expanding, the increase in income leads to growing demand for many in-person service jobs.<sup>26</sup> For example, a recent study by Goos et al. (2015) shows that one additional technology job in Europe generates around 5 new jobs in the local nontradable sector.

### **2.3 The causes of polarization: technology or globalization?**

While it is well established that the arrival of computer technology has had a substantial impact on labour markets across the European Union, the relative importance of technology and globalization for understanding these trends is still subject of disagreement. To be sure, globalization and technology are closely intertwined, with the rapid fall in the price of international communication and transportation being one key driver of globalization. Yet, to devise appropriate policies to meet these challenges it is crucial to understand whether the labor market upheavals of recent decades is driven mainly by advances in digital technology or offshoring and trade competition from low-income countries.

Many routine jobs that are automatable are also susceptible to offshoring since they often involve repetitive work activities that can be performed by relatively unskilled workers, which implies that offshoring may be an important alternative explanation for the demise of middle-skill work.<sup>27</sup> Yet, the available evidence suggests that technology is the main culprit of the polarization of European labor markets: studies that examine these alternative explanations typically find that offshoring tends to play a much smaller role as an explanatory factor when pitted against technology.<sup>28</sup> Similar results have been documented for Japan and the United States, showing that while offshoring is contributing to the demise of middle-class work, the substitution of computer technology for routine labor is the single most important factor to understand the polarization of labor markets.<sup>29</sup>

At the same time as labor markets have polarized due to the spread of computer technology, labor has seen their share of income decline. In more than two-thirds of the countries examined by Karabarbounis and Neiman (2013), including most European countries, the share of GDP that accrues to labor has declined over past decades. This decline is also evident in emerging economies such as China, suggesting that the woes of European labor are not solely a result of low-wage competition from developing countries. Instead, they find that

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<sup>26</sup> Moretti (2010).

<sup>27</sup> Typically, economists think of jobs with the following attributes to be offshorable: (1) no required face-to-face interaction; (2) no physical proximity to a customer's worksite required; (3) an output that can be traded; (4) intensive use of ICT; and (5) a highly codifiable knowledge content. Against the background of these bottlenecks, estimates suggest that some 20-30 percent of jobs in Europe and the US are *potentially* offshorable (see van Welsum and Reif, 2005 and Blinder, 2009).

<sup>28</sup> See, for example, Autor and Dorn (2013) that examines the United States and Goos et al. (2013; 2014) that examines European countries.

<sup>29</sup> Autor and Dorn (2013) and Michaels et al. (2014).

about half of the decline in labor's share of income is attributable to rapid price declines in investment goods, reflecting in particular the precipitous declines in the price of computer technology over the investigated period.<sup>30</sup>

## **2.4 The digital revolution and the task model**

According to the task model of Acemoglu and Autor (2011), computerization is largely confined to routine tasks. Several studies have confirmed this intuition, showing that routine jobs have experienced a secular decline in employment over recent decades.<sup>31</sup> Yet, in recent years, the scope of automation has widened considerably as a range of non-routine tasks, which were previously outside the domains of computers, have successfully been transformed into well-defined problems that lend themselves to automation. Most strikingly, such technological breakthroughs appear at multiple fronts, promising to reshape a wide range of jobs.<sup>32</sup> In particular, advances in natural language processing, pattern recognition, and machine perception has pushed the boundaries for the types of tasks computer-controlled equipment can execute, at the same time as precipitous price declines of computer technology has made it cost effective to automate a wider range of work.

While the cost of computing power has been falling for decades, making computers cheaper substitutes for human workers, the advent of cloud computing is now transforming companies and industries, allowing firms to buy technology capacity as needed, and at ever lower prices. Over the past decade, the costs of cloud computing are estimated to have fallen 50 percent every three years.<sup>33</sup> In 2014, almost one in five (19 percent) European companies relied on cloud services (Figure 2.2), in particular acquiring e-mail (12 percent of firms), file storage (10 percent), and more advanced cloud services such as accounting applications and CRM software (9 percent). In the coming years, the use of cloud computing is likely to increase further since investments in cloud computing infrastructure is an explicit priority under the European Commission's Digital Single Market initiative.<sup>34</sup>

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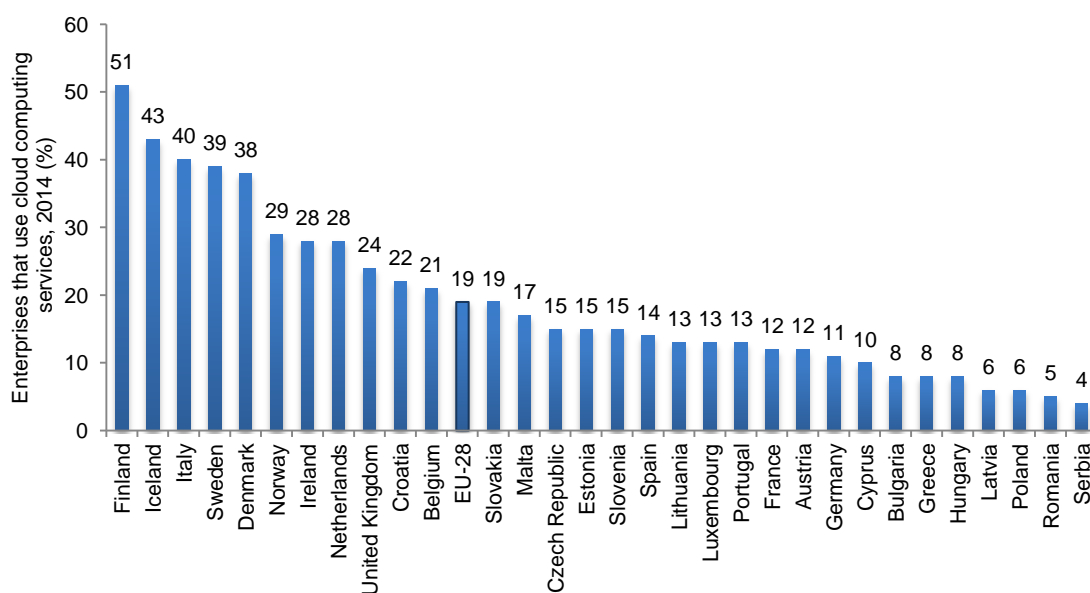
<sup>30</sup> Nordhaus (2007).

<sup>31</sup> See Autor et al. (2003), Autor and Dorn (2013), and Goos et al. (2010).

<sup>32</sup> See, for example, Brynjolfsson and McAfee (2014).

<sup>33</sup> The Economist (2014).

<sup>34</sup> See [http://ec.europa.eu/priorities/digital-single-market/economy/index\\_en.htm](http://ec.europa.eu/priorities/digital-single-market/economy/index_en.htm)



Notes: This figure shows the percentage of non-financial enterprises, employing 10 or more workers, that uses cloud computing services for selected European countries, based on data from Eurostat.

**Figure 2.2 Use of Cloud Computing in European Firms, 2014.**

Importantly, the rise of cloud computing has contributed to an ever-growing amount of big data becoming available for sophisticated algorithms to draw upon.<sup>35</sup> As a result, as a wider range of work has become automatable, firms are increasingly prioritizing the use of digital technology to rationalize business and production processes. For the fourth survey in a row, the perceived importance of automating and/or improving business processes had increased in the McKinsey Global Survey—in the most recent wave, more than half of respondents cite it as a top-three priority for their organization. Furthermore, in the most recent Citigroup report on disruptive innovations (Citi, 2015), six out of the ten most significant developments are related to automation technology, including: (i) Commercial and personal drones; (ii) Autonomous driving; (iii) Machine learning and artificial intelligence; (iv) Public APIs; (v) Robo-advisors; and (vi) The sharing economy. To be sure, while the sharing economy is not an automation technology itself, it remains a key enabling technology.<sup>36</sup> Take the example of Work Fusion, a software firm that helps businesses automate complex processes.<sup>37</sup> It uses automation software to divide the work into tasks that are easily automatable and tasks that require human input; the latter are then outsourced to freelancers through online platforms. As the freelancers execute their tasks, the software analyzes how they solve them and drawing on ML algorithms it learns to perform these tasks over time.

<sup>35</sup> In financial services, for example, Citi recently launched the Citi Mobile Challenge—a virtual competition designed to accelerate the pace of digital banking innovation by allowing developers to create applications for its Digital Banking platforms and foster mobile solutions for their personal banking clients.

<sup>36</sup> A recent report by Bank of America Merrill Lynch similarly identifies the sharing economy as one of three digital technology clusters that are likely to bring significant disruption to businesses (BoFA, 2015). The other two technology clusters identified in BoFA (2015) are online services and the Internet of Things (IoT).

<sup>37</sup> Ford (2015).

Digital technologies also have a range of applications in the physical world. Autonomous vehicles are perhaps the most widely cited example of the rapid pace of technological advances in these domains. Less than a decade ago, most professional observers thought that navigating a car without human input was impossible.<sup>38</sup> Within seven years, however, Google’s autonomous car had proven the feasibility of fully autonomous navigation, drawing upon big data analytics that exploit the increased availability of 3D maps. Today, almost every major car manufacturer is developing autonomous vehicles, promising to reshape the logistics and transportation sector. Meanwhile, advances in robotics—with a simultaneous expansion of robotic capabilities and rapid price declines—are for the first time making a wide range of non-routine manual tasks in manufacturing, construction, and services susceptible to automation. Robots already perform tasks such as gutter cleaning, mopping and vacuuming; commercial service robots are now also capable of accomplishing more complex tasks in commercial cleaning and food preparation.<sup>39</sup> In addition, recent advances in natural language processing and machine vision suggest that robots may soon expand into an even wider range of service jobs that revolve around very basic social interactions.

In the light of this expanding scope of automation, Frey and Osborne (2013) recently revisited the task model, arguing that while a wide range of non-routine jobs are now susceptible to computerization, human workers still have the comparative advantage in tasks requiring:<sup>40</sup>

1. **Creativity:** (i) The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem; and (ii) Knowledge of theory and techniques required to compose, produce, and perform works of music, dance, visual arts, drama, and sculpture.
2. **Perception and manipulation:** (i) The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects; (ii) The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects; and (iii) Working in cramped work spaces that requires getting into awkward positions.
3. **Social intelligence:** (i) Bringing others together and trying to reconcile differences; (ii) Persuading others to change their minds or behaviour; and (iii) Providing personal assistance, medical attention, emotional support, or other personal care to others such as co-workers, customers, or patients.

A key question is therefore how intensive current jobs are in tasks requiring such skills. According to their estimates, about 47 percent of jobs in the United States are at “high risk” of

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<sup>38</sup> In 2004, Frank Levy and Richard Murnane, for example, argued that “executing a left turn against oncoming traffic involves so many factors that it is hard to imagine discovering the set of rules that can replicate a driver’s behavior” (see Levy and Murnane, 2004).

<sup>39</sup> McKinsey (2013).

<sup>40</sup> See Frey and Osborne (2013) for an in depth discussion of these bottlenecks. Task definitions are based on the O\*NET descriptions (see <https://www.onetonline.org/>).

automation over the next decades. In the next section we discuss these estimates in the European context.<sup>41</sup>

## **2.5 How susceptible are current jobs to computerization?**

While occupational employment statistics outside the United States are typically less detailed, the findings of Frey and Osborne (2013) have been translated to a range of European countries. Estimates suggest that roughly 48 percent of jobs in Switzerland, 42 percent of jobs in Germany, and 35 percent of jobs in the United Kingdom, Denmark, and Finland are highly susceptible to automation.<sup>42</sup> Similarly, a recent study conducted by Bowles (2014) found that some 54 percent of EU jobs are at risk of automation, ranging from 47 percent in Sweden to 62 percent in Romania (Figure 2.3).<sup>43</sup> An important caveat is that translating these findings across countries rests on the assumption that the job of a taxi driver, for example, is equally automatable in Sweden as in Italy. In other words, differences in countries susceptibility to automation solely reflect different occupational specialization patterns.

Across all countries, most workers in administration and office jobs as well as transportation and logistics thus fall in the high risk category. Similarly, a wide range of production jobs are highly susceptible to computerization, reflecting a long-standing trend of automation of industrial work. On the other hand, workers in occupations that require creativity (e.g., jobs in the arts and media) and workers in jobs that require social intelligence (e.g., jobs in business, management, and finance) remain in the low risk category. Thus, countries with lower per capita incomes at the eastern and southern European periphery have a higher share of jobs at risk (Figure 2.3), reflecting the larger share of low-skill work in their labor markets, while jobs in the northwest are on average less susceptible to automation.

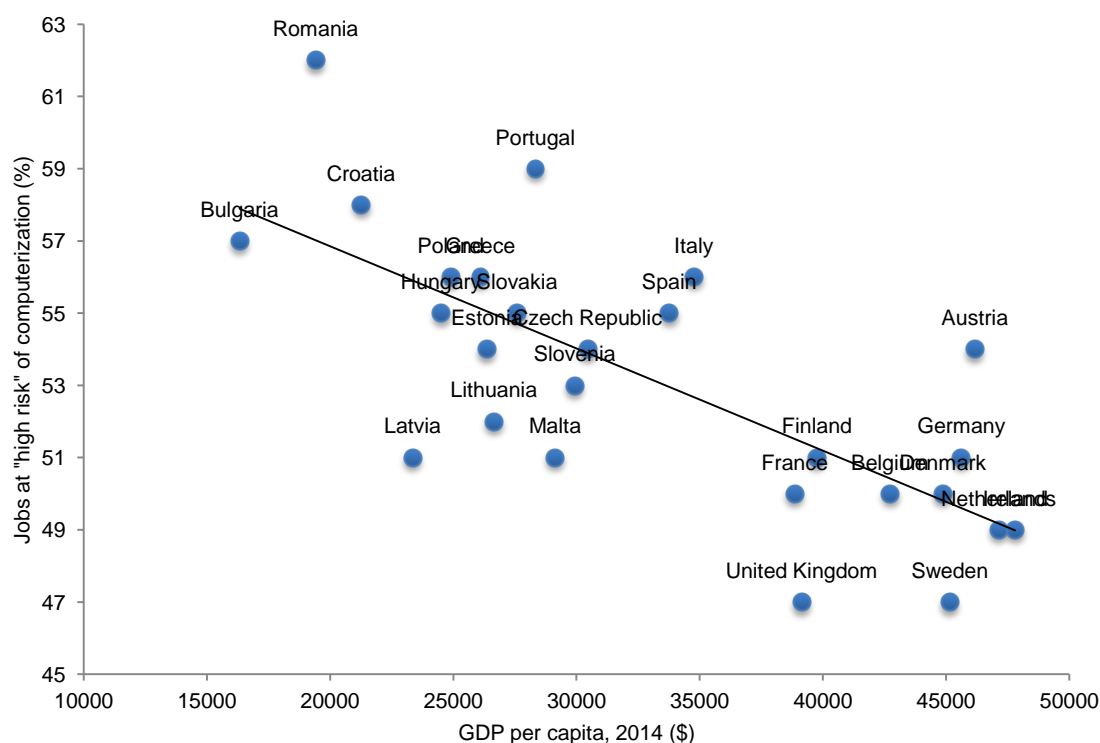
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<sup>41</sup> An occupation falls in the "high risk" category if the probability that it can be automated exceeds 70 percent.

<sup>42</sup> See Deloitte (2015c), ETLA (2014), Frey and Osborne (2014), and SSF (2014).

<sup>43</sup> It should be noted that these estimates are not directly comparable to those in the original Frey and Osborne (2013) study, due to differences in the level of aggregation of occupations in the European and US data. Yet, while a direct comparison between the exposure of European and US jobs may be slightly problematic, such problems do not plague a comparison of exposure between European countries, as these estimates rely on harmonized occupational classifications.





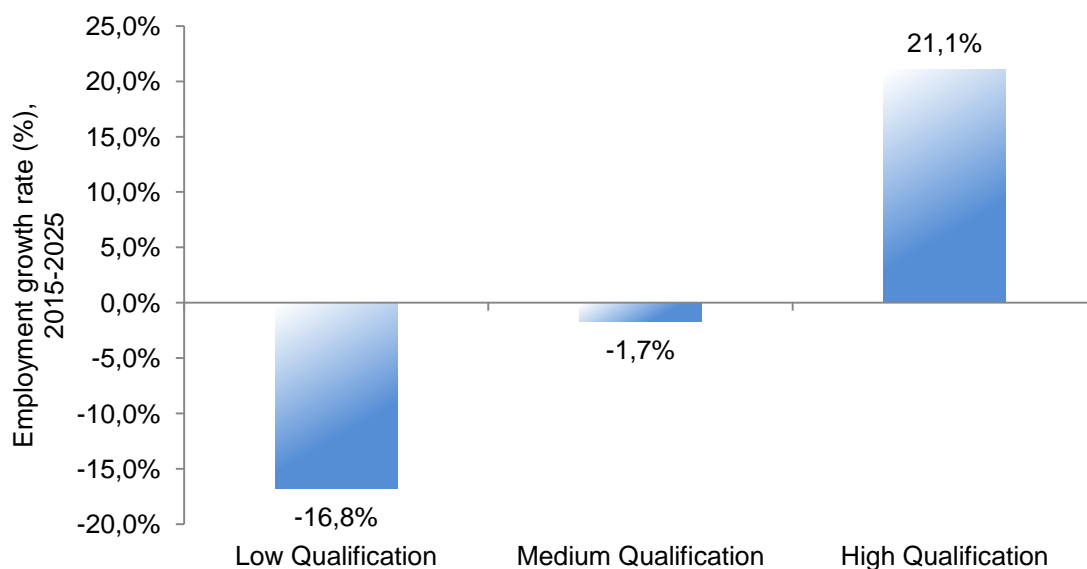
Notes: This figure shows the share of jobs that are at “high risk” of computerization based on the methodology in Frey and Osborne (2013). Data is based on Bowles (2014) and GDP per capita data is obtained from the World Bank and refers to the year 2014 measured in international dollars. Data for Malta refer to the year 2013, due to data availability. Also shown is a fitted OLS regression line.

**Figure 2.3 European Jobs at “High Risk” of Computerization.**

A crucial question remains how accurate these predictions are. A recent study by Deloitte (2015b), applying the methodology of Frey and Osborne (2013) to the United Kingdom, finds that UK employment in the high risk category experienced sharp employment declines between 2010 and 2015, while employment in the middle and low risk category experienced rapid growth, as the framework of Frey and Osborne (2013) implies. Moreover, preliminary results from an ongoing research project by McKinsey—that examines around 2,000 work activities against 18 different capabilities that are required to perform these tasks to assess which tasks can be automated—shows that 45 percent of the work activities that US workers perform today can be automated with existing technology.<sup>44</sup> Although this study examines work activities rather than occupations, the share of work that is automatable is of similar magnitude to the estimates by Frey and Osborne (2013). Finally, one key finding of Frey and Osborne (2013) is that instead of middle-skilled workers, low-skilled workers are now for the first time most susceptible to automation. A recent study by Graetz and Michaels (2013) lends some support to this prediction, showing that the diffusion of robots has contributed to declining hours worked mostly for low-skilled workers. More broadly, such a break in the distributional impact of technology is further consistent with employment projections for the

<sup>44</sup> McKinsey (2015b).

EU-28 constructed by Cedefop, suggesting that employment growth is expected to monotonically increase in the level of skill over the next decade (Figure 2.3). Thus, while the estimates of Frey and Osborne (2013) reflect the *potential* impact of technology on employment, rather than a forecast of the actual number of jobs that will disappear, recent occupational shifts and existing employment projections are broadly in line with their predictions.



Notes: This figure shows projected employment growth in low-, medium-, and highly qualified jobs in the EU-28 between 2015 and 2025, based on CEDEFOP's 2015 skills forecast. For details on the underlying assumptions and methodology, see <http://www.cedefop.europa.eu/en/publications-and-resources/data-visualisations/employment-trends>.

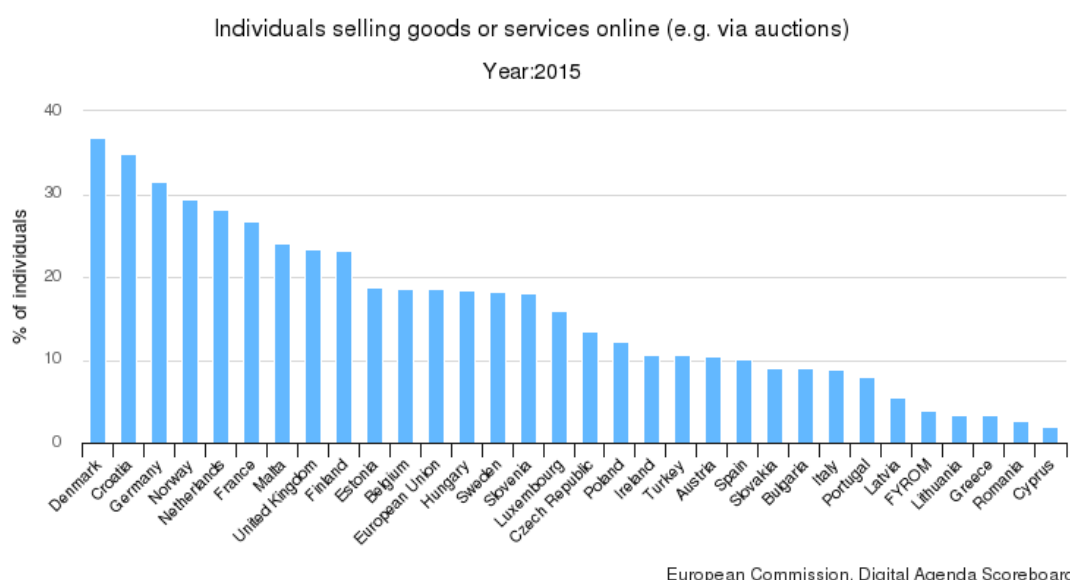
**Figure 2.3 Projected Employment Growth in the EU-28, 2015-2025.**

### 3. Competing for talent: skill requirements in the digital economy

In this section, we examine the emergence of new jobs and associated skill requirements. Doing so, we show that while digital technologies have created few new employment opportunities directly, they affect the demand for skills in most sectors of the economy. Furthermore, although projections about future skill demand are subject to substantial uncertainty, most available evidence points at a growing demand for digital skills, also outside the technology sector.

#### 3.1 New jobs and the changing demand for skills

While the diffusion of digital technology is displacing workers in some tasks, it is also creating entirely new jobs while transforming existing occupations and industries. A frequently cited example of such transformation is the sharing economy (see section 2.4), where a growing share of workers is employed as freelancers or for shorter “gigs”. At least in part, this growth is enabled by an increased use of networking and freelancing platforms, as well as remote working apps: Etsy allows millions of artisans to sell their crafts to a global customer base, Uber allows individuals to perform transportation services, and Airbnb allows apartment owners to provide accommodation services. More advanced service delivery is also facilitated by digital technology: the online marketplace Upwork, for example, matches some nine million freelance workers in fields such as mobile development and software programming with more than 3.6 million businesses to execute isolated assignments or tasks. To be sure, the digital economy provides opportunities for workers to either fully shift to such new modes of work, or to supplement incomes from more traditional work.



Notes: This figure shows the percentage of individuals that sold goods or services online in 2015 in selected European countries, based on data from the European Commission’s Digital Agenda Scoreboard. Source: <http://digital-agenda-data.eu/charts/>.

**Figure 3.1 Participation in the Sharing Economy, 2015.**

The net employment effect of sharing economy is however difficult to assess: while Uber and Airbnb, for example, may have created additional demand for taxi and accommodation services, they have also taken a share of existing markets from traditional transportation and accommodation industries. Furthermore, official data suggest that a relatively small share of workers actually are employed in the sharing economy, though it is notoriously difficult to capture freelance workers in official labor market statistics due to the wide variety of working arrangements. A recent survey of UK workers by software provider Inuit, for example, estimated that some 6 percent of British workers earned income in the sharing economy—an estimate that is larger than that reported in official data.<sup>45</sup> Yet, in several European countries as many as one in five individuals currently use online platforms to sell goods or services (Figure 3.1), suggesting that how we define participation in the sharing economy is crucial for its estimated importance. Furthermore, there are estimates suggesting that the sharing economy may grow substantially in the future: a recent PwC report found that some 46 percent of HR professionals expect that at least one in five of their workers will be made up of contractors or temporary workers by 2020, which will likely be enabled by an increased use of freelancing and networking platforms.<sup>46</sup>

Technological advances are also leading to the emergence of new jobs, which is evident from official occupational classifications. Although such data is associated with time lags, as statistical agencies only gradually identify new industries and occupations, they bear witness to a wide range of new jobs emerging. Table 3.1 report examples of new occupations from the Occupational Information Network (O\*NET), which maintains an up-to-date database of new and emerging jobs that appear in rapidly growing sectors of the economy.<sup>47</sup> Importantly, many of these jobs are directly related to the arrival of new technologies, including distance learning coordinators, nanosystems engineers, and wind energy engineers.

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<sup>45</sup> Gardiner (2015).

<sup>46</sup> See [www.pwc.com/futureofwork](http://www.pwc.com/futureofwork).

<sup>47</sup> <http://www.onetonline.org/find/bright?b=3andg=Go>

Occupation	Description	Examples of Skills
Robotics Engineers	Research, design, develop, or test robotic applications.	Critical Thinking; Complex Problem Solving; Quality Control Analysis.
Biostatisticians	Develop and apply biostatistical theory and methods to the study of life sciences.	Inductive Reasoning; Oral Expression; Mathematical Reasoning.
Chief Sustainability Officers	Communicate and coordinate with management, shareholders, customers, and employees to address sustainability issues. Enact or oversee a corporate sustainability strategy.	Complex Problem Solving; Management of Personnel Resources; Service Orientation
Fuel Cell Engineers	Design, evaluate, modify, or construct fuel cell components or systems for transportation, stationary, or portable applications.	Judgment and Decision Making; Writing; Critical Thinking.
Nanosystems Engineers	Design, develop, or supervise the production of materials, devices, or systems of unique molecular or macromolecular composition, applying principles of nanoscale physics and electrical, chemical, or biological engineering.	Critical Thinking; Science; Writing
Solar Sales Representatives and Assessors	Contact new or existing customers to determine their solar equipment needs, suggest systems or equipment, or estimate costs.	Active Listening; Persuasion; Social Perceptiveness.
Video Game Designers	Design core features of video games. Specify innovative game and role-play mechanics, story lines, and character biographies. Create and maintain design documentation. Guide and collaborate with production staff to produce games as designed.	Programming; Critical Thinking; Complex Problem Solving.
Wind Energy Engineers	Design underground or overhead wind farm collector systems and prepare and develop site specifications.	Active Learning; Complex Problem Solving; Systems Analysis.

Notes: This table reports examples of New and Emerging occupations and their skill requirements, as defined by O\*NET. See <http://www.onetonline.org/find/bright?b=3andg=Go> for a detailed description of the methodology used to identify new and emerging occupations.

**Table 3.1 Examples of New and Emerging Jobs and Skills in the 21<sup>st</sup> century.**

While there is no precise way to determine whether more jobs will be created than will be destroyed in the future,<sup>48</sup> the best available evidence, based on updates of official occupational classifications, suggests that the pace of new job creation stemming directly from the arrival of new technologies has stagnated since the computer revolution of the 1980s. A recent study by Lin (2011), for example, documents that the share of US workers employed in new types of occupations declined from some 8.2 percent in the 1980s to 4.4 percent in the 1990s. Similarly, estimates by Berger and Frey (2015a) shows that less than 0.5 percent of US workers are employed in technology-related industries that have been created in the past decade.<sup>49</sup> More broadly, a slowdown in new job creation is consistent with a declining dynamism in the US high-tech sector in the 2000s, as rates of new firm formation and job reallocation have seen marked declines.<sup>50</sup> Although we lack data to make the same exercises for Europe, the available evidence suggest that new job creation has stagnated in individual European countries, such as the United Kingdom: while 5.4 percent of the UK workforce had shifted into jobs that did not exist in 1990 by 2004, it had grown to a meager 6 percent by 2014.<sup>51</sup> Because both the United Kingdom and the United States arguably are two of the leaders of the digital revolution, there are good reasons to believe that new job creation in most other European countries, if anything, has been slower.

Even if digital technologies have created few new employment opportunities directly in technology industries, they have significantly shaped skill requirements in a wide range of occupations. In particular, technology has increased the demand for workers that perform more complex tasks that are not easily automatable. Consequently, despite the expanding scope of automation, employment is likely to increase in jobs intensive in tasks that require creative, social, and perception and manipulation skills, as suggested by Frey and Osborne (2013). A recent study by Deloitte (2015b) indeed confirms this intuition, showing that employment in such jobs expanded rapidly in the UK between 2010 and 2015.

Meanwhile, as digital technology diffuses across industries and occupations, the demand for ICT skills is expected to increase also outside the technology sector: nearly every emerging job listed in Table 3.4, for example, involves work activities such as “Analyzing Data or

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<sup>48</sup> In Germany, for example, the impacts of digital technologies on manufacturing jobs and businesses is currently widely discussed, as there is a growing concern that German companies will lose their competitive manufacturing edge if they fail to embrace the digital revolution (The Economist, 2015). To be sure, recent estimates by the Boston Consulting Group (BCG) suggest that the impact of digitalization on manufacturing jobs in Germany could be substantial: while 610,000 jobs are projected be lost due to an increased implementation of computer technology and robotics, digital technologies are expected to generate demand for an additional 210,000 highly skilled workers, in IT and RandD, and some additional 760,000 jobs are projected to be created due to faster industry growth. Thus, according to the BCG estimates, the answer to the question of whether new jobs can make up for potential job losses is seemingly “yes”, although the study does not provide the transparency necessary to assess the plausibility of these predictions.

<sup>49</sup> It shall be noted that these figures are not directly comparable, and that estimating the share of new jobs resulting from the emergence of new technologies is associated with some measurement problems. Nevertheless, they remain suggestive of a downward trend in new job creation.

<sup>50</sup> Haltiwanger et al. (2013).

<sup>51</sup> Frey (2015).

Information” or “Interacting with Computers”.<sup>52</sup> That technology is augmenting workers with problem-solving and technical skills is also reflected in the growth of a wide range of engineering and science jobs (see Table 3.1), which typically require a STEM degree.<sup>53</sup> Consistent with new job creation increasing the demand for such skills, available projections suggest that the demand for STEM professionals in Europe will expand by some 8 percent until 2025, though the accuracy of such forecasts depend on the assumptions made.<sup>54</sup>

Narrow technical skillsets are, however, unlikely to be sufficient. A recent report by the BCG, for example, argues that in sectors directly affected by digital advances, workers will increasingly be required to possess a variety of “hard” skills such as STEM or advanced IT skills, while at the same time acquiring “soft” skills that allow them to adapt to rapidly changing work environments.<sup>55</sup> Similarly, while the skill requirements in sectors such as bio- and nanotechnology include technical (STEM) skills, they also require workers to have non-technical skills such as emotional intelligence and innovative skills.<sup>56</sup> The importance of such cross-functional skillsets was also recently underlined by the UK Select Committee on Digital Skills, concluding that employers are particularly looking for workers with *fusion skills*—a mix of creative, social, and technical skills.<sup>57</sup> More broadly, these arguments are further consistent with the conclusions of the Centre for Curriculum Redesign’s third colloquium—on the theme of “AI/Robotics and Employability”—that the jobs of the future will be those that are “full of challenges with new discoveries to be made, new performances to be obtained, new things to be learned and shared with others.”<sup>58</sup>

Finally, technology also has indirect effects on employment as it generates additional income for workers, which spurs a rising demand for a wide range of services. Importantly, many service jobs—such as those of baristas, fitness instructors, and hairdressers—remain intensive in manual tasks, which make such “technologically lagging” sectors relatively unaffected by technological advances.<sup>59</sup> However, because the demand for most such services is income elastic, rising aggregate incomes tend to contribute to employment growth in manual task-

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<sup>52</sup> O\*NET defines the work activity Analyzing Data or Information as “Identifying the underlying principles, reasons, or facts of information by breaking down information or data into separate parts” and the work activity Interacting With Computers as “Using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information”. Many emerging occupations require high-level technical skills; Nanosystems engineers, for example, are required to have a deep understanding of “of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming”.

<sup>53</sup> Berger and Frey (2015a) show that having a STEM degree is an important predictor of whether or not a worker transitions into employment in a new technology-related industry.

<sup>54</sup> See Cedefop (2014). Variations exist between sectors, however, with employment in computing and professional services projected to expand by some 8-15 percent, while the pharmaceuticals industry is expected to see zero growth.

<sup>55</sup> Bolle et al. (2015).

<sup>56</sup> Dervojeda and Schretlen (2015).

<sup>57</sup> See: <http://www.publications.parliament.uk/pa/ld201415/ldselect/lddigital/111/11106.html#footnote-1158-198>

<sup>58</sup> See <http://curriculumredesign.org/ccrs-third-colloquium-on-airobotics-and-employability-highlights-the-complexity-of-broad-predictions/#sthash.FMgphPp4.dpuf>

<sup>59</sup> Baumol (1967).

intensive occupations.<sup>60</sup> In the context of the European Union, recent estimates by Goos et al. (2015) suggest that the creation of one additional job in the high-tech sector generates as many as five additional jobs locally in the service sector. The expansion of low-skill service jobs, which has been a key source of employment growth in most European countries over past decades (see Figure 2.1), therefore in part depends on the ability of countries and regions to create and attract technology jobs.

Thus, although technological advances may not create many jobs directly in the high-tech sector, they contribute indirectly to growth in a wide range of work that is itself not directly affected by technology. While some of that demand results in growth in traditional services (for example, for lawyers and taxi drivers) rising incomes sometimes spur demand for entirely new types of services and skills: a recent LinkedIn study, that examined the fastest growing job titles that did not exist in 2008, found that Zumba instructors and Beachbody coaches—services arguably unrelated to technology itself—were two of the 10 jobs that had seen the most rapid growth.<sup>61</sup> In other words, technological advances have dynamic effects on both employment and skill demand also outside technology sectors.

### 3.2 The demand for digital skills

The adoption of digital technologies has created new demand for digital skills, encompassing a broad range of abilities and competencies; ranging from accessing interfaces and basic manipulation of spreadsheets to advanced analytics and programming. Broadly following the European e-Skills Forum's 2004 Synthesis Report, we distinguish between three types of digital skills, including:<sup>62</sup>

- **Practitioner skills:** the skills required to develop, design, install, manage, and market ICT systems, most often required by workers that are employed in the ICT sector itself.
- **User skills:** the capabilities that allow workers to use ICT as tools in their own jobs, most often outside of the ICT sector, which may involve the use of generic software or specialized ICT tools.
- **E-leadership skills:** encompassing both ICT and management skills, that enables professionals to adapt businesses and organizations to accommodate ICT technology, as well as finding new ways to conduct business or identifying innovation opportunities.

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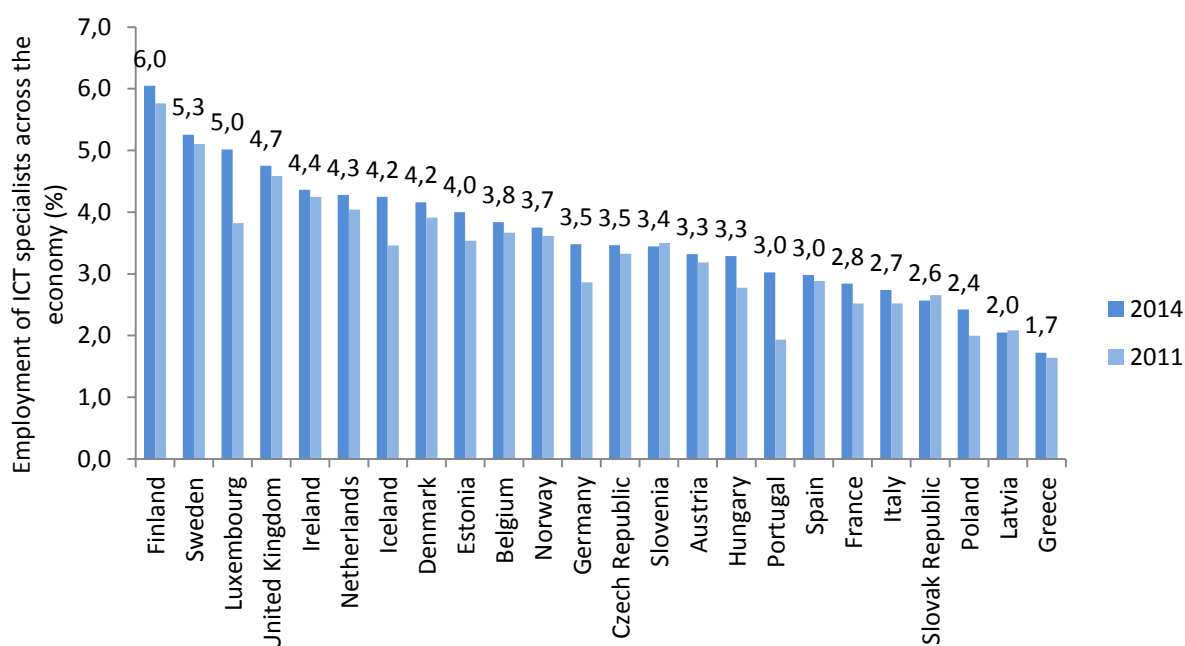
<sup>60</sup> Autor and Dorn (2013) and Autor (2015).

<sup>61</sup> See <https://business.linkedin.com/talent-solutions/blog/2014/01/top-10-job-titles-that-didnt-exist-5-years-ago-infographic>

<sup>62</sup> The European e-Skills Forum's definitions of digital skills overlap with many other widely used classifications, such as, for example, the UK Digital Skills Taskforce's three-band classification of skill requirements into 'digital citizens', 'digital workers', and 'digital makers'.



While all three types of ICT skills are expected to increase in importance, available estimates suggest that the next decades are likely to see a growing demand in particular for more advanced digital skills, though such projections typically have a wide error margin. In past years, ICT specialists have grown as a share of employment in most of Europe, contributing roughly 6 percent of employment in the leading ICT countries (Figure 3.2). Estimates from the European Commission further suggest that the demand for workers with specialist digital skills is expected to grow by some 4 percent annually, reflecting in particular a secular increase in the demand for workers with high-level ICT practitioner skills. According to recent projections by Empirica, employment in development specialist occupations and management are similarly expected to increase by some 44 percent through 2020, while employment in “infrastructure occupations” is expected to decline, due to increased computerization and offshoring of such jobs (Figure 3.3).<sup>63</sup> In addition, advanced analytic skills are increasingly perceived as important. Nearly three-quarters (73 percent) of respondents to a recent Harvard Business Review survey, mainly among executive and senior managers, stated that data analytics was “extremely important” to their business. Yet, only one in five rated their skills as “high” in this area and some 37 percent of managers wished they had deeper knowledge in the fields of data mining and analytics.<sup>64</sup>

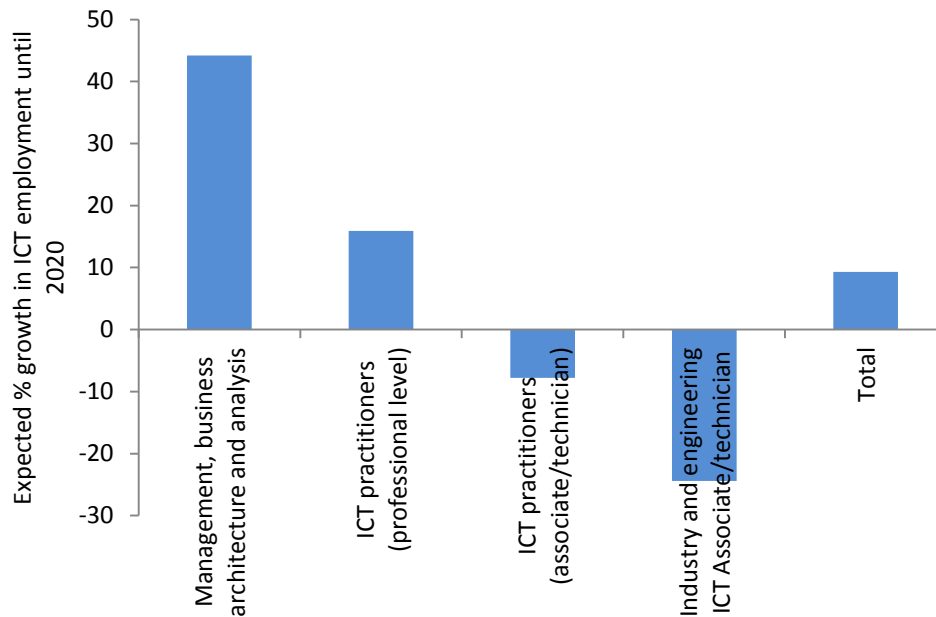


Notes: This figure reports the share of ICT specialists in total employment for selected European countries. Data is based on the European LFS. For more information about definitions and the underlying methodology, see OECD (2015).

**Figure 3.2 ICT Specialists are Increasing as a Share of Employment, 2011-2014.**

<sup>63</sup> Hüsing et al. (2013).

<sup>64</sup> Harvard Business Review (2015).



Notes: This figure reports projected ICT employment growth until 2020 by Hüsing et al. (2013), based on Eurostat LFS data. Percentage increases are measured relative to 2011. See Hüsing et al. (2013) for a thorough discussion of the maintained assumptions and methodology.

**Figure 3.3 Projected Growth in ICT Employment until 2020.**

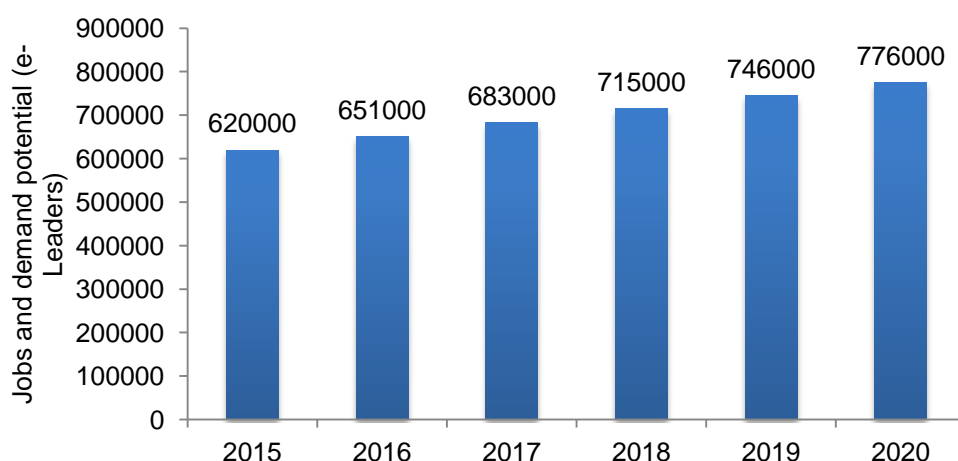
Moreover, in tandem with the digital transformation of companies and industries, available estimates suggest that the demand for e-leaders will increase at some 4.6 percent annually through 2020 (Figure 3.4).<sup>65</sup> Although these projections suggest that the demand for e-leaders is growing in tandem with the more general demand for digital specialists (see above), it may require attention from policy makers since e-leaders are expected to be of particular importance in adapting to technological advances such as Big Data and the IoT.<sup>66</sup> To be sure, companies are already perceiving technological advances and pressure from competitors as key drivers of an accelerated pace of change: between 32-50 percent of the companies in a recent survey by the Economist's Intelligence Unit stated that the rapid appearance of new digital technologies are increasing the pace of change in their industry.<sup>67</sup> To keep up with a more rapid technological change, e-leadership is arguably not only essential to create new businesses or entering new markets, but in particular to integrate digital technology to strengthen existing businesses: according to the most recent McKinsey Global survey, some two-thirds of executives state that digital initiatives have already been integrated.<sup>68</sup>

<sup>65</sup> Hüsing et al. (2015).

<sup>66</sup> Hüsing et al. (2013).

<sup>67</sup> The Economist (2015a).

<sup>68</sup> McKinsey (2015a).



Notes: This figure shows the projected demand for e-Leaders in Europe, 2015-2020. For details on the underlying assumptions and methodology, see Hüsing et al. (2015).

**Figure 3.4 Projected Demand for e-Leaders in Europe, 2015-2020.**

Although the trend of a growing demand for high-level ICT skills is expected to continue as companies manage their digital transformation, basic user skills is at the same time becoming a necessity for most workers. Already today, workers without basic ICT user skills are hard pressed to find a job in many European labor markets. Evidence presented to the UK Select Committee on Digital Skills, for example, suggests a meager 7 percent of UK workers are employed in jobs that require no digital skills.<sup>69</sup> A recent Populus survey of 2,500 firms in five European countries similarly shows that some 60 percent of firms currently report that their employees need computer skills, whereas the demand for other types of skills such as reading/writing four pages of text (35 percent of firms), mathematical abilities (24 percent), or technical skills (21 percent) were less important relatively speaking.<sup>70</sup> Similarly, about half of all European workers currently use an Internet-connected computer on the job, a share that is likely to increase considerably over the coming decades as firms increasingly exploit the near-universal availability of high-speed broadband in Europe.<sup>71</sup>

In the coming years, digital literacy is thus likely to become increasingly ubiquitous as ICT continues to reshape European firms, which is underscored by the results of a recent Deloitte survey, which found that nearly all UK firms believe that technology will significantly change their business.<sup>72</sup> A growing importance of basic user skills to accommodate the implementation of digital technology is further underlined by recent estimates from the

<sup>69</sup> See: <http://www.publications.parliament.uk/pa/ld201415/ldselect/lddigital/111/11106.html#footnote-1158-198>

<sup>70</sup> See Dolphin (2015). However, there exist considerable differences in computer use across European industries, ranging from some 44 percent of workers in construction to 75 percent of employees in the real estate sector using a computer in their daily job.

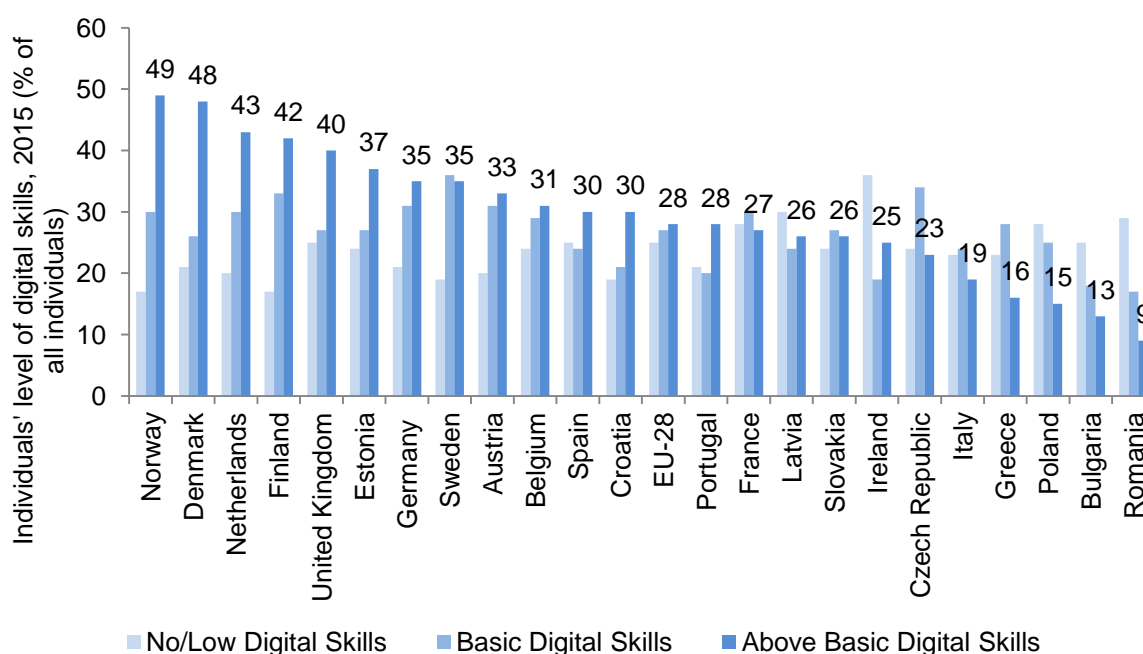
<sup>71</sup> In the EU-27, the share of non-financial enterprises with at least 10 employees with broadband access increased from 85 percent to 94 percent between 2010 and 2014 according to data from Eurostat. Many countries with initially low penetration saw rapid growth, leading to convergence in connectivity: Latvia, at 68 percent in 2010, had by 2014 increased connectivity to 95 percent. Similarly, over the same period, Poland and Slovakia saw increases from some 69 and 78 percent to 90 and 93 percent respectively.

<sup>72</sup> Deloitte (2015b).

European Commission, suggesting some 90 percent of jobs in careers such as accountancy, engineering, medicine, and nursing will require digital skills in the near future.<sup>73</sup>

### 3.3 The European skills gap

Against the backdrop of a growing demand for digital skills, Europe faces critical skills shortages in terms of the supply of both basic user skills and digital specialists. Evidence from the OECD's PIAAC study, for example, suggests that as many 10 percent of European adults currently lack basic computer skills such as scrolling through a webpage.<sup>74</sup> In countries such as Poland, as many as 25 percent of workers lack the elementary skills needed to use digital tools to execute basic tasks. A similar picture is painted by the latest Eurostat data: in 2015, 24 percent of individuals in the EU-28 had no or low digital skills, though substantial differences exist between Member States (Figure 3.5). Workers that lack fundamental skills such as using a computer mouse or a web browser will find it near impossible to remain in the labour force over forthcoming decades. Moreover, since low-educated workers are at greater risk of seeing their jobs being computerized (Frey and Osborne, 2013)—which will require them to transition into new types of work—the fact that as many as 60 percent of European workers in the ESJ survey report that their digital skills are insufficient to apply for a new job is a cause of concern.



Notes: This figure shows the percentage of individuals with different levels of digital skills for selected European countries, based on data from Eurostat.

**Figure 3.5 Digital Skills in Europe, 2015.**

<sup>73</sup> European Commission (2014).

<sup>74</sup> OECD (2013).

At the same time as many European workers lack basic computer skills, there is also a substantial shortfall of digital specialists in many Member States. Despite a growing demand for workers with ICT practitioner skills, the supply of workers with such skills has declined in many countries. Graduation rates from Computer Sciences have been in decline since the mid-2000s, leading to a shortfall that is expected to be exacerbated as an increasing number of older ICT specialists retire from the labor force. Although estimates and forecasts of current and future skill gaps are sensitive to assumptions and methodologies, most studies point to a shortfall of workers with specialist skills. A recent Empirica analysis of online vacancy data, for example, suggests an excess demand for ICT professionals and practitioners of about 373,000 workers in Europe.<sup>75</sup> Estimates of the demand for e-leadership skills further suggest that Europe will need an additional 40,000 to 50,000 e-leaders per year until 2020 to satisfy expansion and replacement demand (Figure 3.4).<sup>76</sup> Similarly, a recent report by the BCG estimated that German manufacturers' will see a shortfall of some 120,000 university graduates in computer engineering and IT within a decade.<sup>77</sup> Furthermore, according to the most recent McKinsey Global Survey, executives emphasize the pressing need for digital specialists with experience in mobile development and user experience, as well as analytics and data science.<sup>78</sup> Importantly, while individual projections have a considerable margin of error, the fact that the available estimates all point to a growing deficit of digital specialists suggest that these shortfalls may constitute a bottleneck to the digital transformation of European firms.

Skill gaps, however, also extend beyond the ICT sector itself. More generally, European companies are finding it increasingly difficult to find workers with the right skills: recently some 40 percent of European firms stated that they were having difficulties filling vacancies, due to a lack of workers with adequate skills.<sup>79</sup> In particular, there is a perceived shortfall of workers with STEM skills: estimates from the Royal Academy of Engineering, for example, suggest that the UK needs to produce at least 100,000 additional STEM graduates per year until 2020 to avoid a widening skill gap, with a similar shortfall reported in countries such as Austria and Sweden.<sup>80</sup> Although stakeholders in France indicate that the supply of engineers is currently sufficient to meet industry demand in sectors such as bio- and nanotechnology, the number of graduates in nanoelectronics is expected to fall short of demand in the near future.<sup>81</sup>

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<sup>75</sup> Hüsing, T., Werner B. Korte and Eriona Dashja: e-Skills in Europe. Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020). empirica Working Paper. November 2015

<sup>76</sup> Hüsing et al. (2013) and Hüsing et al. (2015).

<sup>77</sup> Bolle et al. (2015).

<sup>78</sup> McKinsey (2015a).

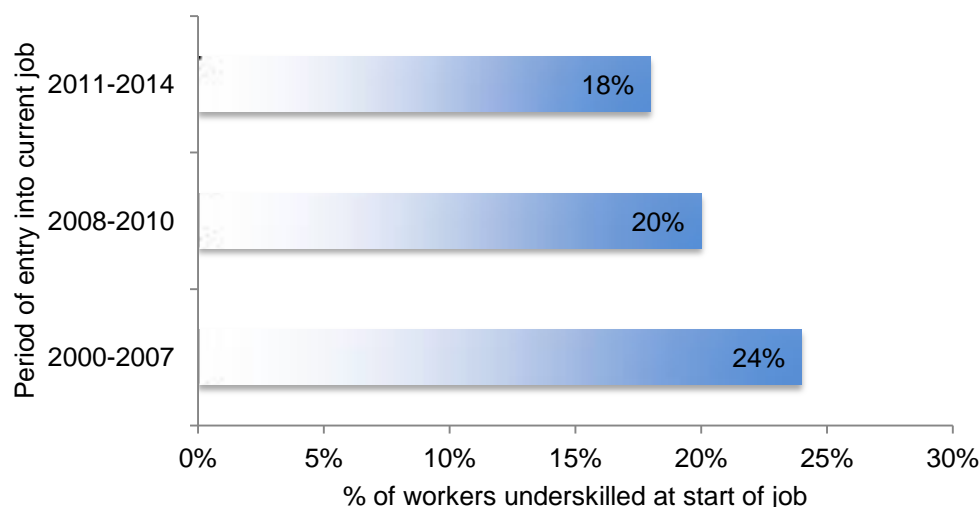
<sup>79</sup> See the Eurofound 3rd European Company survey (<http://www.eurofound.europa.eu/surveys/ecs>) and the European Commission (2014): <http://ec.europa.eu/social/main.jsp?langId=elandcatId=89andnewsId=2131>.

<sup>79</sup> Cedefop (2014).

<sup>80</sup> Cedefop (2014).

<sup>81</sup> Yet, recent estimates by PwC suggest that the problem is one of mismatch rather than supply: while the supply of STEM graduates could potentially meet the demand for skills, the fact that graduates currently choose to work in other sectors will lead to a shortfall of workers. See Dervojeđa and Schretlen (2015).

Yet, while these estimates suggest that there will be a lack of workers with appropriate skills, part of the European skills gap also reflects skills mismatch, rather than a supply side problem. Research from Cedefop, drawing on the ESJ and PIAAC surveys, document a substantial over- *and* underutilization of workers' skills: in 2014, some 39 percent of EU workers reported that their skills were not being fully used in their current job. Although the share of underskilled workers have decreased over the past decade, nearly one in five European workers lack adequate skills upon entry into a new job (Figure 3.6). Of equal concern is the fact that nearly one in three (27 percent) stated that they had little potential for further skill development. Thus, finding ways of putting workers' skills to better use by reducing skills mismatch and to promote the creation of quality jobs that allow workers to develop their skills throughout work life is thus a crucial challenge for policy makers.



Notes: This figure reports the percentage of workers that had insufficient skills upon entry into a job, based on data from Cedefop and the ESJ survey (see <http://www.cedefop.europa.eu/en/publications-and-resources/statistics-and-indicators/statistics-and-graphs/esjsurvey-insights-no1>).

**Figure 3.6 Underskilled Workers in the EU, 2000-2014.**

## 4. Bridging the skills gap

As European economies transition into the digital age, workers will have to reallocate to new types of industries, occupations, and tasks. Against the backdrop of substantial skill shortages in Europe and different skill requirements associated with new jobs, many workers will need to update their skillsets in order to manage these shifts. In this section, we discuss how these challenges can be met, focusing on how higher educational institutions, industry, and governments should adapt the provision of education and training to upskill the European workforce in order to facilitate the digital transformation of European firms.

### 4.1 Long-term perspectives on fostering digital skills

Adapting educational institutions and training providers to the digital age is a cornerstone of any long-term strategy to foster digital skills among European workers, as formal schooling remains the main way in which workers acquire digital skills: according to the most recent Eurostat data, two thirds (67 percent) of European workers, aged 16-29, report that they obtained their digital skills through formal training.<sup>82</sup> Substantial variations, however, exist between Member States. In both Latvia and Lithuania, for example, the share is above 90 percent, while Southern Europe lags behind; in Italy and Spain the corresponding shares are 49 percent and 53 percent respectively. Such substantial differences between Member States suggests that policies should be tailored to specific country needs, while the high shares of workers that have obtained their digital skills through formal training even in lagging countries reaffirms the central role of educational institutions in addressing Europe's digital divide.

Taking a more holistic perspective, infusing the curricula with digital learning from the earliest stages of formalized schooling throughout higher education is key to address the digital divide. Many Member Countries have recently taken steps in these directions. In the UK, for example, children now learn about algorithms, coding, and logical reasoning as these fields have been introduced in the curriculum.<sup>83</sup> Integrating digital technology in such ways should serve to support other curricular goals, by introducing digital tools to aid learning in other subject areas.<sup>84</sup> At the same time, estimates by the European Commission, however, suggests that some 60 percent of students never use digital tools in the classroom, which points to a considerable scope to expand ICT-enhanced learning.<sup>85</sup>

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<sup>82</sup> Also including older workers, aged above 30, reduces that share to about a third (28 percent) that reflects an increased level of education and shifting focus towards teaching digital skills for more recent cohorts.

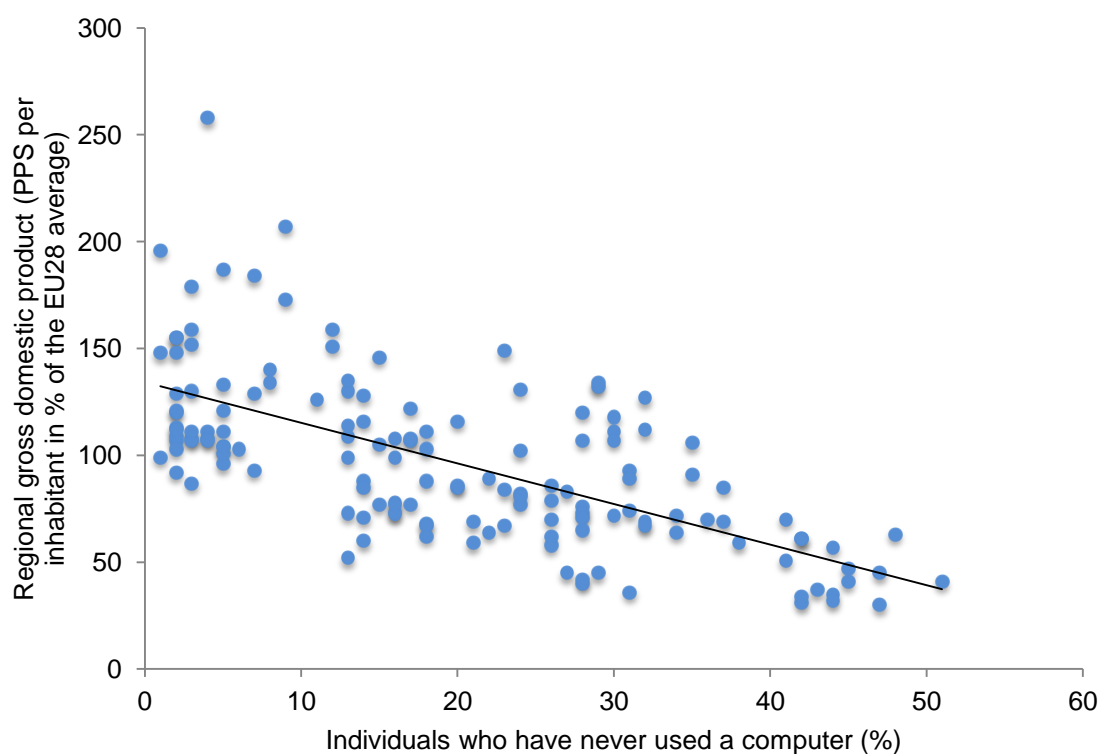
<sup>83</sup> <http://www.telegraph.co.uk/technology/news/10410036/Teachingour-children-to-code-a-quiet-revolution.html>

<sup>84</sup> The UK Select Committee on Digital Skills further concluded that there is "a strong consensus on the need for digital literacy to be embedded within the curriculum not just as a separate subject, but as a third core subject underpinning all others" (see:

<http://www.publications.parliament.uk/pa/ld201415/ldselect/lddigital/111/11106.html#footnote-1158-198>).

<sup>85</sup> See <https://ec.europa.eu/digital-agenda/en/skills-jobs>

Moreover, educational providers should work closely with other stakeholders, such as community organizations, that may contribute to exposing school children to the merits of digital technology. CoderDojo, for example, is a global movement of volunteer-led coding clubs for children aged 7 to 17, which provides teaching in app development, coding, and game design in an informal environment. Such initiatives may be crucial to attract young individuals to study ICT: in the UK, for example, a meager 4 percent of 15-year olds are interested in pursuing careers in computing or engineering according to data from the OECD.<sup>86</sup>



Notes: This figure shows GDP per inhabitant in purchasing power adjusted € expressed as a percentage of the average GDP per inhabitant across EU-28 NUTS-2 regions, and the percentage of individuals in each NUTS-2 region that have never used a computer. Data is obtained from Eurostat and is available for 147 NUTS-2 regions. Also shown is a fitted OLS regression line.

**Figure 4.1 Regional Development and Computer Experience.**

An additional way to encourage young Europeans to pursue careers in ICT-related fields is to ensure an early exposure to the Internet. In the Nordic countries and Estonia, some 80 percent of students accessed the Internet before age 10, while that share is as low as 30 percent in countries such as Greece and the Slovak Republic.<sup>87</sup> At the regional level, differences in experiences of interacting with computers are equally striking: in several European (NUTS-2) regions with less than 50 percent of the average GDP per capita across the EU-28, between 30

<sup>86</sup> See: [http://www.oecd-ilibrary.org/education/education-at-a-glance-2012/percentage-of-15-year-old-boys-and-girls-planning-a-science-related-career-or-a-career-in-engineering-and-computing-at-age-30-by-gender\\_eag-2012-table37-en](http://www.oecd-ilibrary.org/education/education-at-a-glance-2012/percentage-of-15-year-old-boys-and-girls-planning-a-science-related-career-or-a-career-in-engineering-and-computing-at-age-30-by-gender_eag-2012-table37-en)

<sup>87</sup> OECD (2015).



and 50 percent of individuals have never used a computer (Figure 4.1), which further suggests that the 18 percent of the EU population—mostly elderly and low-skill individuals—that have never used the Internet are concentrated in disadvantaged regions.<sup>88</sup> Making sure that students are exposed to digital technology early on and that such technologies also are used to create and evaluate information in other subject fields should be a priority when overhauling curricula at all levels of education. Capitalizing on early exposure to digital technology is a fruitful way to encourage young Europeans to pursue careers in ICT-related fields and thus to reduce the shortfall of digital workers over the long run.

Nevertheless, adapting the curriculum should go beyond the infusion of digital skills to also address the role of e-leadership skills—the skills required of an individual to initiate and achieve digital transformation across companies and industries. The European Commission has taken steps in this direction with the European e-Leadership Initiative that started in 2013, which was expanded to also address SMEs in 2014 ([www.eskills-guide.eu](http://www.eskills-guide.eu) and [www.eskills-lead.eu](http://www.eskills-lead.eu)). In this initiative, guidelines for new curricula and curriculum profile development have been developed, implemented and piloted at a number of universities and business schools throughout Europe. These are building on the European e-Competence Framework (e-CF) for the specification of competences to be achieved. The core of each profile comprises learning outcomes from completion: the knowledge, skills, and competences that a programme delivers to shape e-leadership skills (see chapter 4.3). As such, this mechanism provides the urgently needed transparency and comparability in the content of programmes and helps curricula to keep up with a changing environment (<http://eskills-guide.eu/documents/>). Moreover, to further foster the creation of cross-functional skills, policy makers should encourage the creation of interdisciplinary programs that infuse the curricula of traditional academic programs in, for example, mathematics and physics with digital coursework.<sup>89</sup>

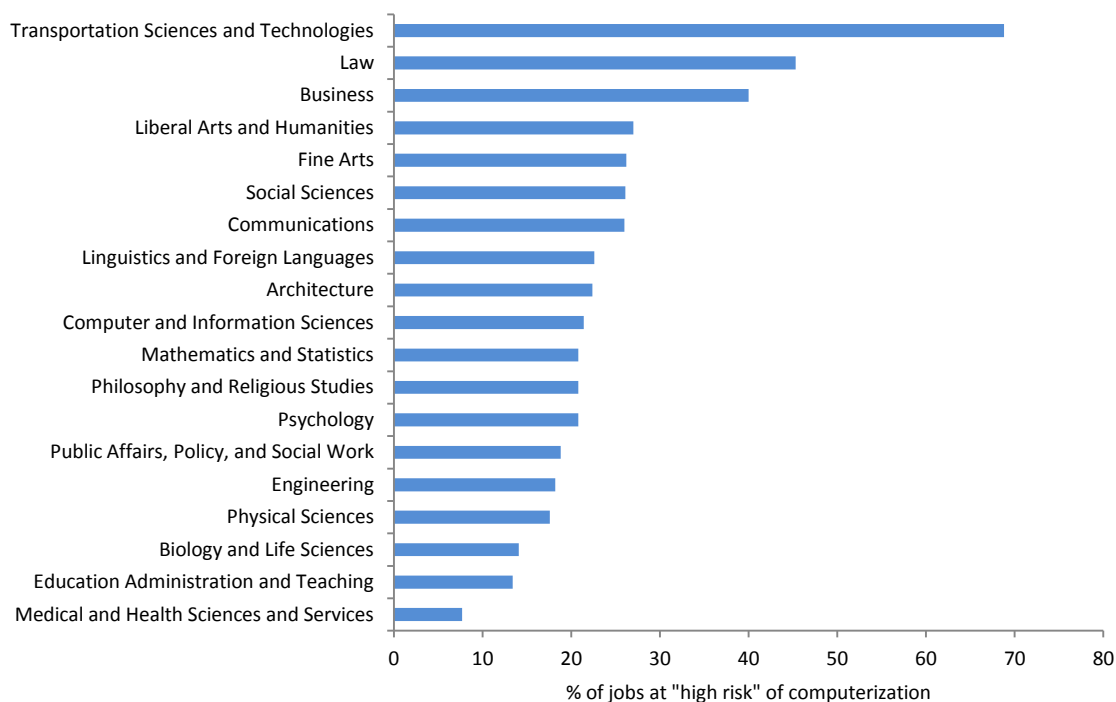
In the near future, disruptive technological advances in Machine Learning and Mobile Robotics are projected to significantly shape skill demands (see section 2): while these advances will increase the demand for some educational fields, there will be a lesser demand for other degrees. To systematically identify the potential impact of technological advances on educational demands over the next decades, Figure 4.2 reports the share of jobs that are at “high risk” of computerization by different types of university degrees based on data from Frey and Osborne (2013). Workers in fields such as education and medical services have a low risk of seeing displacement due to automation, while between 40 and 70 percent of jobs are at “high risk” of computerization in fields such as business, law, and transportations services. Differences across fields reflect the extent to which these jobs require creativity and social intelligence, implying that graduates in fields where such skills are developed have bright prospects also in the digital age. According to a recent report by McKinsey, only about

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<sup>88</sup> See <https://ec.europa.eu/digital-agenda/en/news/digital-agenda-scoreboard-2015-most-targets-reached-time-has-come-lift-digital-borders>

<sup>89</sup> Bolle et al (2015).

4 percent of the work carried out by US workers require creativity at a median human performance, while some 29 percent require sensing emotion, suggesting that there is a substantial scope for an increased importance for both these skillsets in the future.<sup>90</sup>



Notes: This figure shows the percentage of jobs that are at “high risk” of computerization based on the definitions derived in Frey and Osborne (2013) by field of college degrees. Data is based on Frey and Osborne (2013) and the 2010 American Community Survey, that provides a 1 percent random sample of the US population, restricted to employed workers aged 18-65. We match data from Frey and Osborne (2013) of each job’s probability of computerization to the worker-level data in the ACS sample to calculate the share of jobs at “high risk” of automation by field of degree.

**Figure 4.2 Jobs at “High Risk” of Computerization by Field of Degree.**

As the pace of technological change accelerates, employment durations are likely to continue to decline. As workers are changing jobs more frequently, employers are increasingly demanding that workers possess broad skillsets that are adaptable to changing circumstances.<sup>91</sup> For workers with narrow skillsets, it will become increasingly essential that education and training programmes are provided that help them refine and update their skillsets throughout their careers, as their skills are made redundant.<sup>92</sup> Skill obsolescence is indeed already becoming increasingly common among European workers: a study by the European Centre for the Development of Vocational Training, for example, found that nearly one in five German, Hungarian, Dutch, and Finnish workers had seen their skills becoming obsolete in the past two years. In particular, ICT-related and digital skills were rapidly

<sup>90</sup> McKinsey (2015b). We note that such estimates critically depend on the definition of creativity.

<sup>91</sup> AACandU (2007).

<sup>92</sup> Cedefop (2014).

becoming outdated.<sup>93</sup> Similarly, more than one in five (21 percent) workers currently believes that their skills will be outdated over a five-year period according to the ESJ survey.

In the light of these developments, vocational programs have a particularly important role to play in bridging such emerging skill gaps, as they can be more rapidly adapted to fill well-defined skill gaps in the labor market. Moreover, vocational training or work-based learning (WBL) is an effective way to foster more rapid skill development and to counter skill obsolescence: 16 percent of workers in the ESJ survey that did not take part in WBL experienced no skill development in their first job, compared to 11 percent among workers exposed to WBL.<sup>94</sup> Despite its obvious benefits, apprenticeships and WBL remains underutilized in many occupations, suggesting a scope for expanding such opportunities.

While training has important effects on skill development, relatively few workers have taken part in formal training on demand from employers: although 75 percent of new hires that participated in formal training considerably improved their skills in the ESJ survey, only 14 percent of workers in the EU-28 have obtained IT skills through formal educational institutions on the demand from employers, according to Eurostat data. Furthermore, large variations exist between countries. In Sweden, some 44 percent of workers have taken part in formal IT training on the demand of employers, while in Greece a meager 6 percent have gone through such training. Given Sweden's generally high level of IT skills, such differences seemingly suggest that employer-demanded training reflects a way to maintain a workforce with high-level IT skills rather than reflecting a perceived lack of skilled IT workers from employers. Identifying best practices and promoting partnerships between training associations and businesses is an important way to close this gap.

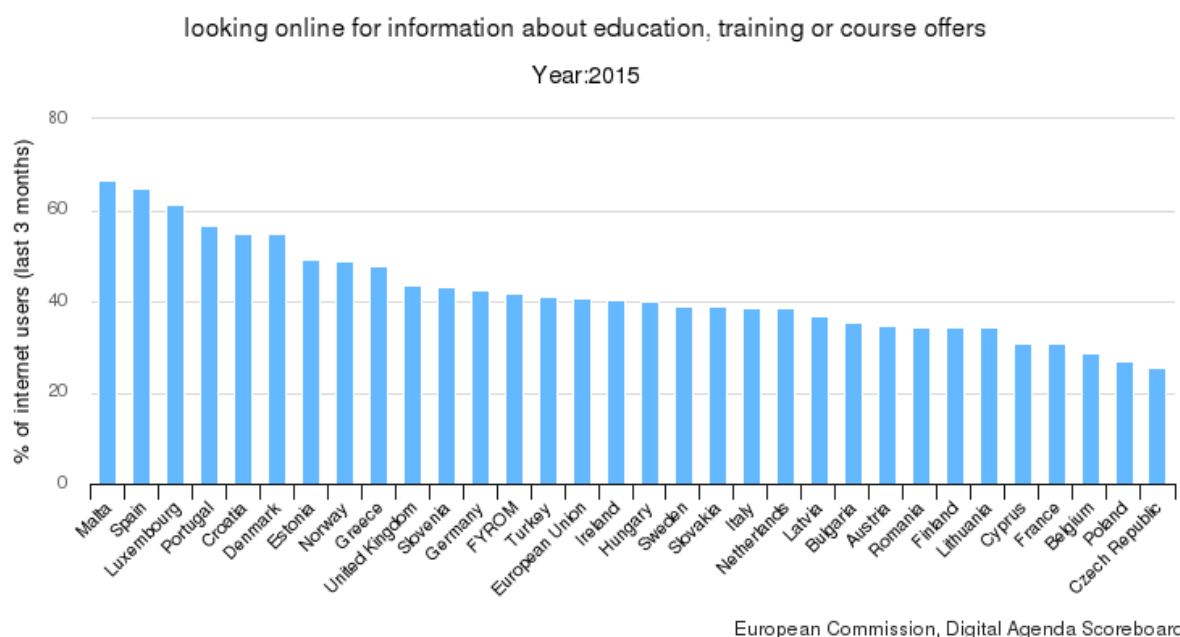
Furthermore, shorter employment durations have reduced the willingness of firms to invest in the training of their workers, meaning that workers themselves are bearing an increasing amount of the responsibility for reskilling. Although formal training remains an important avenue for acquiring new skills, self-directed learning is also a complementary way of digital skills acquisition: some 72 percent of European workers, aged 16-29, state that they have obtained IT skills through learning by doing, according to the latest data from Eurostat. Similarly, nearly 40 percent of respondents to a recent Harvard Business Review survey stated that self-study and independent research were the preferred means to learn about new digital technology.<sup>95</sup> At the same time, about 40 percent of European Internet users have used online resources to obtain information about education, training, or course offers in the past three months (Figure 4.3). Thus, although much of the focus of policy considers the role of formal educational institutions, ensuring that also low-income households have online access and the basic digital skills required to take part in online course offerings could have considerable long-term effects on the level of digital skills of the European workforce—a factor that could be particularly important for disadvantaged regions (Figure 4.1).

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<sup>93</sup> Cedefop (2012).

<sup>94</sup> Cedefop (2015b).

<sup>95</sup> Harvard Business Review (2015).



Notes: This figure shows the percentage of Internet users in selected European countries that used online resources to obtain information about training opportunities, based on the European Commission's Digital Agenda Scoreboard. Source: <http://digital-agenda-data.eu/charts/>

**Figure 4.3 Use of Online Information about Training Opportunities, 2015.**

As the role of reskilling and life-long learning increases, what will increasingly matter is the potential for acquiring new knowledge and skills, rather than accumulated work experience or previously obtained degrees. Thus, industries should strive to develop recruitment policies that make better use of underrepresented groups such as females and immigrants with potentially little prior work experience.<sup>96</sup> Tapping into such talent reserves may have substantial effects on growth and productivity: a recent study by the European Commission, for example, predicted that if women held ICT jobs to the same extent as men, this would contribute some €9 billion to annual GDP in Europe.<sup>97</sup>

## 4.2 Using digital technology to provide cost-effective education

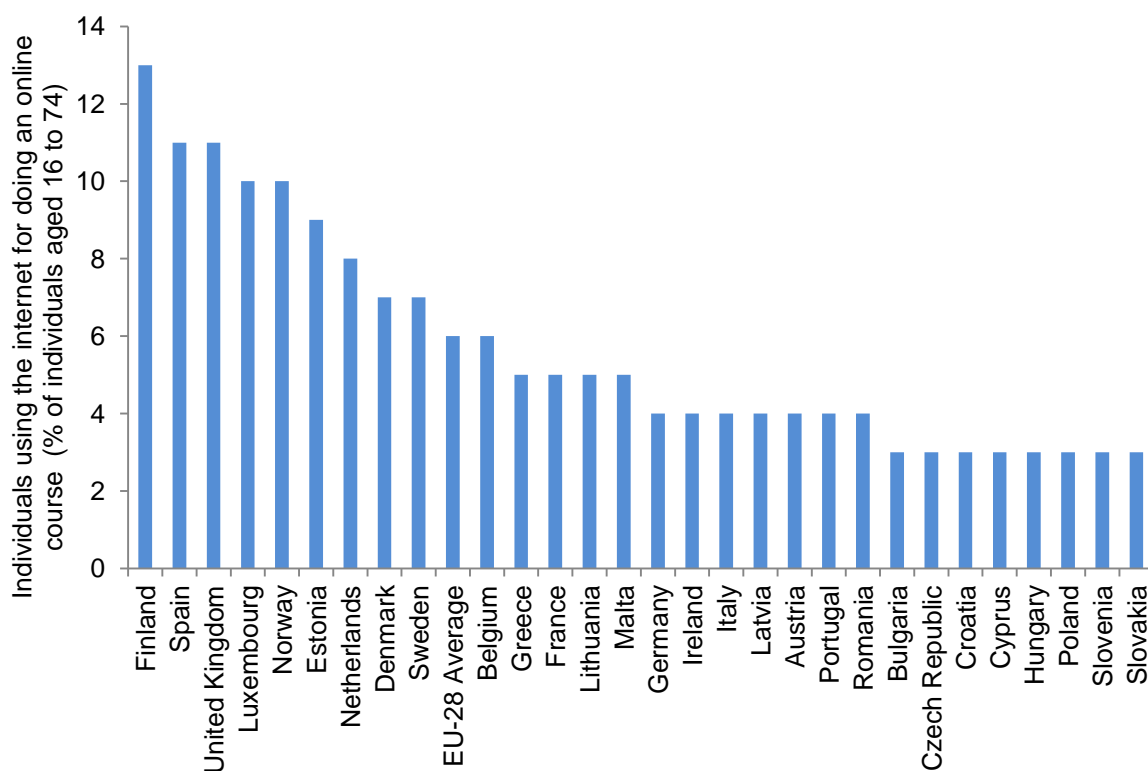
Digital technology may itself provide ways to reshape the provision of education as educational games, lecture videos, massive open online courses (MOOCs), and interactive problem sets with automated feedback and grading become increasingly available. E-learning is already complementing traditional modes of education: in 2015, some 6 percent of Europeans took part in an online course, more than doubling since 2007.<sup>98</sup> Substantial differences in the use of online learning tools, however, exist between Member Countries: in Finland, some 13 percent participates in online courses, while the share is as low as 3 percent in Poland and Slovakia (Figure 4.4).

<sup>96</sup> Cedefop (2015b).

<sup>97</sup> [http://europa.eu/rapid/press-release\\_IP-13-905\\_en.htm](http://europa.eu/rapid/press-release_IP-13-905_en.htm)

<sup>98</sup> OECD (2015) reports similar data, showing that some 7 percent of European Internet users participated in e-learning in 2013.

Importantly, MOOCs also provide avenues for autonomous innovation in teaching. Dynamic instruction systems that allow the learning load to match a student's progress, for example, may augment traditional modes of teaching.<sup>99</sup> Furthermore, lectures can be attended several times, at no additional cost, and tests can be retaken until the desired level of proficiency is achieved. As technologies develop further, the availability of big data and sophisticated algorithms will enable “interactive tutors” that generate assessment and teaching strategies that are optimized for each individual student. Rather than today's one-size-fits-all approach, such individualized teaching approaches have the potential to reshape the entire educational model.<sup>100</sup> Finally, MOOCs may also contribute to lifelong learning, by providing modularized approaches to education that enables workers to acquire specific skills and competencies at any point during their career, without completing an extensive academic program. In that sense, online learning tools provide opportunities for both flexible and low-cost ways to reskill and upgrade workers' skillsets throughout their work life.



Notes: This figure shows the percentage of individuals, aged 16-74, that used the Internet for online learning in 2015, based on data from Eurostat.

**Figure 4.4 Participation in E-learning, 2015.**

Critics of MOOCs often cite high dropout rates as a cause of concern and a lower quality of online learning relative to traditional classroom instruction. Completion rates indeed often fall below 10 percent. Yet, an important difference relative to enrollment in formal education is

<sup>99</sup> McKinsey (2013).

<sup>100</sup> Woolf (2010).

that MOOCs are able to tap the entire pool of potentially successful students. At the same time, the marginal cost of each additional student is essentially zero, making this a negligible problem from the point of view of the educational provider. Furthermore, a recent evaluation of a MIT Physics MOOC showed that online students outperformed their on-campus counterparts, suggesting that MOOCs does not necessarily provide a lower quality education.<sup>101</sup> Importantly, however, students that followed the course online performed worse in one key area—group work—that highlights the limits of online learning, namely the lack of social interaction that comes from classroom debates, discussion, and presentations.

As creative, interactive, and social skills are likely to increase in importance over the next decades (Frey and Osborne, 2013), online learning thus needs to be complemented with face-to-face interaction to foster the skills needed to compete in the twenty-first century labor market. To achieve this, more investment in tutorial style teaching and problem-based learning (PBL) is needed. Such teaching revolves around small groups of students being taught by tutors in sessions, receiving direct feedback on their work while being required to analyze, critique, and defend the work of fellow students that directly fosters creative thinking as well as social skills. PBL has in a similar way been shown to foster critical thinking, problem-solving, and interpersonal skills.<sup>102</sup> As noted by Miller (2015, p.5), with such modes of learning: “the room is no longer quiet, and the students are more personally engaged in their learning, with public speaking and presentation a common expectation.”

Some of Europe’s leading universities, including Cambridge and Oxford, indeed rely on such modes of teaching, helping students to develop relevant skills while tackling real-world challenges. Although such teaching models may inflate costs, this could at least in part be counterbalanced by lowering the costs of traditional lectures through a more extensive use of online provision of traditional lectures and the automation of back office work currently being performed by teachers. Many educational institutions indeed already use such blended learning models, building on MOOCs to improve the learning experience rather than wholly shifting the provision of education online.

### **4.3 Anticipating and identifying skill shortages**

Anticipating and identifying skill shortages and mismatch is a key challenge for governments, industry, and training providers and is crucial to keep pace with the rapidly changing needs of European businesses. In particular, since the existing projections of skill demands are highly uncertain, maintaining real time monitoring of evolving skill gaps is a key challenge. Member Countries ability to prevent skill shortages to arise depends critically on the flexibility to adapt school curricula, realign training programs, and the ability to quickly accommodate the recognition and validation of new types of skills.<sup>103</sup> Labor market intelligence systems that provide accurate, transparent, and up-to-date information are thus critical to identify and address emerging skill gaps in expanding industries, which could have substantial effects on

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<sup>101</sup> Colvin et al. (2014).

<sup>102</sup> Hoidn and Kärkkäinen (2014).

<sup>103</sup> Cedefop (2015b).

productivity.<sup>104</sup> A recent report from McKinsey (2015c), for example, estimates that widespread adoption of online talent platforms could increase global GDP by \$2.7 trillion (2 percent) by 2025, while increasing employment by some 72 million full-time-equivalent positions. Importantly, these gains are predicted to be concentrated to countries with low labor force participation and persistently high unemployment, such as Greece and Spain.<sup>105</sup>

To reduce skill mismatch, industry associations should work together with governments and educational institutions to provide high quality and up-to-date information about job opportunities, career prospects, and the evolving skill demands of industry. Initiating multi-stakeholder partnerships (MSPs) is key to meet these goals, which was underlined by the 2013 launch of the European Commission's Grand Coalition for Digital Jobs that support collaboration between formal educational institutions, businesses, as well as other public and private actors, in order to attract students to IT-related fields of study and provide digitally aligned curricula and degrees.<sup>106</sup>

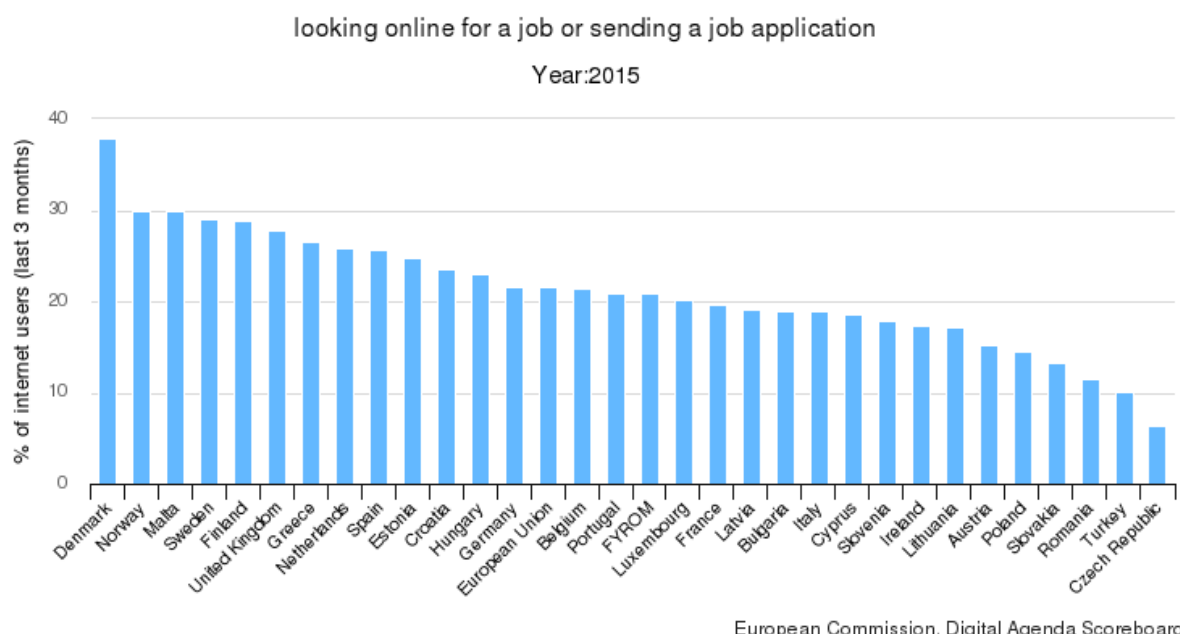
Closely aligned with the ambitions of the Grand Coalition, a unified online job market for digital workers where prospective students can obtain an accurate picture of existing and future job prospects, with information on the skills required to follow specific career paths, is a crucial instrument to prevent future skill shortages. An online job service should further integrate information on different types of training providers—from higher educational institutions to VET programs and online courses—providing a direct and transparent link between emerging skill demands and ways to acquire those skills. European workers are already turning to such online resources to obtain information about training opportunities (Figure 4.3). Initiatives in these directions exist. For example, the Skills Panorama of Cedefop integrates in one single portal data and information on skills and labour markets and turns labour market data into useful, accurate, and timely intelligence that helps policy makers in making their decisions on skills and job in Europe. Its aim is to improve Europe's capacity to assess and anticipate skill needs, to help make education and training systems more responsive to labour market needs, and to more efficiently match skill supply and demand across Europe. Furthermore, the European Jobs Network (EURES) provides online listings of some 1,000,000 job vacancies among more than 5,000 employers, working to provide advice and information, as well as recruitment services, to ease the matching of employers and workers.

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<sup>104</sup> Cedefop (2015b).

<sup>105</sup> McKinsey (2015c).

<sup>106</sup> The Grand Coalition has gained wide support, with concrete commitments from more than 80 stakeholders to take action to bridge the digital divide; see <http://ec.europa.eu/digital-agenda/make-pledge> for more information. Initiated by the European Commission, several hundred MSPs on digital skills, e-skills, and e-leadership skills have been identified and analysed in all EU28 Member States and the different national policies were investigated and together with the best practice MSPs reported on in EU28 Country Reports (see: <http://eskills-lead.eu/documents/> and <http://eskills-monitor2013.eu/results/>).



Notes: This figure shows the percentage of Internet users that used online resources to find a job or submit a job application in 2015, based on the European Commission's Digital Agenda Scoreboard. Source: <http://digital-agenda-data.eu/charts/>

**Figure 4.5 Online Resources are an Important Job-Matching Mechanism, 2015.**

A cornerstone of these labor market systems are transparent and standardized ways of certifying competencies and skills. Certification instruments should be standardized to provide unified definitions of curricular content and e-skills in Europe, which would substantially lower search costs and provide transparent ways for workers to identify job opportunities that match their skill profile or needs for re-skilling.<sup>107</sup> The European e-Leadership Initiative already referred to above has done work in this area ([www.eskills-guide.eu](http://www.eskills-guide.eu)). Similarly, another European Commission initiative on e-skills quality labels for ICT industry training and certification demonstrated how these can play a major role in reducing e-skills shortages and mismatch in Europe and provided tools and services mapping against the e-CF bringing transparency and guidance to the training and certification market ([www.eskills-quality.eu](http://www.eskills-quality.eu)). Standardization efforts should be closely aligned with initiatives such as the European Classification of Skills, Competences, Qualifications and Occupations (ESCO) that provides a structure for ICT workers to describe their skills and competencies.<sup>108</sup>

Labor market intelligence systems, online job matching services, and harmonized definitions of digital competencies and skills lowers recruitment costs of employers, provides

<sup>107</sup> According to Hüsing et al. (2015), curriculum profiles should be streamlined in a standardized manner clearly stating: (1) The relevance and demand for the profile; (2) Provide examples of typical job tasks; (3) Main topics covered; (4) Information on learning outcomes; and (5) Competencies mapped to the e-CF (The European e-Competence Framework) maintains a list of 40 core competencies that allows ICT practitioners to assess their proficiency in an objective and uniform manner and firms to identify job requirements in a consistent way across Europe. See: <http://www.ecompetences.eu/>

<sup>108</sup> ESCO is a multilingual classification of competences, occupations, qualifications and skills, with an expected launch in 2016.



transparency for prospective students when choosing their field of degree, while also facilitating intra-European mobility of ICT professionals. Taken together, such initiatives could substantially reduce skills mismatch with considerable contributions to the productivity of European companies. At the same time, it enables individual students and workers to make informed decisions that ultimately may increase the returns to educational investments.

## 5. Conclusions and policy responses

In this paper, we document how rapid technological progress is transforming companies and industries in Europe and its associated implications for the demand for skills. Surveying the literature, we find that while digital literacy will be required in the vast majority of jobs, also outside the technology sector, a number of studies document that a large share of European workers lack basic digital skills: (i) the OECD's PIAAC study show that as many as one in ten European adults lack elementary digital skills such as using a computer mouse or scrolling through a webpage; (ii) some 25 percent of workers in the EU-28 have none or low digital skills, according to the Eurostat; and (iii) the European Commission reports that about 18 percent of the EU population—mostly elderly and low-skill individuals—have never used the Internet. Furthermore, skills are unequally distributed across countries and regions and are intimately associated with economic outcomes: (i) in regions with less than half of the average GDP per capita in the EU-28, some 30-50 percent of individuals have never used a computer; and (ii) differences in digital skills is also reflected in convergence in high-tech employment taking place at a glacial pace; according to recent estimates, it would take the Centro Region in Portugal until 2070 to close half of the gap to Stockholm (Goos et al., 2015); and (iii) disadvantaged regions are more likely to be negatively affected by automation, as advances in Machine Learning and Mobile Robotics permit the computerization of a wider range of low-skill work (Frey and Osborne, 2013). Thus, to achieve sustained economic convergence in Europe, the diffusion of basic digital skills across regions needs to be a key priority.

To address the lack of basic digital skills, **we argue that a digital competence centre should be established in each NUTS2 region, with two main objectives:** (i) they should support and incentivise the adoption of digital technology in local companies; and (ii) engage with local stakeholders—including community organizations, employment agencies, and training providers—to promote the development of basic digital skills of individuals located in disadvantaged regions and urban areas, which would involve promoting exposure to digital technology. Such an initiative would contribute to a more balanced regional development and could be linked to and create synergies with existing e-government centres and telecentre initiatives throughout Europe, as well as the more recently established networks of national and local coalitions for digital jobs established under the European Commission's Grand Coalition for Digital Jobs.

Importantly, by sharing technological knowledge with local businesses and training the local workforce, these centres could help boost local productivity. A special focus should be on addressing and supporting very small companies, since these tend to lag behind most in terms of moving ahead and reaping the benefits of a digital transformation of their businesses. Moreover, training providers and consulting organisations should address SMEs requirements for the further development of their skills base and alignment of their businesses, considering the latest technology and industry developments. National and regional governments could play an important role in getting such an initiative started and off the ground. In order to reach out to a maximum of relevant actors and stakeholders, European- and national-level

associations of different types, including the chambers of commerce networks, should be involved in addition to the regional higher and executive education and training institutions. Yet, a decentralized approach should be encouraged when designing these institutions, to allow them to involve also local stakeholders and tailor the services provided to meet specific challenges specific to the regional economy. Such an approach would further provide opportunities to identify best practices and scale up successful examples. Finally, this initiative should be aligned with the Europe 2020 Strategy's Pillar VI ("Enhancing digital literacy, skills and inclusion")<sup>109</sup> and could further be embedded in the actions of the European Regional Development Fund or the European Social Fund, consistent with the latter's focus on prioritising digital literacy.<sup>110</sup>

Second, a wealth of evidence cited in the paper suggests that Europe is facing a shortage of digital specialists, summarized by the European Commission's forecast that there will be a shortfall of 756,000 digital professionals by 2020. Furthermore, other studies suggest that Europe is facing a skills shortage associated with a range of emerging technologies, including nanotechnology and biotechnology.<sup>111</sup> Although meeting these challenges will require complex solutions—ranging from increasing the attractiveness of ICT studies to encouraging more women to choose ICT-related careers in particular, and STEM subjects in general (see section 4)—evidence cited in the paper suggest that there is a considerable scope to increase the use of online learning tools: in 2015, a meager 6 percent of Europeans participated in an online course. At the same time, evidence suggests that digital specialists in particular, obtain knowledge about new technologies through self-directed learning and obtain new skills through shorter online courses that exploit blended learning models. Finally, studies suggest that adapting the curriculum should go beyond the infusion of digital skills to also address the role of e-leadership skills—the skills required of an individual to initiate and achieve digital transformation across companies and industries. Accordingly, we emphasize the need for teaching creative, social and leadership skills, in combination with technical skills, which are also least susceptible to automation.<sup>112</sup> Here the European Commission e-Leadership Skills Initiative (2013-2015) has done important work, providing tools which support and enable higher and executive education and training institutions, but also other training providers in adapting their programmes and courses and developing new ones to best address and meet industry ([www.eskills-guide.eu](http://www.eskills-guide.eu)) and SME ([www.eskills-lead.eu](http://www.eskills-lead.eu)) requirements. E-leadership skills guidelines and curriculum profiles have been developed for use by others, making it possible to scale up such course provision in Europe.

To address these skill demands, **we argue that online learning provides an effective and financially attractive way to teach high level technical skills, while tutorial style teaching is best suited to deliver creative, social and leadership skills.** Today, most Master's level

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<sup>109</sup> See <http://ec.europa.eu/digital-agenda/en/our-goals/pillar-vi-enhancing-digital-literacy-skills-and-inclusion>

<sup>110</sup> See, for example, Action 57 under Pillar VI: Prioritize digital literacy and competences for the European Social Fund (<http://ec.europa.eu/digital-agenda/en/pillar-vi-enhancing-digital-literacy-skills-and-inclusion/action-57-prioritize-digital-literacy-and>)

<sup>111</sup> PwC (2015)

<sup>112</sup> Frey and Osborne (2013).

programmes in ICT are taught at a physical campus, with online provision typically limited to entry-level courses in fields that have changed little over recent decades.<sup>113</sup> Online provision should be particularly appealing in ICT-related fields where new technologies and tools appear at a rapid pace, since it offers flexible and low-cost ways to adapt and realign course offerings and curricula. Developing relevant online courses requires that stakeholders are capable of identifying the skills that are demanded by employers, and course content should be designed with considerable input from businesses to facilitate the development of skills that are aligned with industry demand. Indeed, the EU's Agenda for Modernising Higher Education emphasises the importance of cooperation between industry players and educational institutions. Although educational institutions in individual Member States would bear the costs involved in a shift to online provision, EU-wide online courses should be considered, which would further promote regional convergence by making high-class educational offerings available to everyone.

Finally, a number of studies suggest that the pace of technological change is likely to accelerate in the near future, which will significantly increase the incidence of skill obsolescence, making many workers' skillsets rapidly outdated. Indeed, according to the ESJ survey, some 47 percent of European workers have seen new technologies used on the job since they started their employment, and 21 percent of EU workers believe that their skills will be outdated within five years. Furthermore, evidence cited in the paper suggests that more than 50 percent of European jobs are highly susceptible to automation, pointing to the potentially disruptive effects of technology in the next decades.

For skills delivery to keep pace with rapid technological change, skill anticipation systems that provide up-to-date labour market intelligence are crucial to monitor evolving industry skill demands. While policy making is often based on highly uncertain projections about skill demand, skill anticipation system could reduce the dependence on projections by providing real-time information. **To generate real-time labor market intelligence, opportunities for exploiting big data analytics and information generated on online talent platforms and job-matching sites should be explored.** These could also be utilised to develop innovative diagnosis tools and approaches for **online skills profiling and demand and supply mapping to optimise matching processes, leading to significantly improved recruitment processes and highly focussed and targeted career development aligned with industry and market requirements.** Furthermore, the European Commission should work with national employment agencies to ensure that national systems are aligned with Europe-wide initiatives whereby it should build on and make use of the experiences initiatives such online systems like 'die Arbeitsmarktmonitor' (labour market monitor) and 'Berufsentwicklungsnavigator' (navigator for career advancement) run by the national German employment agency (Bundesagentur für Arbeit). These can help to facilitate workers' shifting into new types of jobs, through training providers exploiting labour market intelligence to offer relevant learning opportunities that allow workers to plug skill gaps as they emerge over the course of work life. Provision of short and flexible digital apprenticeships, which plugs emerging needs

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<sup>113</sup> Hüsing et al. (2015).

in technology sectors, should be developed and continuously realigned to match emerging skill gaps. Such policies could be funded by the Sector Skills Alliances of the Erasmus+ programme, initiated to support the design of joint vocational training curricula and programmes.

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