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6/8

Chapter 4

The labour market implications of ICT development and digitalisation

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CHAPTER 4

The labour market implications of ICT development and digitalisation

INTRODUCTION ([1])

This chapter looks at the possible labour market implications of the development of Information and Communication Technology (ICT), the digitalisation of the economy and the automation/robotisation of tasks ([2]). It reviews existing literature and evidence on how digitalisation and automation/robotisation can affect employment, productivity and growth, and whether this may result in wage and job polarisation. It also considers the development of on-line platforms, the related opportunities for business development and job creation and the challenges that the development of on-line platforms may generate. It ends with a brief overview of how prepared EU societies are to face and benefit from digitalisation in terms of infrastructure and skills.

Since the mid-1990s, labour markets have been undergoing major structural transformation driven by technological progress, population ageing, globalisation and the greening of the economy. Technological progress in particular has had a big impact on the way goods and services are produced, bringing important changes to all sectors, from primary activities (agriculture, mining), to manufacturing (such as textiles and the car industry) and more recently to communication industries and the liberal professions. ICT development and digitalisation are now expected to bring yet more radical changes to the production and delivery of goods and services.

ICT development and digitalisation may be generating an economic transformation that will affect all industries on a scale comparable to the impact of the steam engine during the first industrial revolution. For this reason, it has been called the Fourth Industrial Revolution (see Annex for an overview of previous industrial revolutions). Societies are expected to see fundamental changes in the way we live, work and relate to one another – changes of a scale, scope and complexity that may never have been experienced before (World Economic Forum, 2016; ILO, 2015). This has important implications for employment,

([1]) This chapter was written by Fabienne Abadie, Federico Biagi, Katarina Jaksic, Sonia Jemmotte, Simone Marino, Giuseppe Piroli and Ana Xavier with contributions from Margherita Bacigalupo, Marc Bogdanowicz, Nicholas Costello, Marie Lagarrigue, Guy Lejeune, Gianluca Misuraca, Maria Nyberg, Yves Punie and Ibrahim Kholilul Rohman.

([2]) Automation is the replacement by computers of tasks formerly carried out by humans. Robotisation is the introduction of robots to carry out tasks.

education and skills, labour market institutions and social protection systems (e.g. the ability of legislation to adjust to changes in the way we work).

Digitalisation and the ensuing automation can generate new business opportunities through new production processes, new products and new markets. For instance, the development of mobile phone applications has created new opportunities for small and medium-sized enterprises (SMEs). These applications can reduce substantially the costs of starting a new business, and therefore encourage product innovation. They can help to reduce bureaucracy and administrative costs for businesses, with positive implications for job creation. Also, by allowing jobs to be broken down into component tasks, digitalisation enables the use of cheaper global options, creating more and wider global value chains.

These new technologies may also enlarge the possibilities for new ways of working and new types of activities. They may increase opportunities for self-employment, increase workers' autonomy, make career patterns more diverse and help to reduce barriers to the labour market participation of women, older workers, those with family responsibilities and disabled workers (ESDE, 2014). New and more flexible working arrangements, in terms of both time and place of work, may allow workers to perform tasks in ways that best fit their abilities and preferences. Shorter working days, working from home, flexible work and other adjustments to traditional working patterns can give workers a better work-life balance. They may also make it easier to ensure skill matching through e-employment services (e.g. Eures) and therefore enhance the mobility of workers and improve the allocation of resources.

The impact of digitalisation is also visible in the role that ICTs are playing in increasing transparency, promoting anti-corruption and reducing red tape within governments and public authorities (e.g. e-government). Allowing citizens to track government activities and monitor the work of public administrations could, in turn, increase trust in public authorities as well as promoting good governance and strengthening reform-oriented initiatives (Bertot et al., 2010).

There are nevertheless some concerns about the potentially adverse effects of digitalisation on jobs and workers. One such effect is the reduction of a number of occupations by automation ([3]). Digitalisation may render some production processes, tasks and professions obsolete. Digitalisation allows some tasks to be done by machines considerably faster than humans can do them, so is likely to change the allocation of tasks between humans and machines and the content of jobs. In extreme cases, robots will be able to take up the whole bundle of tasks that make up a job, so that that job disappears. Many examples of this can be found in the car industry but robots/machines now carry out a number of medical care ([4]) tasks previously done by humans. In several professions, digitalising tasks and breaking them down into smaller components allows tasks to be shared across a range of players and locations globally. One example is customer services in banks.

Some authors suggest that up to 50% of all professions at different skill levels could be automated to the extent that they disappear as now known (e.g. Frey and Osborne, 2013). Other studies expect a smaller impact (Arntz et al., 2016). Important questions therefore arise: which occupations or tasks are likely to disappear and which are likely to remain? Will the tasks and jobs that become obsolete be replaced by new, different tasks or jobs so that additional jobs are created? And which new skills will be needed in these new tasks and jobs? This chapter looks at some of these questions.

In addition, concerns have been expressed ([5]) about the types of employment contracts likely to develop and the implications for wages and access to social protection (pension rights, health insurance, unemployment benefits and childcare).

([3]) SWD(2016) 51 final "Key economic, employment and social trends behind a European Pillar of Social Rights". ILO (2015) "World Employment and Social Outlook–trends 2015": http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_337069.pdf

([4]) E.g. WebMD and NetDoctor.

([5]) For example the UK government recently announced a six-month review of modern working practices and is setting up a new unit to review new types of work contracts.

Overall, there is evidence that societies want to embrace and pioneer further technological and digital progress. Governments are investing in infrastructure, policies and funding to enable further digitalisation (Yates et al., 2015) as a means of supporting new businesses and business models, increasing employment, productivity and GDP growth. Some believe that global value chains could create new kinds of work in the EU, as low-skilled jobs, displaced elsewhere in the globe, are replaced by higher-skilled and better paid jobs: they may even reduce business relocation and outsourcing because digitalisation reduces costs.

In this context, it is important that EU societies are prepared to reap the benefits of ICT development and digitalisation, notably in terms of infrastructure and skills. The need to draw the maximum benefits from ICT development and digitalisation through coordinated action at EU level is highlighted in the Digital Single Market strategy ([6]), as well as in the Commission's Communication on 'Digitising European Industry – Reaping the full benefits of a Digital Single Market' ([7]).

This chapter starts by looking at the potential impact on employment of ICT development and digitalisation, particularly substitution and compensation effects and wage and job polarisation (section 1). It then reviews the development of the online economy and the collaborative economy (section 2) before assessing how prepared EU countries are to face and benefit from the digital revolution (section 3).

1. THE IMPACT OF ICT DEVELOPMENT AND DIGITALISATION ON EMPLOYMENT

1.1. The scope of the economic transformation due to ICT development and digitalisation

Rapid ICT development and digitalisation can be expected to have major consequences for job creation, business innovation, new services and industries, productivity and growth. Some trends can already be observed, as summarised below.

- Job creation. Between 2003 and 2013 employment in ICT occupations grew between 16% and 30% for 25 European countries (OECD, 2014) and is expected to continue to do so ([8]). Over the last decade, an extra 2 million ICT specialist jobs have been created, one million in the last three years alone. It has been estimated that 4 to 5 jobs are created in the economy for each new ICT job (European Commission, 2016; Moretti, 2012). The demand for medical robotics is expected to grow massively over the next few years, leading to a 21-24% increase in new jobs associated with the manufacturing and marketing of service robots (IFR, 2013). Demand for skilled ICT professionals is already outstripping the supply: 39% of companies that recruited or tried to recruit ICT specialists in 2014 reported difficulties in filling the vacancies. Latest estimates suggest that by 2020 there could be around 756,000 unfilled vacancies for ICT specialists in the EU (Hüsing et al., 2015). Increasingly these specialist jobs are created outside the ICT sector, in sectors such as the automotive industry. Over half of ICT professional jobs are now outside the ICT sector, as the whole economy becomes digital.

- Business innovation. In OECD countries, more than 95% of businesses have an online presence. ICT tools are increasingly used by companies to promote business processes and improve efficiency. They are changing business strategies and creating new opportunities for business (see section 3).

- Emergence of new services and industries. Both public and private services are benefiting from ICT development. New economic sectors are appearing, such as the app industry. Facebook apps alone created over 182,000 jobs in 2011 (DIGITS, 2011). Some governments (e.g. in Moldova) have shifted

([6]) COM (2015) 192 final, 6.5.2015.

([7]) COM (2016) 180 final, 19.4.2016.

([8]) Namely: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, and the UK.

their IT infrastructure into the Cloud and launched mobile e-services for citizens and businesses (The World Economic Forum, 2013).

- Productivity. In the EU, the slow-down in productivity growth in the last 15 years has been attributed to the limited size of the ICT sector and insufficient adoption of ICT. As a result, the contribution of ICT to labour productivity in Europe fell from 1.3 percentage points (pps) for the period 1980-1995 to 0.9 pps for the period 1995-2004 (Van Ark et al., 2008). By contrast, in the US over the same period the contribution of ICT went up from 1 to 2.2 pps. A study of firms in 13 European countries between 1998 and 2008 found that a 10% increase in ICT capital was associated with an increase in output of between 0.9% and 0.23%. Various studies have shown a significant relationship between ICT investment intensity and sales per employee for large firms. Moreover, ICT investment has a greater positive effect on productivity when coupled with investment in complementary assets, such as organisational and human capital (Brynjolfsson, 2003; Bloom et al., 2012). The Annex to this chapter reviews in more detail the impact of ICT development and digitalisation on productivity.

- Contribution to GDP Growth. A 10% increase in broadband penetration has been found to increase economic growth from a low of 0.24% to a high of 1.50% (The World Bank, 2013). ICT investment was found to have contributed to one fifth of all economic growth in the EU during the period from 1995 to 2010. For the period 2005-2010, one third of all EU growth has been traced back to investment in ICT (Koutroumpis et al., 2012).

- New ways of working. With the rise of the collaborative economy, more and more individuals can work using digital platforms (see section 3).

To understand better how ICT development and digitalisation lead to such outcomes, it is useful to look at some key technological developments in this area. A key technological development that has changed the economic model of many companies and generated a new typology of jobs is the use of new types of algorithms. The '*algorithmic revolution*' (Martin and Zysman, 2016) has allowed the development of digital platforms for the exchange of services and goods including labour. It has also transformed traditional companies by enabling them to manage their business using digital processes. This has cut costs and facilitated the entry of newcomers into the market. Cloud computing ([9]), for example, has radically reduced the costs of using ICT tools.

More specifically, three factors combined can explain the recent transformation: 1) the falling prices of IT tools; 2) the fact that ICT can boost labour productivity and increase efficiency; and 3) the increased usability of ICT over the last decade.

Users of technology – individuals, SMEs, start-ups and bigger corporations – have benefited from a reduction in monetary and non-monetary barriers to the use of ICT. These processes have fostered business innovation, the production of new goods and therefore job creation, and have increased labour productivity. They have drastically changed the way in which people communicate and exchange information and knowledge.

The existence of digital platforms is an example of the potential of ICT and digitalisation. Digital platforms are a mixture of different technologies – related to the internet, computation and data usage – and their success lies in the ability to connect software, hardware, operations and networks. Digital platforms can also facilitate the growth of other digital platforms. For instance, many of the current internet platform firms use Amazon Web Services. The ecosystem generated by digital platforms is a source of value in itself and regulates the terms by which the different actors can take part in it.

([9]) Cloud computing is a type of internet-based computing that provides shared processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services), which can be rapidly provisioned and released with minimal management effort. Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centres. It relies on sharing of resources to achieve coherence and economies of scale, similar to a utility (like the electricity grid) over a network.

ICT has also supported the emergence of a globalised market in goods and services. Whether through computer-based logistics systems that help firms manage complex globalised supply-chains, through increased communication capability for managers, or through software that facilitates the organisation of business activities in dispersed locations, ICT has not only enhanced communication systems, but also contributed significantly to cutting costs and expanding businesses.

By improving supply chains, providing information on potential economic opportunities and reducing communication costs, ICT is allowing businesses - and indeed most organisations - to rearrange inputs (labour and capital) as never before ([10]). These new globalised production chains enable enterprises to specialise in what they are good at and contract out what they are not good at, or find too expensive to do themselves.

At the same time, advances in technology can be expected to reduce the use of some of the outsourcing processes of the past. At present, manufacturing remains highly concentrated in large factories. Components and finished goods are transported at great cost and with high impact on the environment. Offshoring and outsourcing have made manufacturing plants bigger and lengthened the distances goods travel. New technologies such as robotics and 3D printing could radically change this, making it possible to manage capacity and demand flexibly through internet-linked networks of small, localised manufacturers (MIT, 2014).

While the acquisition and application of technology is a key factor in achieving economic transformation, economic activities are themselves a source of technological progress. Economic growth, economic transformation and technological change are interlinked and reinforce each other (Ibrahim, 2012).

1.2. The substitution and compensation effect of technological progress and digitalisation

This section looks at the relationship between ICT on the one hand, and employment levels and composition on the other. Economic theory identifies two main effects of technological change on employment at firm level: the substitution effect and the compensation effect. According to economic theory ([11]), process innovation and organisational change can lead to capital-labour substitution, or the substitution effect, where ICT-driven innovations such as robots directly replace human workers. The compensation effect is where technological progress leads to job creation through product innovation, commercialisation of new products and demand for new equipment. In addition, lower production costs and prices may increase demand for a firm's products. This generates higher production and therefore increases employment. Both effects (substitution and compensation) combine to produce the net employment effect.

While generating jobs, the compensation effect is often accompanied by changes in the skill composition of labour demand. In the case of ICT and digitalisation this is likely to favour the highly skilled, with potential consequences for skill mismatch, unemployment and ultimately growth. This is because, first, the input of high-skilled workers is fundamental to R&D and innovation; and second, innovative firms often participate in the global economy, and human capital is necessary for firms to compete in that space.

Substitution and compensation effects interact in a number of ways:

1. Digital technologies allow automatisation of some tasks, especially those that involve repetitive and standardisable activities. These activities can be more productively performed by “machines” (i.e. ICT capital, both hardware and software, and robots). Therefore, there is task reallocation between workers and "machines" (and hence the task content of jobs), which in some cases can take up the whole bundle of tasks that make up a job profile so that the job disappears (e.g. robots have replaced workers in the automobile industry);

([10]) ILO (2016) Guidance on "decent work in global supply chains": Conclusions of the International Labour Conference 2016 http://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_497555.pdf and http://www.ilo.org/ilc/ILCSessions/105/committees/supply-chains/lang--en/index.htm.

([11]) For example, in Schumpeterian models of creative destruction, faster innovation is accompanied by faster obsolescence of skills and, hence higher labour turnover and (structural) unemployment.

2. Digital technologies allow the transfer of many tasks across space with close to zero marginal costs. This applies both to new tasks (e.g. programming) and traditional tasks (e.g. translation). In both cases, workers in one country/region are at risk of substitution by workers who live in places where labour costs are lower, and/or by ICT capital in areas where the level of technological advance is higher. However, the emergence of a larger pool of potential employers could compensate for the higher risk of substitution;

3. Increased digitalisation brings with it the need (and demand) for new job profiles (e.g. ICT specialists), while also affecting the skill-competence requirements across all sectors and within the general population. Now even traditional jobs (e.g. secretary, accountant, lawyer) now require some digital competences. More generally, digital skills and competences cannot function in isolation; the ICT-driven knowledge economy requires individuals not only to be able to deal with digital technology but also to possess transferable skills and competences that can be applied to a broad range of occupations and sectors. Overall, the digitalisation of the economy requires a re-skilling and up-skilling of the labour force. These effects can be seen as stimuli to human capital accumulation arising from the demand side that induce a response from the supply side; the extent of that response will determine the extent to which the substitution and compensation effects offset each other;

4. ICT provides the technology that reduces transaction costs and information asymmetries in trading. This is reflected in the importance of platforms and in the rise of the collaborative economy. From a substitution vs. compensation perspective, the main issues are the extent to which labour platforms: i) increase efficiency in the labour matching process (i.e. enlarge the size of the labour market and matching efficiency); ii) reinforce or mitigate the effects of globalisation (i.e. the trading of tasks between more and less developed areas); iii) stimulate or delay capital-labour substitution (due to the effect of point ii); and iv) affect wage and job polarisation;

5. ICT acts as a driver of organisational change ([12]) and leads to gains in productivity especially if coupled with investment in complementary assets such as organisational change and human capital ([13]). Human capital is an important driver of the diffusion of digital technologies. This can create complex feedbacks in the relationship between ICT and employment that further complicate the analysis in terms of substitution and compensation effects.

Theoretical macro models have been used to model and estimate the impact of technology change on employment. Due to the difficulty in directly measuring technological change, when analysing the relationship between technology progress and employment, many economists focus on indirect measures, such as those related to innovation. Different measures of innovation can be used. Some of them relate to inputs to the innovation process (such as R&D expenses or R&D intensity), while others refer to outputs such as patents or product ([14]), process ([15]), organisational ([16]) and marketing ([17]) innovations (OECD/Eurostat, 2005). This section focuses on process and product innovation because they are most clearly related to the substitution and compensation effects of innovation on employment.

Process innovation (a new or significantly improved production or delivery method) is the use or adoption of a new production or delivery method ([18]). It tends to be labour-saving as it reduces the variable costs of production (i.e. the same output can be produced with lower variable costs or more output can be

([12]) The literature that, in the last 15 years, has addressed the relationship between ICT, organisational change and human capital covers two main areas: a) the effect of work-practices on productivity and wage inequality; and b) the impact of ICT-induced changes on firms' organisational structure and productivity (see the work of Brynjolfsson and co-authors).

([13]) This is the so-called Complementary Hypothesis, which goes back to Milgrom and Roberts (1990).

([14]) Defined as a good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user-friendliness or other functional characteristics.

([15]) Defined as a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

([16]) Defined as a new organisational method in business practices, workplace organisation or external relations.

([17]) Defined as a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

([18]) Since it includes new techniques, new equipment and new software, it is consistent with both embodied and disembodied technological progress.

produced with the same variable costs). It is the type of innovation most often associated with capital-labour substitution ([19]). Product innovation (a new or significantly improved good or service), improves firms' competitive positions and hence the demand for their products. This provides a positive stimulus to employment in innovating firms (possibly at the expense of non-innovating firms).

In addition, demand and therefore employment will increase in the industries which create the new capital goods (the 'machines') that may replace workers in other industries (while employment will decrease in the industries producing the old capital goods) (e.g. Vivarelli, 2007) ([20]). Product and process innovation can also lead to higher profits for the innovating firms and these profits can be reinvested, thus supporting aggregate demand for other goods and services. This in turn can generate higher employment in the sectors producing and delivering such goods and services ([21]).

The empirical evidence is generally consistent with the hypothesis that process innovation tends to be labour-saving, whereas invention, development and commercialisation of new products (including new equipment goods) tend to have a positive effect on the demand for labour and hence on employment growth. Existing studies also indicate that the effects of (product and process) innovation vary by firms' size and by sector ([22]): large firms and firms in high-tech sectors tend to exhibit larger substitution effects.

However, empirical evidence on the specific relationship between ICT (digitalisation) and employment is limited. Only a few papers address it specifically and even fewer look at multiple countries. Studies based on macro or sectoral data often indicate that the substitution and compensation effects tend to cancel each other out (OECD, 2016; Falk and Biagi, 2015), or find that ICT usage by individuals and firms is associated with employment growth (Evangelista et al., 2014). Studies based on firm-level data find that internet-related product or service innovations and ICT firm-wide applications tend to be positively associated with employment growth (Koellinger, 2008; Atasoy, 2013) or do not find evidence that ICT has had a significant negative substitution effect on employment at the firm level (Pantea et al., 2014) ([23]).

Chart 4.1, showing percentage changes in ICT investment and employment, suggests (reassuringly) that higher ICT investment is not associated with a reduction in employment. In other words, ICT development and digitalisation do not appear to have led to labour substitution. This may not hold true, however, for every sector or occupation.

([19]) Note that process innovation can still have a positive indirect effect on employment in the following way. Higher productivity brought about by process innovation may lead to lower product prices which may in turn result in higher demand for the product and therefore higher employment. This may be especially the case when demand is responsive to price changes.

([20]) Note that the general equilibrium effects would also show up at the meso and micro levels (even for non-innovating firms). This implies that these effects would bias downward the estimates of the substitution effects at the firm level.

([21]) Whether these effects, and therefore the compensation effect, materialise is uncertain and depends upon: 1) future profits and whether and where they are invested; and 2) the elasticity of demand and of substitution between labour and capital. If profits are reinvested in activities related to process innovation there is a possibility that they will reinforce the labour substitution effect.

([22]) The level of data aggregation at which the analysis of the relationship between innovation and employment is conducted plays an important role. Firm-level data can be useful, as it measures the innovation input (R&D expense) or output (product, process innovation and patents) directly, and often data is collected for multiple periods of time (which allows researchers to control for some unobservable factors). However, it is not well fitted to capturing more complex or aggregate effects such as "business stealing" effects (see Greenan and Guellec, 2000).

([23]) For more information on the data used in the following two charts and other data on the ICT sector, see the Annex to this chapter.

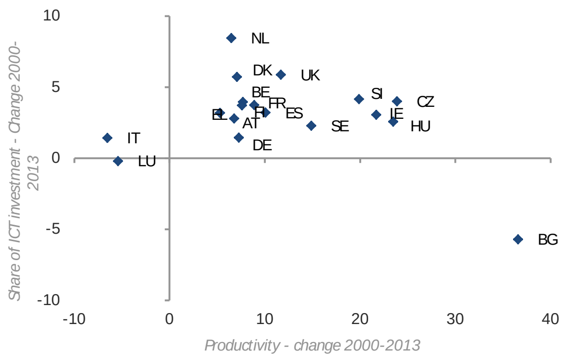
Chart 4.1: Share in ICT investment and employment – Change between 2000 and 2013

Source: Eurostat, elaborated by European Commission, DG Employment, Social Affairs and Inclusion

Click here to download chart.

Chart 4.2, using ICT investment share and productivity measured as real labour productivity per person (index 2010=100 by Eurostat), indicates a positive, although weak, correlation between these variables .

Chart 4.2: Share of ICT investment and productivity – Changes 2000-2013



Source: Eurostat, elaborated by European Commission, DG Employment, Social Affairs and Inclusion

Click here to download chart.

In sum, existing studies do not support the hypothesis that ICT developments have so far produced a loss in employment. Instead, ICT development and digitalisation have in overall terms had a positive or neutral effect on employment and a positive effect on productivity. However, that may change in the future, given the current pace of technological development in artificial intelligence and machine learning.

1.3. Skill-Biased Technological Change vs. Routine-Biased Technical Change: implications for wage and job polarisation

The labour market impact of digitalisation can be analysed using the Skill-Biased Technological Change (SBTC) hypothesis (Hornstein et al., 2005; Acemoglu, 2002; Krusell et al., 2000). This hypothesis is based on the assumption that technological change such as ICT and digitalisation, by improving the productivity of capital, increases the relative demand for skilled labour because this is more complementary to capital than unskilled labour. At the core of the SBTC hypothesis is the assumption that technological change is not factor-neutral, as in standard neoclassical growth models ([24]).

([24]) The more general version of the SBTC hypothesis - the "canonical model" in Acemoglu and Autor, 2011 - does not impose substitution between ICT capital and unskilled labour and simply assumes that technological change favours skilled workers. In this case SBTC leads to wage growth for both skilled and unskilled workers but the gains are larger for the skilled workers, implying an increase in the skilled/unskilled wage gap. In Krusell et al. (2000) the SBTC hypothesis is interpreted as an increase in capital-skill complementarity. This can be interpreted as an intermediate step towards the models where capital (i.e. ICT capital) complements skilled labour and replaces unskilled labour (as in the RBTC hypothesis).

The hypothesis that ICT and digitalisation induce an increase in the demand for skilled labour relative to unskilled labour suggests, other things being equal ([25]), an increase in the return to education. It also suggests higher wage and employment/unemployment differentials between skilled and unskilled. Many empirical studies have provided estimates for the increase in the (pre-tax) wage premium for higher education ([26]) or the increase in (pre-tax) wage inequality ([27]).

Some authors have argued that it is important to disentangle the effects attributable to SBTC from those arising from increased trade and globalisation or from changes in labour market institutions such as the change in minimum wages and unionisation ([28]) (Card et al., 2004; Koeninger et al., 2004; Jaumotte and Osorio-Buitron, 2015). Other studies, investigating the potential rigidity of EU labour markets ([29]), have looked at the unemployment consequences of ICT-induced SBTC, taking into account demographic change, shifts in the educational composition of the workforce and the role of labour market institutions (Biagi and Lucifora, 2008).

The relationship between skill-biased technological change and digitalisation can be summarised as follows:

1. The SBTC hypothesis postulates that improvements in technology in the ICT-producing sector will affect the whole economy through direct and indirect mechanisms;

2. This generates an increase in the returns to ICT capital accumulation and to the accumulation of complementary factors such as skilled labour, which in turn can induce investment in human capital;

3. Depending on the 'race' between ICT-induced technological change and investment in human capital (Goldin and Katz, 2008), these labour demand and labour supply effects will determine the evolution of the skill premium and wage inequality (inequality and the returns to education would increase if demand factors prevail);

4. Labour demand and supply evolution will also determine employment patterns; however in this case both supply and demand factors go in the same direction and lead to higher employment of skilled workers;

5. The increased demand for skills and competences brought about by the ICT revolution is compatible with the increase in residual wage inequality ([30]) observed in many countries.

Some authors consider that the SBTC hypothesis accounts for the wage and employment patterns observed in the US in the 1980s. However, the hypothesis does not appear to explain fully the wage and employment patterns observed in other countries or other periods. In particular, the SBTC hypothesis cannot account for the wage and employment patterns observed in the US after 1990, and particularly the fall in the wage differential between the first and the fifth decile ([31]) observed during the 1990s. It also

([25]) In practice, the ceteris paribus condition is not fully exactly satisfied because of changes in the educational composition of the workforce.

([26]) While some studies have looked simply at the characterisation of the wage premium (Katz and Murphy, 1992; Juhn et al., 1993; MaCurdy T. and T. Mroz, 1995; Beaudry and Green, 2000; Brunello et al., 2000) others have tried to separately estimate the impacts of labour demand changes separately from those arising from the labour supply (demographic change and changes in education composition; see Card and Lemieux 2001)

([27]) See for example ILO (2015) World Employment and Social Outlook - Trends 2015 http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_337069.pdf.

([28]) On the interplay between inequality and different labour market policies, DiNardo et al. (1996) show that the reduction in real minimum wages and de- unionisation can account for more than one third of the increase in male wage inequality in the US (as measured by the standard deviation). See also Blau and Khan (1996) and Firpo et al. (2011) for more recent contributions.

([29]) The intuition is that ICT-induced technological change affects mostly wages in the US and mostly unemployment in the EU, due to more rigid labour markets in the EU.

([30]) Residual wage inequality is that part of inequality that cannot be accounted for by observable variables such as education, experience, age, gender and occupation type.

([31]) This is the ratio between the median real wage and the average real wage of the first decile. It is often used as a measure of lower tail inequality. Similarly, the ratio of the average real wage in the 9th decile and the median real wage (p90/p50) is considered a measure of upper tail inequality.

cannot explain the drop in employment in middle-skilled jobs and the increase in high-skilled and low-skilled occupations observed during the same decade.

A proposed revised version of the SBTC hypothesis was therefore developed, often referred to as Routine-Biased Technological Change (RBTC) (Autor et al., 2003; Acemoglu and Autor, 2011). According to the RBTC hypothesis, the production process can be defined in terms of tasks, as opposed to capital and labour (and where labour is both high- and low-skilled). Job tasks are allocated to workers or to capital ('machines') depending on, first, the degree to which they are automatable (repetitive and replaceable by code and machines); second, whether they are separable from other tasks; and third, the relative costs of using 'machines' and human beings ([32]). In this context, 'machines' includes hardware, software and combinations of the two, such as robots.

The RBTC hypothesis is based on the idea that tasks can be categorised as either routine or non-routine, and either cognitive or manual ([33]) in content. Jobs are seen as bundles of tasks. The hypothesis is that computers and advanced machinery can more easily replace workers employed in jobs that are very intensive in routine tasks. These are tasks that are repetitive and can be easily codified and programmed into some form of algorithm. They are:

1. Routine manual tasks which involve repetitive physical labour that can easily be replicated by machines and automated; these are typical of production and operative occupations, such as assemblers and machine operators, usually performed by middle-skilled workers;

2. Routine cognitive tasks such as those involving gathering and processing of information. These tasks are characteristic of clerical and administrative occupations where middle-skilled workers are typically employed.

There are also non-routine manual and non-routine cognitive tasks:

1. Non-routine manual tasks are non-repetitive tasks of a physical nature, typical of low- skilled service occupations such as truck drivers, plumbers or janitors and some types of support care (cleaning, shopping). These tasks exhibit neither strong substitution nor complementarity with computers.

2. Non-routine cognitive tasks imply non-repetitive or non-codifiable analytic and interactive work. They are carried out mainly within managerial, professional and creative occupations and are usually performed by high-skilled workers. Tasks of this type cannot be easily replaced by machines. The hypothesis is that ICT developments and digitalisation tend to complement (and increase the output of) jobs involving non-routine cognitive tasks.

Therefore, the RBTC hypothesis predicts that ICT development and digitalisation lead to a decline in jobs that are rich in the routine component (manual or cognitive) and an increase in the number of jobs that are rich in the cognitive non-routine component. The theory does not make clear predictions about employment in jobs that are mostly manual and non-routine, as these are not directly affected by the digital revolution (the indirect effects are considered below).

The effects of ICT-driven technological change on the demand for tasks are magnified by globalisation and free trade, since the ability to separate tasks and the availability of a technology through global trade allows for their outsourcing ([34]).

([32]) There is a clear distinction between tasks (which arise from the demand side) and skills (which are possessed by workers).

([33]) In the pioneering paper by Autor et al. (2003) there was a distinction between a) cognitive vs. manual vs. interactive tasks and between b) routine vs. non routine tasks. In Autor and Dorn (2013) the distinction between manual and interactive is abandoned and leaves the following possible task combinations: i) cognitive–routine; ii) cognitive–non-routine; iii) manual-routine and iii) manual–non-routine. This is the approach more prevalent in the literature (e.g. Eurofound, 2016).

([34]) Research has shown that these factors combined make outsourcing of middle-skilled occupation cheap and easy (e.g. Blinder, 2009).

1.3.1. Wage and job polarisation

The 'routinisation' hypothesis can help to explain job and wage polarisation ([35]). Polarisation is a peculiar-shaped job or wage distribution in which over time many individuals concentrate at the extremes of the distribution.

Wage polarisation happens when wages tend to grow faster at the extremes of the distribution than at the centre ([36]). Wage polarisation was observed in the US in the 1990s, when wages in the 9th decile of the distribution increased compared with the 5th decile, and wages in the 5th decile decreased compared with the 1st decile.

An increase in the demand for ICT-complementary skills, typically requiring higher education, tends to drive the wages of highly educated individuals up because such skills are relatively scarce. By contrast, a reduction in the demand for skills for which ICT provides valuable substitutes - typically those of individuals with intermediate levels of education - tends to drive the wages of those in the middle of the income distribution down as they are in excess supply. As for low-skilled labour, in some cases the demand for low skills will decrease due to substitution by ICT, with a direct negative impact on wages, while in others it will rise, due to the rise in demand for personal services in an affluent and ageing society. In this latter case, upward pressure on wages for low-skilled workers may not be observed because some of the displaced medium-skilled workers are now competing for jobs requiring less skill, counteracting the upward pressure coming from the demand side.

Job polarisation sees employment becoming concentrated at the extremes of the wage ([37]) distribution. This is because over time employment in high and low-wage jobs grows faster than employment at the centre of the wage distribution. This hypothesis is rationalised as follows:

1. Workers employed in jobs that involve manual routine tasks are likely to be replaced by machines. They typically have lower education and wages;

2. More generally, workers employed in jobs that have highly routine and standardised tasks are more likely to be replaced by technology. These workers tend to have an intermediate level of education and wages;

3. Workers employed in highly cognitive, non-routine and non-standardised jobs perform tasks that are difficult to replace by technology. In fact, in many cases their productivity is enhanced by ICT. These workers typically have higher education and higher wages, and the demand for such workers is increasing;

4. Workers involved in tasks that - in spite of being manual - are not easily performed or replaced by machines (such as those related to people care and education) will not be negatively affected by digitalisation. These may be workers with lower or intermediate education but the demand for such non-routine tasks appears to be growing. This demand is partly due to population ageing, partly due to the increased demand for personal services from the richer part of the population (Mazzolari and Ragusa, 2013) and partly due to the general equilibrium effects of ICT-induced technological change (Autor and Dorn, 2013) ([38]).

([35]) For complementary explanations see job polarisation as the result of globalisation (Blinder, 2009) or the result of high skilled consumption spillovers (Mazzolari and Ragusa, 2013).

([36]) An interesting case of wage polarisation is the one observed in the US and discussed by Autor et al. (2006), where they show that monotone wage growth along the wage distribution during the period 1973-1988 has been followed by wage polarisation in the period 1988-2004.

([37]) Other alternative dimensions/distributions to consider include job quality or education. However, the wage dimension is the one most often used to order jobs as it is continuous and allows for a comparison of wage and job polarisation.

([38]) Technological change will increase productivity and reduce prices, which will boost purchasing power, providing a demand-driver to growth and employment. Applying a spatial equilibrium model, the authors find that local labour markets specialised in routine tasks adopted information technology, reallocated low-skilled labour into service occupations (employment polarisation), experienced earnings growth at the tails of the distribution (wage polarisation) and received inflows of skilled labour.

Whether job polarisation is accompanied by wage polarisation depends on the structure of the respective labour market segments. It also depends on existing labour market institutions. Compared with the USA, for example, labour market institutions in Europe may make labour markets more rigid in terms of wages. This may explain the more substantial evidence of job polarisation rather than wage polarisation in Europe (Bertola and Ichino, 1995). As wages adjust less quickly to supply and demand shifts, the shifts show up in quantities (i.e. employment/unemployment). This might also lead to polarisation of unemployment. Middle-skilled individuals who are less in demand because of technological progress may not find employment in either high-skilled jobs (because they cannot perform the tasks required) or low-skilled jobs (because of wage rigidity or labour market frictions) ([39]).

1.3.2. Empirical evidence on "routinisation" and wage and job polarisation in the EU

Analysis of industry level and individual level data for 12 EU countries in the period 1995-2007 does not show a generalised wage polarisation (Naticchioni et al., 2014). Mild wage polarisation has been found in the UK (Machin, 2011) and in Germany (Antonczyk et al., 2010; Dustmann et al., 2009).

Evidence from the European Labour Force Survey (LFS) for the period 1993-2010 reveals that some job polarisation has been occurring in all the EU countries considered with the exception of Finland and Luxembourg, where hours worked by low-wage workers have actually declined (Goos et al., 2014). The job polarisation hypothesis is also confirmed for selected OECD countries in the period 1990-2012, but such effects disappear in the long run (OECD, 2016). Evidence supporting job polarisation is also found for the USA, Japan and nine EU countries using EU KLEMS data over the period 1980-2004 (Michaels et al., 2014). Results suggest that industries that experienced the fastest growth in ICT investment also experienced the fastest growth in the demand for high-skilled workers and a fall in the demand for workers with intermediate levels of education.

Looking at wage and job polarisation in the EU and in individual Member States before the crisis (1995-2007) and during the crisis (2008-2010) there is some evidence that the crisis has added to the pre-existing polarisation for the EU as a whole: changes in employment across the wage distribution during the subsequent recession were much larger than those prior to the recession (Eurofound, 2013). However, when countries are analysed separately, large country differences emerge.

Job polarisation is observed in some countries but for many Member States there is evidence in favour of occupational upgrading in all sectors (Fernández-Macías and Hurley, 2016). Data covering the period 2013 Q2-2015 Q2 confirm a very mild upgrading with large cross-country differences (Eurofound, 2016).

For the USA, there is clear evidence of wage and job polarisation, at least for the period 1990-2000 (e.g. Firpo et al., 2013).

1.3.3. Looking to the future

Trying to forecast changes in employment is a very complex exercise because it requires forecasters need to predict the evolution of technology and of labour markets at the same time. The longer the time horizon considered, the riskier it is to draw conclusions ([40]).

An interesting and pioneering attempt in this direction is the study by Frey and Osborne (2013) who use the US 2010 O*NET dataset to compute an estimate of the overall employment impact of the ICT revolution in the US. Their work is influenced by the RBTC hypothesis and by recent developments in Computer Science ([41]) that allow the computerisation of non-routine cognitive tasks (such as those used

([39]) Note that some authors point to evidence indicating that the rise in demand for cognitive tasks in the US has started to decline as of year 2000, as a consequence of the GPT aspects of ICT reaching maturity. Beaudry et al. (2016) argue that the large cognitive skill-biased productivity-enhancing effects of the ICT revolution in the US were basically over in the year 2000. This means that the demand for higher skills has in fact started to decline in the US. The implication is that wages are stagnating overall, and that individuals with higher skills are now competing with individuals with middle and lower skills in jobs that require less cognitive tasks and more in-person tasks. This would imply that: 1) wage inequality is reduced; and 2) some of the lowest- skilled individuals are expelled from the market. It is not obvious that this type of interpretation applies to the EU.

([40]) Different institutions are paying attention to this topic. See, for example, 'The future of work' by ILO.

([41]) Mostly related to Big Data analytics and to advances in algorithms.

by lawyers, doctors, accountants, financial analysts, law enforcers) or manual tasks (such as those used by truck drivers or workers employed in food manufacturing) - tasks that had previously been considered 'safe' from computerisation (see also Brynjolfsson and McAfee, 2014).

The authors calculate the likelihood that a given occupation will become automated in the future. Occupations are categorised as low vs. middle vs. high risk; no clear time span is provided. They conclude that about 47% of current US jobs face a high risk of substitution because of the ability of machines to replace humans in tasks that can easily be automated (possibly in the next two decades, starting with workers in transportation, logistics and administration support and followed by workers in services, sales and construction).

They also find that 'generalist occupations requiring knowledge of human techniques, and specialist occupations involving the development of novel ideas and artefacts, are the least susceptible to computerisation'. Such low-risk groups include most management, business and finance occupations (due to the role of social intelligence) and engineering and science occupations (due to the role of creativity). They also predict that, in future, computerisation will mostly substitute for unskilled labour - particularly in the service sector - putting an end to job polarisation in the USA (a fact already suggested by existing data).

Applying to the EU employment structure this method of calculating the likelihood of substitution for given occupations, Bruegel ([42]) found that the percentage of jobs at risk of substitution by ICT is even higher in Europe than in the US (54% compared with 47%), particularly in Southern Europe where employment in occupations at high risk of substitution is higher. It is therefore important to equip the EU labour force with appropriate skills allowing workers to adapt to technological progress. European funds can be used for that purpose as part of regional Smart Specialisation Strategies.

The findings of Frey and Osborne have been challenged, on the grounds that they focus on jobs as opposed to tasks, which may be inappropriate. Arntz et al. (2016) argue that jobs are bundles of tasks, and even if some tasks are substitutable by 'machines' this does not imply that the whole job will disappear. Their own analysis of data from PIAAC - a survey of adult skills in 21 OECD countries - suggests that about 9% of jobs are at high risk of substitution ([43]) by 'machines', ranging from around 12% of jobs in Austria, Germany and Spain to around 6% in Finland and Estonia.

Countries that have a larger share of employment dedicated to occupations involving face-to-face interaction are less likely to suffer the consequences of the digital revolution. Across all countries, workers with the lowest level of education are those with the highest risk of displacement: 40% of workers educated only to lower secondary level are in jobs that have a high risk of automation, while the same is true for fewer than 5% of the workers educated to tertiary level. This underlines the importance of investing in skills and higher education.

In addition, it has been suggested that the distribution of skills among the workforce and the level of human capital are also important in determining the impact of ICT investment and organisational change.

Another important issue is the impact of robotisation on employment. Is increased robotisation reducing employment as robots replace labour? A firm-level analysis using data from the European Manufacturing Survey ([44]) shows the positive effects of robotisation on both labour productivity and employment. Key results include:

- companies using industrial robots more intensively are more efficient than those not using robots. They show significantly higher levels of labour productivity. The deployment of industrial robot applications in production leads to more efficient production processes, by reducing processing times and idle times while increasing process quality and competitive economies of scale;

([42]) See http://bruegel.org/2014/07/the-computerisation-of-european-jobs/.

([43]) These are jobs for which at least 70% of tasks are automatable.

([44]) European Commission, (2015) Analysis of the Impact of robotic systems on employment in the European Union. DG Communication Networks, Content and Technology.

- companies with a higher number of value-creating processes in-house show higher efficiency in terms of both labour productivity and total factor productivity;
- companies that deploy industrial robots in their manufacturing and production processes are less likely to relocate or offshore their production outside Europe;
- the use of industrial robots does not have significant negative effects on employment and employment growth, despite its positive effect on productivity. The increase in efficiency and competiveness obtained by the deployment of industrial robots is either neutral, or stimulates employment growth at company level. Analysis shows a slight positive (though not statistically significant) effect of robot utilisation on employment ([45]). Therefore, the implementation of industrial robots does not necessarily mean following the 'low road' of rationalisation by job cuts;
- the use of robots seems crucial to increasing firms' global competition capacity and Europe's ability to maintain and create jobs. In future, stiffer international competition may force companies that cannot increase their productivity and business outreach to close. Therefore, investing in technology can be an effective way to increase efficiency and maintain employment in Europe.

There is also evidence of the impact of robotisation at firm level, suggesting that: the continuous rise of operational manufacturing robots may improve the quality of jobs and strengthen global competitiveness; robotisation can improve safety and ergonomics; it can improve working conditions and reduce medical problems; and it can make systems more responsive and reduce lead times, by combining robot precision with human intelligence (Robotics VO, 2013; Lin et al., 2011; Surdilovic et al., 2010).

Data on industrial robots in 17 countries from 1993-2007 showed that increased use of industrial robots increased labour productivity and raised countries' average growth by about 0.4 percentage points (Graetz and Michaels, 2015). Robots increased both wages and total factor productivity. They did not have a major impact on total hours worked, but there was some evidence that they reduced the hours of work for low- and middle-skilled individuals.

To sum up, the evidence is that ICT development and digitalisation can have a positive impact on labour productivity across many activities. The effect of ICT development on employment also appears to be neutral if not positive – though this does not necessarily mean that there are no effects on the composition of employment or in particular sectors and occupations. The evidence also shows the complementarity between ICT, organisational capital and human capital.

2. THE RISE OF ONLINE PLATFORMS AND THE COLLABORATIVE ECONOMY: NEW OPPORTUNITIES AND CHALLENGES

This section looks at the digital economy and specifically at the development of digital platforms in the context of the collaborative economy. The definition of the collaborative economy is 'business models where activities are facilitated by collaborative platforms that create an open marketplace for the temporary usage of goods or services often provided by private individuals' (COM(2016) 356 final; SWD (2016) 184 final) ([46]). *Collaborative platforms* are typically transaction-based platforms, similar to the peer-to-peer e-commerce platforms founded in the early phase of the internet. Collaborative platforms have expanded peer-to-peer e-commerce into more complex service sectors, such as transport and accommodation, as a result of key technological improvements such as Cloud computing, the advent of algorithms and the capacity to manage and process Big Data. Digitalisation and digital platforms leverage the use of private assets (e.g. time, property, private cars) which their owners are not using fully all the time. While the collaborative economy brings new opportunities for consumers and entrepreneurs and has the potential to create jobs, some uncertainty and concerns remain about the rights and obligations of those taking part. These relate to, for example, lack of information on service providers, consumer and social protection and taxation. Some Member States have started to address these issues.

([45]) These results seem to provide some support for the hypothesis of compensation effect discussed in the previous section.
([46]) at http://ec.europa.eu/growth/single-market/strategy/collaborative-economy_en

2.1. Platforms typology and relevance

2.1.1. Activities in the collaborative economy

The collaborative economy involves three types of actors:

- service providers who share assets, resources, time and skills (e.g. private individuals offering services on an occasional basis ('peers') or professional service providers);
- users of these services; and
- collaborative economy platforms that connect providers with users and facilitate transactions between them, also ensuring the quality of these transactions e.g. through after-sale services (handling complaints), insurance services, etc.

Activities in the collaborative economy do not always involve financial remuneration. Providers may, for instance, receive financial contributions to cover costs incurred to provide a service intended to increase social innovation. Another example is 'time banking', which links people who want to share their time and skills.

The label 'collaborative economy' covers various types of platforms that share a number of characteristics but can have widely different policy and regulatory implications (for market access, taxation, consumer protection and liability, protection of personal data, labour matters, etc.) Also, some have a user base of a few hundred or thousand individuals, others of millions of people. Even within a type of service, say, ride services, the way the service is provided and the implications can differ. Ride services (e.g. Uber) differ from ride sharing (e.g. BlaBlaCar) and car sharing (e.g. Turo, formerly known as RelayRides). While they are all labour-intensive, ride services usually involve financial remuneration and profit, while car and ride sharing may have a wider range of aims (e.g. company while driving), and is seen as a way of sharing costs rather than necessarily making a profit. In addition, ride services have raised the issue of market access (i.e. licensing) and have provoked strong protests from incumbents, while car and ride sharing have not.

2.1.2. The extent of the platform phenomenon

There are no systematic quantifications of the size of the 'collaborative economy', in terms of the revenues or number of individuals directly involved, but emerging estimates indicate that it is sizeable (Codagnone et al., 2016). It has been estimated that collaborative economy platforms involve around 1% of the US workforce. A recent survey indicated that in the UK 11% of the population aged 15-75 (i.e. 5 million individuals) have found work at least once in labour platforms (Huws & Joyce, 2016). Another survey found that in 2013, about 29% of the British population had engaged at least once in a 'collaborative economy' transaction (Owyang et al., 2014). In Sweden, a survey shows that 24% of individuals aged 16-65 (1.4 million people) have looked for jobs in the collaborative economy, 12% (700,000) have worked through platforms at least once, 4% (245,000) worked through platforms every month and 3% (170,000) every week (Huws & Joyce, 2016). A recent study by the French government ([47]) estimates that in France, 'Airbnb' activities produce turnover of €2.5 billion and generate 13,000 permanent jobs.

At the end of 2015, there were at least 20 platforms worth more than USD 1 billion. Uber is valued at USD 50 billion ([48]) and is present in 230 cities in 60 countries. Airbnb is worth USD 20 billion, is present in 34,000 cities in 190 countries, and has had 35 million guests and 2 million listings since its launch in 2008 ([49]). BlaBlaCar has expanded beyond France's borders and has now recruited 10 million members in 13 countries.

([47]) See "Economic Impact of Airbnb in France Grows to €2.5 Billion" at https://www.airbnb.com/press/news/economic-impact-of-airbnb-in-france-grows-to-2-5-billion.

([48]) Valued at July 2015. See Wall Street Journal http://www.wsj.com/articles/uber-valued-at-more-than-50-billion-1438367457

([49]) Valued June 2015 http://nextjuggernaut.com/blog/airbnb-business-model-canvas-how-airbnb-works-revenue-insights/

Though in its infancy, this new phenomenon increasingly covers both factor (capital and labour) and product markets (goods and services), and therefore the entire economy. Owyang (2014) and VB Profiles & Crowd Companies (2015) found that there are 17 billion-dollar companies in the collaborative economy globally, of which 14 are in the goods, space, money and transport sectors. Of the 17, 12 are US-based and 8 are in California. Other sectors, such as corporate, food, health and municipal, have yet to see large companies emerging.

Platforms enable individuals to provide work. As they grow in scale and complexity they continue to innovate (Zhu and Furr, 2016). If smartly incorporated within the existing labour market, platforms could increase transparency in the jobs market and increase the active labour force by efficiently matching work demand and supply. From this point of view, online or mobile labour market platforms are particularly interesting. Their impact is still limited (it has been estimated that they involve just 1% of the US and 3% of the UK workforce) but the growth in numbers of providers for certain platforms has been phenomenal in recent years: for instance, oDesk (now Upwork) saw the number of contractors per quarter increasing by approximately 1,000% between 2009 and 2013.

There are no statistics or large empirical studies to provide reliable information on the number of individuals employing their time and skills to deliver services through digital platforms under different labour arrangements in the EU. A selective review of platforms identified a total of 52 million registered individuals. This could be an under-estimate if some platforms are not included, or an over-estimate if individuals are registered with several platforms (Codagnone et al., 2016).

The limited evidence available on on-demand service providers' profiles and their working conditions suggests that platform service providers:

- tend to be younger and more highly educated than the general population, with women overrepresented (but not on all platforms);
- may work long hours on several platforms, earning below or just above minimum wages - or may use the collaborative economy earnings as an income top-up, putting in only a few additional working hours;
- may have no social protection or risk insurance.

More evidence is necessary to understand if these features are common to most platforms and services, or are specific to some. It is also important to establish how many service providers use the collaborative economy for their main income, as opposed to top-up income.

Online and mobile labour market platforms have the potential to improve the matching process between labour demand and supply by reducing transaction costs and information asymmetries (Codagnone et al., 2016). However, some field experiments (Pallais, 2014) have shown that service providers with referrals are more likely to be hired than those without referrals. This reflects a hiring bias and hiring inefficiencies, since decisions not to hire potentially suitable workers are made solely on the basis of referrals. Another study (Stanton and Thomas, 2014) showed that inexperienced contractors are more likely to find a job on a platform (and earn more) if they are affiliated with an intermediary agency. Such agencies screen service providers and communicate with users, thus reducing information frictions.

Empirical evidence on the net effects of labour platforms on employment and incomes is limited. It is hard to tell whether their impact on the labour market is positive (e.g. creating a large number of jobs, including for the inactive and unemployed, reducing income inequality) or negative (e.g. leading to further job or wage polarisation, increasing income inequality) or both, or either, depending on circumstances. Evidence is also limited on aggregate social welfare effects and whether labour market efficiency and production efficiency increase. More data and research are therefore needed ([50]).

([50]) Commission services are exploring different possibilities to collect data on digital platforms. For example, the "Community survey on ICT usage in households and by individuals", in 2017, will include two questions on digital platforms in accommodation and transport.

2.1.3. Implications of digital platforms for the future of work and business

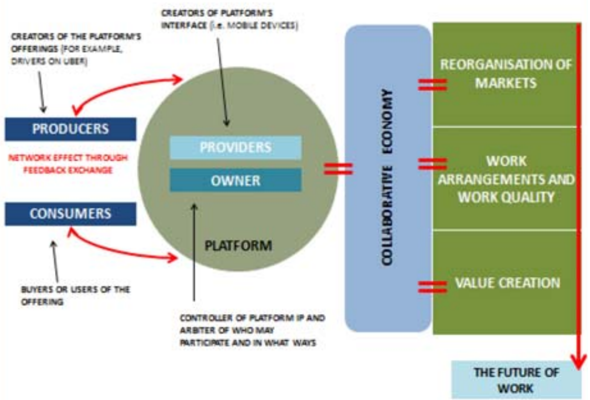
The existence of platforms is not a novelty but ICTs have played a big role in the emergence of digital platforms, and of companies such as Alibaba, Uber, Etsy, Salesforce and Airbnb. The use of computable algorithms and data clouding has initiated a profound reorganisation of sectors as diverse as service, manufacturing, consumption and leisure. These technologies have led to drastic cost reductions for businesses and lowered barriers to accessing services, thus creating the infrastructure needed for this new ecosystem to grow (Figure 4.1).

There are three distinct but connected dimensions related to the potential transformative power of this economy model for both business and work:

- platforms are leading economic actors in the reorganisation of different markets and transform competition;
- platforms transform work arrangements and influence work quality; and
- their business models use strategies to secure value creation different to those of 'pipeline' businesses.

The infrastructure and rules introduced by platforms constitute the backbone of a new marketplace which brings together producers and consumers. As shown in Figure 4.1, the main actors of this ecosystem play different roles and sometimes shift rapidly from one to another. They include a) the producers or providers of goods and services (i.e. individuals or businesses), b) the consumers or users of the goods and services supplied (i.e. buyers), and c) the platforms that connect them. Additional players include infrastructure/interface providers (who develop the interfaces which allow platforms to operate) and platform owners (who control the platform IP and define the participation rules).

Figure 4.1: The collaborative economy ecosystem



Source: created by European Commission, DG Employment, Social Affairs and Inclusion

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The interaction among these actors and their exchange of data and feedback produce the *network effect*. This is what creates value for the platform business. When an actor believes their needs can be met more efficiently elsewhere, they may defect and disrupt the platform's ecosystem, which increases volatility compared with traditional pipeline businesses ([51]).

Pipeline firms usually have clearly defined customers and competitive strategies, and make a clear distinction between suppliers, customers and competitors. To create value, pipeline firms must control a linear set of activities - the value-chain model (Parker et al., 2016). In contrast, for platforms it is the

([51]) Pipeline business is often used as a synonym of supply chain business management (Christopher, 1992). In this context, pipeline business is used to highlight the different characteristics of traditional business compare to platform management strategies, particularly in reference to management processes and the structural organisation of business. With pipeline management the company controls both a linear set of activities from the inputs it receives to the outputs produced and the process of production. This management strategy differs radically from the one adopted by platforms, as explained in the text.

community in which they operate and the resources of their members that determine interactions. Platforms tend to coordinate rather than exercise direct control over the resources 'traded' and platforms' assets are the network of producers and consumers they control. Hence platforms flourish when they succeed in facilitating external interactions. Their goal is the efficient governance of the ecosystem and maximising ecosystem value (rather than just customer value) by 'expanding the ecosystem in a circular, iterative, feedback-driven process' ([52]). The higher the number of participants and interactions, the higher the value created and the easier it will be for consumers to access their chosen service (e.g. ride on Uber) and for producers to maximise profit (by finding a high number of consumers).

Some research shows that the presence of platforms, alongside pipeline businesses, may increase competition in certain activities, but other research seems to suggest the opposite ([53]). For instance, Airbnb has become a serious competitor to conventional hotel chains ([54]). The impressive growth of its market share and market value epitomises the potential of online markets (Table 4.1) and explains why pipeline giants in the US such as Walmart, Nike, John Deere and GE are all considering the possibility of introducing platform marketplaces alongside their established business model ([55]).

Table 4.1: Airbnb successful growth

COMPANY	NUMBER OF ROOMS	FOUNDED	MARKET CAP	TIME TO 1M ROOMS	REAL ESTATE ASSETS
Airbnb	1M+	2008	€ 25B	7 YRS	€ 0
Marriott	1.1M	1957	€ 16B	58 YRS	€ 985M
Hilton	745K	1919	€ 19B	N/A	€ 9.1B
Intercontinental Hotel Group	727K	1988	€ 9B	N/A	€ 741M

Note: Data as of end of 2015; data accessed October 2016

Source: Hagiu and Rothman (2016)

Click here to download table.

As employment has only partially recovered from the prolonged EU economic crisis, a significant number of new jobs have already emerged around digital platforms. Hundreds of thousands of small vendors already use digital e-commerce platforms such as Alibaba, Amazon, and eBay to go global. Global estimates (data on the EU alone are not available) forecast that the collaborative economy could be worth an additional 2.4 trillion EUR (i.e. +2% of global GDP) and create 72 million new jobs (McKinsey Global Institute, 2015) ([56]).

Worldwide up to 540 million individuals could benefit from online platforms by 2025. As many as 230 million could shorten search times between jobs, while 200 million who are inactive or working part-time could work additional hours through platforms. Moreover, 60 million people could find work that more closely suits their skills or preferences, and another 50 million could shift from the informal to the formal sector. Countries with persistently high unemployment and low participation, such as Greece, Spain or Italy, could potentially benefit the most (McKinsey Global Institute, 2015).

This holds particularly true if one considers that *total job opportunities* are the sum of newly-created jobs (*expansion demand*) and jobs arising from the need to replace people (*replacement demand*). In the EU up to 2025, replacement demand is forecast to provide nine times more job opportunities than expansion demand (CEDEFOP, 2015). However, the net amount of new job creation in the future is likely to be

([52]) Parker et al., 2016.

([53]) For a discussion regarding the effects of digital platforms on competition see for instance Van Alstyne et al. (2016), Strowel and Vergote (2015) or Winston and Pénard (2015).

([54]) Another example, in Denmark, a loss of 500,000 rides for taxis has been reported in the greater Copenhagen area for the period Jan-May 2016 vs 2015, corresponding to an estimated loss of more than 12 million EUR, which is attributed to Uber. http://www.business.dk/transport/taxafirmaer-giver-uber-skyld-for-brat-fald-i-ture.

([55]) Parker et al., 2016.

([56]) Alternative source, EU Parliament report estimates "potential economic gain linked with a better use of capacities (otherwise under-used) as a result of the sharing economy is estimated at €572 billion." http://www.europarl.europa.eu/RegData/etudes/STUD/2016/558777/EPRS_STU(2016)558777_EN.pdf.

concentrated in firms and new economic sectors, which will be transformed by the diffusion of online platforms. In addition, the pool of highly-qualified people could increase.

Digital platforms and the collaborative economy in general might evolve and diversify further to take full advantage of this pool of talent. The presence of highly-qualified workers could lead to further innovation in services and products offered and a boom in small-scale entrepreneurs, in which individuals (rather than corporations) are the main economic actors.

In this hypothetical future, different scenarios can be envisaged. On the one hand, the collaborative economy could improve matching between labour supply and demand. This, in turn, could reduce over-qualification rates. This could be particularly important for countries with high labour market segmentation. With more highly-skilled individuals and the integration of digital platforms into traditional and new firms' strategies, more diverse tasks could be carried out through the collaborative economy, granting the workforce smoother access to jobs which better fit their skills.

A survey of EMEA ([57]) countries conducted by Manpower (2015) found that 38% of employers in 42 countries had difficulties filling vacancies for specific skills profiles, while in the EU one in three employers reported difficulties in finding the right candidate. In theory the collaborative economy, by matching people with the right skills to suitable jobs, could increase employment by putting unemployed or inactive people into work.

This could improve the job prospects of millions of young people who are not in employment, education or training (NEETs): a LinkedIn survey indicated that 37% of young jobseekers worldwide thought that their current job did not allow them to utilise their skills fully or was not challenging enough. It could also benefit older workers and the long-term unemployed, allowing them to make use of their experience and skills, improve their economic prospects and increase their sense of engagement as productive members of society.

It has been argued ([58]) that the forms of employment created by the collaborative economy are a manifestation of more general trends which are linked to digitalisation and likely to change the nature of work. Platforms manage and monitor work; they use the data derived from online monitoring activities (including customer ratings) for setting targets and apply performance monitoring. They also create the potential for work to be carried out beyond the spatial and temporal boundaries of traditional workplaces, with services and goods, and therefore the labour force, available 24/7. This heterogeneous employment configuration is a clear sign of the complexity of the employment and business relationships guiding the development of this new phenomenon. One feature common to all the different platforms is uncertainty regarding earnings and working hours. The individuals working on platforms tend to work as service providers or contractors; they are required to be flexible and reliable, and often receive low remuneration.

Individual flexibility is often cited as an important advantage of working in the collaborative economy. The possibilities of setting one's own schedule, selecting tasks, and to a certain extent negotiating pay, may all function as a motivation for joining the collaborative workforce. However, evidence suggests that the situation may not be as bright (Codagnone et al., 2016), with platforms sometimes incentivising service providers to offer additional services in return. For instance, Uber 'surge prices' may encourage drivers to take more rides where demand exceeds supply, or provide guaranteed gross fares to selected drivers if they accept specific conditions (Rosenblat and Stark, 2015). Of course, service providers remain free to manage their own working time allocation.

While the main motivation of those providing occasional services via platforms is to obtain top-up income, service providers cannot always anticipate when they will make their earnings. For instance, in the USA, 42.9% of collaborative economy providers interviewed cite 'insufficient pay' as one of the reasons for leaving the collaborative economy ([59]). In addition, exogenous economic shocks, such as a downturn in demand or a sudden change in consumer needs, may reduce business opportunities. Also, individual

([57]) EMEA is a shorthand designation meaning Europe, the Middle East and Africa.

([58]) Huws, U. (2015) Labour in the Digital Economy. Monthly Review Press.

([59]) Requests for Startups (2015) The 2015, 1099 Economy Workforce Report.

circumstances such as an accident or sickness are not regulated in the same way as in traditional businesses or standard work contracts. If risks are shifted in full to service providers, the lack of risk insurance may not only lead to income loss, but may also discourage service provision ([60]).

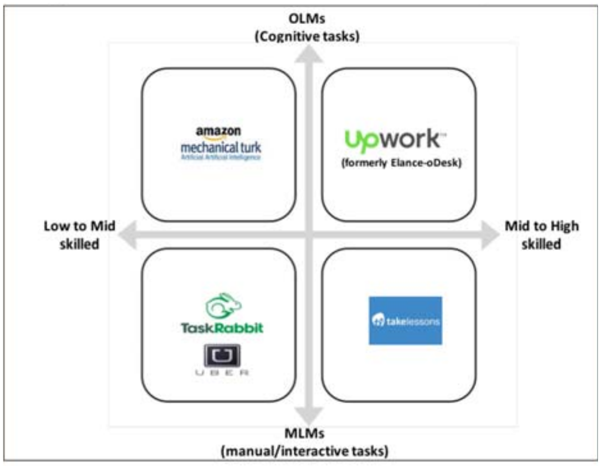
Public authorities could encourage individual freedom and private initiative, which will foster job creation. It is also possible that a clearer definition of the employment model could help in designing a business strategy in which costs, risks and revenues from the collaborative economy are shared more evenly by all stakeholders involved.

2.1.4. Classifying labour market platforms

Labour market platforms bring together service providers (workers or self-employed) and users (peers or businesses) for the delivery of different types of services. In all these platforms, the matching, administration and monitoring of service delivery are largely digitalised. In some of them the services produced by labour are also delivered digitally and remotely (no face-to-face interaction is required) and their reach is global. These have been referred to as online labour markets *(OLM)*. In others, services are delivered physically and the reach is local. These have been referred to as mobile labour markets *(MLM)*. In some platforms the service delivery requires low-skilled work; in others it demands high-skilled work (Codagnone et al., 2016).

Distinguishing between online labour markets and mobile labour markets, i.e. virtual versus physical service delivery, and between low-to-medium and medium-to-high level of skills required to perform a task, allows four types of labour market services to be identified, as shown in Figure 4.2.

Figure 4.2: Classification of labour market platforms



Source: Codagnone et al., 20016

Click here to download figure.

Amazon, MTurk, Clickworker and Crowdflower are examples of platforms in the top left quadrant of Figure 4.2 which trade routine micro-tasks (OLM micro-tasking). These require low levels of skills which individuals provide to businesses (peer-to-business interaction). In these markets, small pieces of work are put out in high volume, with correspondingly low compensation levels and near-complete standardisation; legal disputes have arisen around the classification of service providers as self-employed contractors rather than workers and on minimum wage issues.

In the top right quadrant (OLM macro-tasking), there are platforms dealing with non-routine macro-tasks or projects such as Upwork and Freelancer. These platforms offer truly independent freelancers for work which requires flexibility, creativity, generalised problem-solving and complex communications skills (e.g. software development, data science).

([60]) See Chapter 2 on Employment Dynamics and Social Implications.

In the bottom left quadrant, platforms such as TaskRabbit trade low-skilled personal and home services for consumers (MLM physical services). Problems around the classification of service providers (i.e. self-employed or workers) have also arisen here. Ride services platforms such as Uber and Lyft are a case in point. Although they disrupt licensed and professional services (e.g. taxi business), such services are delivered by individuals with a car who do not necessarily have any professional training, though a licence or authorisation may be requested. These platforms can therefore be placed in the low-to-mid-skilled category.

The fourth quadrant (MLM interactive services) represents local digital markets for high-skilled services which require complex communication skills, like Takelessons which matches students and teachers. These markets currently have a very limited reach.

2.2. The collaborative economy, employment in the informal economy and labour law challenges

New programmes intended to stimulate job creation should take into consideration the great opportunities, as well as the risks, that the collaborative economy brings. Individuals working in the collaborative economy may experience first-hand the benefits and risks of creating and managing a business and working as an independent contractor. This entrepreneurship knowledge could be used to spur innovation across the economy. On the other hand, the risks linked to these new forms of employment can lead to further inequality and social exclusion.

Given the pervasive nature of the collaborative economy model, and the ability of digital platforms to improve matching between job demand and supply, the collaborative economy may well increase formal employment (which differs from standard employment) and consequently reduce employment in the informal sectors of the economy ([61]).

2.2.1. The potential to tackle the informal economy

The collaborative economy could support job creation by transforming informal employment/ undeclared work into formal employment ([62]). Estimates of informal work suggest that informal employment in Europe is a sizeable share of employment which accounts for 17.1% of European GDP (EU 27). It represents 9.7% of GDP in the Nordic countries vs 19.2% of GDP in Southern European countries and 21.5% in East-Central Europe ([63]).

The demographic distribution of employment in the informal economy is U-shaped, meaning that young and older workers are the most likely to be found in this segment. Employment in the informal sector is often not sustainable, as it is associated with low productivity and lack of social protection. In the shadow of the ageing challenge and the resulting workforce decline from around 2020, productivity growth will be critical to sustain economic growth and maintain current welfare levels ([64]). In this context, moving employment from the informal to the formal sector should be seen as a priority.

The collaborative economy has the potential to reduce the informal sector by offering people formal employment in sectors ([65]) particularly prone to undeclared work. This is particularly the case if labour and tax regulations are designed and enforced so that the potential to reduce informality materialises in fair conditions.

([61]) Analysis on crowd work and the sharing economy, in particular as regards labour rights: research conference 2015 "regulating for decent work" http://www.ilo.org/travail/whatwedo/eventsandmeetings/WCMS_314026/lang--en/index.htm.

([62]) See also ILO "Recommendation No. 204 concerning the Transition from the Informal to the Formal Economy" labour standard adopted in 2014 http://www.ilo.org/ilc/ILCSessions/104/texts-adopted/WCMS_377774/lang--en/index.htm.

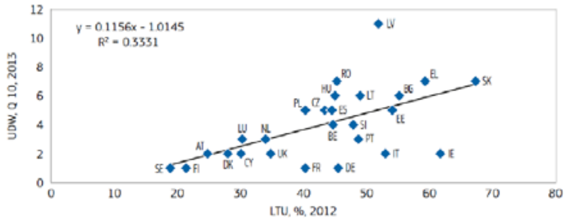
([63]) Williams, C. (2013) Evaluating Cross-National Variation in the Extent and Nature of Informal Employment in the European Union. BRITOW and John Wiley & Sons Ltd.

([64]) ESDE (2014) Chapter 2: Investing in Human Capital and Responding to Long-Term Societal Challenges, and Ageing Report (2015).

([65]) Particularly important sectors for the growth of job opportunities in the collaborative economy would be: household services, including domestic cleaning services and child and elderly care, personal services, private security, industrial cleaning, agriculture and hotel, food industry, transportation, and the green economy.

In addition, the collaborative economy could increase job opportunities for the long-term unemployed. Research ([66]) demonstrates that increasing length of unemployment spells and numbers of discouraged workers are generally seen as conducive to an increase in employment in the informal sector (Chart 4.3).

Chart 4.3: Employment in informal economy v. long-term unemployment



Source: Eurostat LFS [une_ltu_a] and Eurobarometer 2013.

Source: European Commission, European Semester Thematic Fiche: Undeclared Work, 2016 - Page 6

Click here to download chart.

Furthermore, analysis of Eurostat data reveals a negative relationship between job vacancy rates and the extent of employment in the informal economy. The use of digital technologies and online platforms could reverse or at least limit this phenomenon by acting as a tool to match job vacancies and labour supply.

Supporting the transition from low-productivity jobs in the informal economy to formal employment will require investment in skills, particularly digital skills. The new European Commission Communication on the Skills Agenda ([67]) sets out a path to designing specific skills programmes that would help the long-term unemployed, students, women and migrants to move from informal low-productivity jobs to formal employment, thus leading to a net increase in productivity levels and a boost for economic growth. The collaborative economy may facilitate the transition to high-productivity jobs by allocating human capital more efficiently and avoiding skills depreciation.

In addition, the collaborative economy has created new opportunities to help tax authorities and taxpayers with their tax obligations. This is, in particular, thanks to the increased traceability allowed by the intermediation of online platforms. It is already an ongoing practice in some Member States to have agreements with platforms for the collection of taxes. For example, in the accommodation sector, platforms facilitate the payment of tourist taxes on behalf of service providers. There are also cases where tax authorities use the traceability allowed by online platforms to collect taxes from the individual providers (COM(2016) 356 final).

2.2.2. Labour Law Challenges

Alongside the opportunities it presents, including more flexible contracts, the collaborative economy may increase some forms of atypical and non-standard work relationships, including 'bogus self-employment'. Labour law will need to find a balance between facilitating new and flexible ways of work, and avoiding illegal practices.

The changing nature of work ([68]) in this new economy is likely to bring certain challenges. Job quality – including job and earnings security and career progress, access to training, health and safety and autonomy over work, work-life and gender balance – can be affected by technology change. Through the transformation of production processes, the standard full-time organisation of work may give way to new, more flexible but less stable forms of work arrangements (e.g. on-call work or economically dependent

([66]) European Commission: European Semester Thematic Fiche: Undeclared Work, 2016. http://ec.europa.eu/europe2020/pdf/themes/2016/undeclared_work_201605.pdf.

([67]) European Commission Communication "A New Skills Agenda for Europe: Working together to strengthen human capital, employability and competitiveness", Brussels, 2016.

([68]) "World Employment and Social Outlook 2015 - the changing nature of jobs": data/analysis on changes in the employment relationship and through global supply chains. http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_368626.pdf.

Box 4.1: 'Humans-as-a-service' (J. Bezos, CEO Amazon.com)

One of the changes brought about by the platform economy is the **transformation of the role of human beings within the employment relationship:** from a form of production that has relied on individuals to produce certain goods or services, to an economic model which gives companies and customers direct access to *'humans-as-a-service' (*Bezos, opening keynote at 2006 MIT Emerging Technologies Conference*)*. This has important consequences for people's working conditions. The fact that most of these platforms are based on dematerialised relations and customers' reviews modifies the concept of work: individual service providers become the extension of a mobile application. The risk is that of dehumanising as service providers may be expected to work as flawlessly as machines.

self-employment), without the same levels of health and safety, income security or access to social protection.

One important question that arises in this context is the legal nature of the work relationship, and how to ensure that labour legislation is in place to protect all types of service providers.

The 'platformisation' of the economy is commonly associated with the growth of self-employment and appears to challenge the use of traditional standard forms of work. Indeed, working arrangements in the platform economy are often based on individual tasks performed on an ad-hoc basis and multiple job-holding. As a consequence, while platforms may help formalise informal work, this may not in all cases be comparable to more standard forms of work, and, from a legal viewpoint, remain unclear in terms of employment status.

The result could be an increase in non-standard forms of employment such as temporary work, part-time work or contractual arrangements involving multiple parties. These may not always be a stepping stone to better and more stable employment and career opportunities; some workers may be trapped in forms of dependent self-employment. On the other hand, non-standard forms of employment may also offer flexibility in working arrangements which may be more tailored to the needs of individuals.

One criterion that could be used to distinguish self-employment from a worker's status is the degree of control exerted by platforms on key terms of the organisation and conditions of work. In other words, how much autonomy and control do the service providers have over the delivery of the services they offer through the platforms ([69])?

The terms and conditions of work which bind service providers to the platforms are sometimes inconsistent with the idea of individuals working as consultants or self-employed. Some platforms used exclusivity clauses to control individuals' labour practice, which is at odds with the idea of independent contractors able to work freely (e.g. 'You will only accept work product from Providers that has been submitted through the Site' (AMT)) *(*De Stefano, 2016).

Research on these labour platforms (Codagnone et al., 2016) also suggests that aside from a few clear-cut cases, the actual nature of the employment relationship is unclear: social protection is lacking and guarantees are minimal in most situations.

The relationship between platforms and individual service providers may in certain cases entail features of an 'employment relationship' rather than the characteristics of self-employment ([70]). According to the 'subordination' criterion, the provider would act under the direction of the collaborative platform if the platform determines the choice of the activity, remuneration and working conditions. Some platforms are beginning to reclassify their service providers as employees (Instacart, Alfred), while others have revised their terms of payment (TaskRabbit) to avoid having their workers defined as employees. In the USA, labour platforms have faced lawsuits over the application of minimum wage legislation and the status of individuals delivering work through the platforms.

([69]) The legal challenges derived from workers' classification will be further explored in the last section.

([70]) Court cases, i.e. against Uber and Lyft, have resulted in settlements therefore no decision has been made so far.

Service providers are moving towards an embryonic self-organisation of their interests, either by creating new trade unions such as Turkopticon and Freelancer Union, or by using existing actors, like the Global Taxi Network (see Chapter 5 on Social Dialogue for a further discussion).

All these trends illustrate the existing grey zone of employment status in the platform economy, and the steps being taken towards its resolution. More broadly, the platform economy has important implications for the definition of the workplace and of working time (e.g. what is the status of on-call/stand-by time? How should 'search for work' time be regarded?) Wage-setting is also affected, as flexible working hours and task-based work mean flexible wages, not to mention auction wages (i.e. consumers bid a price for the service/good).

European and national policies seek to address these issues in order to support the sustainable development of these new models of production and service delivery from a social viewpoint. These discussions are more advanced in some Member States, such as the UK, where a third category, the category of 'platform workers', is being considered.

The European Commission has already provided some guidance on the issue of 'self-employed and workers in the collaborative economy' in its recent Communication on the collaborative economy ([71]). In the light of new production patterns and broader economic and social trends, the Commission acknowledged the need to consider the best way forward with the current EU social *acquis*, the future of work and the coverage of social protection schemes under the European pillar of social rights and the related public consultation ([72]).

These trends raise both familiar and new issues for social policy. These 'pay-as-you-go' occupations present a risk of demutualisation and shift risks, costs and liabilities from platforms/customers to service providers. There are also concerns regarding the application of EU working time and health and safety legislation, and over work-life balance. For example risks related to on-line work, including postural disorders or stress, may not be identified due to the nature of the job ([73]). The performance of providers may also be subject to strong managerial control and unilateral decisions such as a unilateral change of terms and conditions affecting providers' fees.

Platforms are being increasingly used to manage and monitor work, which could raise issues in terms of data protection. There are also risks of "lock-in" effects: since service providers are not allowed to export their reputations from one platform to another, they may have to conform to any requests (reasonable or not) in order to avoid losing work. In addition, service providers may be subjected to abusive termination or 'deactivation' of their work on the online platform.

In summary, while labour market platforms have the potential to improve the matching between labour demand and supply by reducing transaction costs and information asymmetries, they may pose a number of challenges:

- lack of a precise identification of the employment relationship;
- unclear or lacking contractual obligations for both parties (e.g. they do not cover health and safety at work, collective and individual rights under labour law etc); and
- job quality issues such as *de facto* limited workers' autonomy versus platform control, the risk of bogus self-employment in some cases, atypical forms of employment that limit career progress, limited ability to monitor/ensure adequate working conditions (working time and health and safety) and concerns over *de facto* work-life balance.

([71]) 'A European agenda for the collaborative economy', COM(2016)356 final, 09.06.2016.

([72]) 'Launching a consultation on a European Pillar of Social Rights', COM(2016) 127 final, 08.03.2016.

([73]) While this may be a wider concern for all those using a computer, the question is that of whether it is less identifiable or tackled in the platform context.

There is much discussion about these non-standard forms of employment ([74]) and the associated legal implications. Some consider that platforms may lead to the emergence of a new, intermediate category between employees and independent contractors, which would need to be defined in policy and law. Others maintain that moving beyond the well-established concepts of the self-employed and workers would risk creating legal confusion and undermining rights at work and social protection for all in the long run.

3. IS THE EU READY TO BENEFIT FROM THE 4TH INDUSTRIAL REVOLUTION?

This section considers the readiness of EU countries to benefit from ICT development and digitalisation. Both physical infrastructure, such as availability of and access to broadband, and skills infrastructure are essential if EU countries are to benefit from the transformational power of the digital revolution and to reinforce digitalisation's potential gains.

3.1. Framework conditions for the 4th industrial revolution: ICT infrastructure and digital environment

The availability of ICT infrastructure represents an important pre-condition for exploiting opportunities created by ICT development and digitalisation. The digitalisation level of a country depends on both the development of physical infrastructure and the attitude towards its use of enterprises, households and public administrations. In this context, higher demand for digital infrastructure, contents and services can also induce higher supply.

The Digital Single Market (DSM) strategy and Eurostat have developed a number of interesting indicators which measure the availability of physical infrastructure in EU Member States. These indicators provide a measure of Member States' digital competitiveness. The coverage and speed of the broadband are some examples.

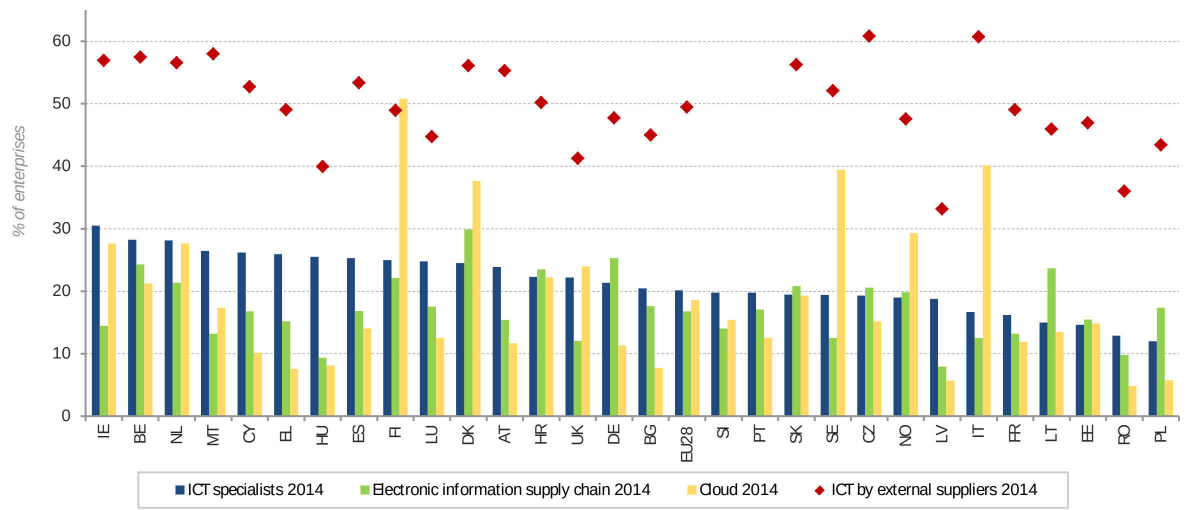
The Commission's strategy on Connectivity for a European Gigabit Society ([75]), adopted in September 2016, sets out a vision of Europe where availability and take-up of very high capacity networks enable the widespread use of products, services and applications in the Digital Single Market. This vision relies on three main strategic objectives for 2025:

- Gigabit connectivity for all main socio-economic drivers,
- uninterrupted 5G coverage for all urban areas and major terrestrial transport paths, and
- access to connectivity offering at least 100 Mbps for all European households.

([74]) See, for example, Eurofound (2015) for a discussion on new form of employment.

([75]) Delivering on its Digital Single Market strategy, the Commission adopted on 14 September 2016 a set of initiatives and legislative proposals to place the EU at the forefront of internet connectivity. https://ec.europa.eu/digital-single-market/en/broadband-europe

Chart 4.4: Enterprises and ICT services



Note: Enterprises with 10 or more persons employed. All manufacturing and service sectors, excluding the financial sector.
Source: Eurostat - Community survey on ICT usage and eCommerce in Enterprises.
Click here to download chart.

Full coverage ([76]) of fixed basic broadband has almost been achieved, with 97.3% of EU households having fixed basic broadband availability. However, not all households with access to broadband make use of it and the rate of usage varies significantly between Member States. Only 71.7% of households in the EU have fixed internet access; the percentage ranges from 94.5% in Luxembourg to 52.6% in Italy.

The picture changes considerably in respect of the availability of fast and superfast broadband (NGA) ([77]). The percentage of households living in areas served by NGA in the EU was 48% in 2011 and reached 70.9% four years later (2015), which is considerable progress. However, country differences are wide. The countries still quite far from this level are Greece (36.3%), Italy (43.8%), France (44.8%), Croatia (52%) and Poland (60.7%).

Chart 4.4 provides information on how ICTs affect the activities of enterprises. It shows the percentages of enterprises which employ ICT specialists ([78]); share electronic information on the supply chain ([79]); buy Cloud computing services ([80]); and outsource ICT functions ([81]). Chart 4.4 shows that in 2014 all countries had significant percentages of enterprises where ICT functions were mainly performed by external suppliers. However, proportions of enterprises buying Cloud computing services varied widely from 5.7% in Latvia to 50.7% in Finland. Similarly, the percentage of enterprises sharing information with the supply chain ranged from 7.9% in Latvia to 25.3% in Ireland.

([76]) Coverage is a supply indicator defined as the percentage of households living in areas served by a certain type of broadband. Standard fixed broadband includes xDSL, cable (basic and NGA), FTTP or WiMax networks. Some studies commissioned by the EC (Point Topic, IHS and Valdani, Vicari & Associati) report that, in 2015, 97.3% of European households had potential access to a standard fixed broadband.

([77]) Next Generation Access includes the following technologies: FTTH, FTTB, Cable Docsis 3.0, VDSL and other superfast broadband (at least 30 Mbps download).

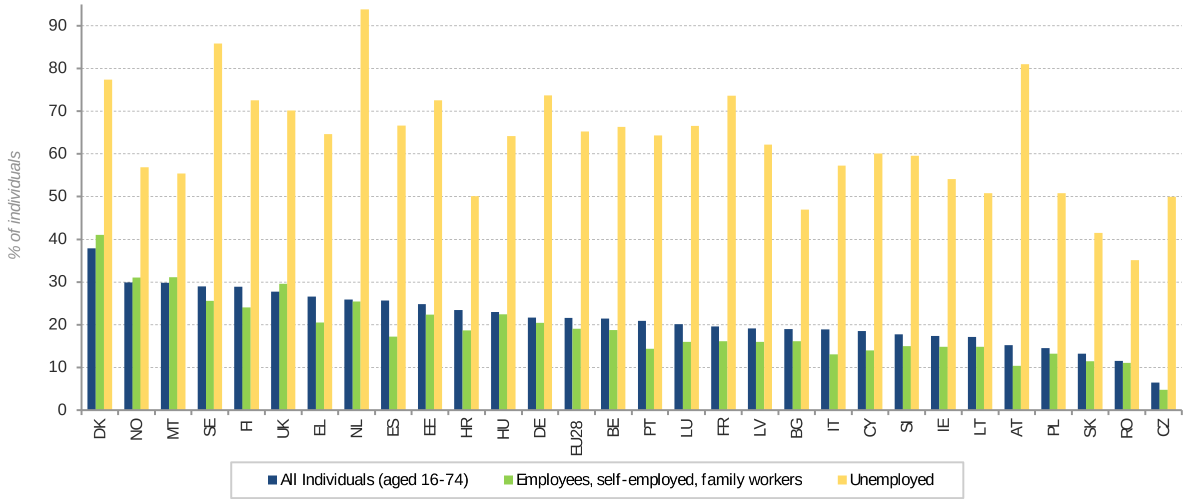
([78]) ICT specialists are employees for whom ICT is the main job: for example, to develop, operate or maintain ICT systems or applications.

([79]) The indicator refers to sending/receiving all types of information on the supply chain (e.g. inventory levels, production plans, forecasts, progress of delivery) via computer networks or via websites, but excluding manually typed e-mail messages.

([80]) Cloud computing and cloud services are services made available to users on demand via the internet from a cloud computing provider's servers as opposed to being provided from a company's own on-premises servers. Cloud services are delivered from servers of service providers, can be easily scaled up or down and can be used on-demand by the user without human interaction with the service provider; they are paid for either per user, by capacity used, or pre-paid.

([81]) The majority of ICT functions, out of a list of seven, are mainly performed by external suppliers and not by own employees or by ICT specialists in parent or affiliate enterprises. The functions include: maintenance of ICT infrastructures, support for office software, development and support for web solutions or business management software/systems (e.g. ERP, CRM, HR, databases), security and data protection.

Chart 4.5: Looking online for a job or sending a job application in 2015 - Percentage of individuals who used Internet in the last 3 months



Source: Eurostat - Community survey on ICT usage in Households and by Individuals
Click here to download chart.

According to Eurostat data ([82]), there has also been an increase in both the share of enterprises selling online ([83]) and electronic sales as a percentage of total turnover. In the EU in 2014, more than 15% of enterprises operated online for about 15% of their total turnover.

From a labour market perspective, one interesting aspect concerns the use of the internet to search for a job or send a job application. Chart 4.5 shows that, on average, unemployed people benefit widely from such an opportunity but that differences between countries exist.

New technologies also allow public administrations to have a direct and more efficient interactions with citizens, reducing administrative burdens and red tape for firms and businesses. Almost 60% of European individuals ([84]) interact online with public authorities.

The Digital Economy and Society Index (DESI) ([85]) - a composite index built by the European Commission using the most recent data available in the Digital Agenda Scoreboard – summarises relevant indicators on Europe's digital performance and highlights the weaknesses and strengths of EU Member States. The index is composed of five domains deemed important in the context of the digital revolution: connectivity, human capital, use of the internet, integration of digital technology and digital public services.

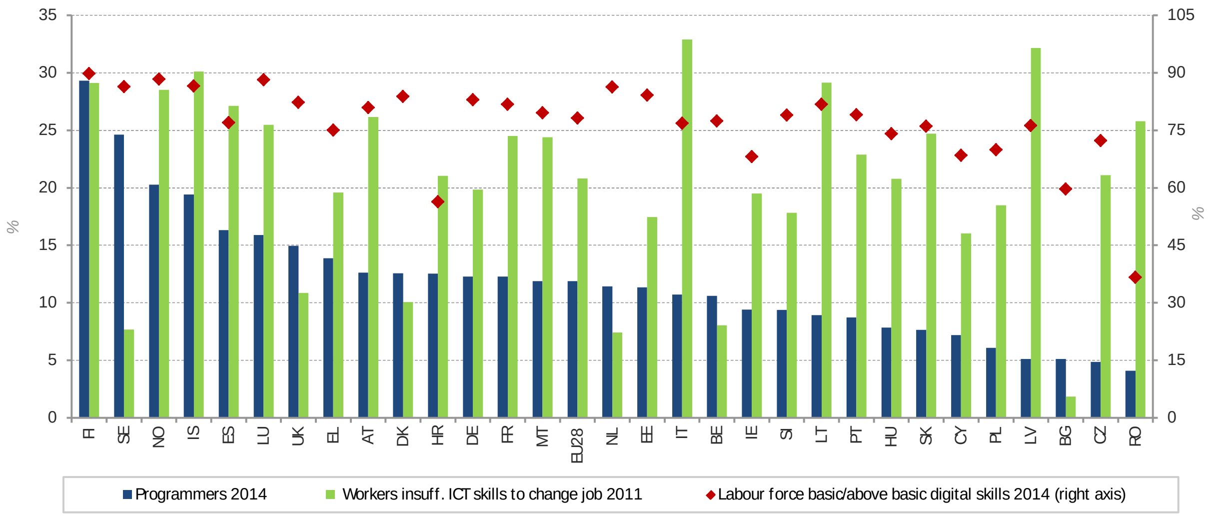
Broadly speaking, all the indicators suggest that, although much progress has been achieved in recent years, some countries lag behind. The data indicates that EU countries can be divided into three groups. The first group, of countries performing above the EU average, includes mainly Nordic countries and Netherlands; the second, of countries below the EU average for almost all the indicators, is composed of Eastern European countries Cyprus, Italy and Greece; and the third group includes (all the other) countries around the EU 28 average. This demonstrates the importance of the continuing implementation of policy initiatives such as the Digital Agenda and the Digital Single Market.

3.2. Skills: are Europeans ready for the new opportunities?

The potential of the knowledge economy and the digital revolution cannot be fully realised without the appropriate human capital. Skills which make it possible to leverage new technologies are in strong demand in the job market. Section 1.3 highlighted the possible implications of digitalisation for routine

([82]) Eurostat, Community survey on ICT usage and eCommerce in Enterprises.
([83]) Enterprises using any computer network for sales (at least 1%).
([84]) Percentage of individuals who used Internet within the last year.
([85]) https://ec.europa.eu/digital-single-market/en/desi

Chart 4.6: ICT skills - Percentage of individuals in the active labour force



Source: Eurostat - Community survey on ICT usage in Households and by Individuals; Pilot work carried out by DG CONNECT/F4 in relation to action 62 of the Digital Agenda to propose "EU-wide indicators of digital competence".

Click here to download chart.

tasks and jobs in medium-skilled medium-paid and low-skilled low-paid occupations. Recent employment and unemployment trends may indicate pervasive mismatches between a) the rapidly changing demand for labour due to ICT-induced innovation in production and consumption and b) the lagged adjustment in the skill composition of the labour supply at individual and institutional level.

Re-skilling and up-skilling are important elements of education and training policies to ensure that individuals are prepared for and can benefit from technology change. In turn, this can provide the fuel for growth and jobs. This is clearly recognised in the Europe 2020 strategy goals and in the European Commission's objectives for growth and jobs. The Europe 2020 strategy states as its objectives: increasing employment by providing the right skills for jobs in demand (including digital skills and increasingly important 'soft skills'); encouraging creativity and entrepreneurship; and encouraging participation in civic life.

The skills necessary to make efficient use of ICT and benefit from the digital revolution include technical ICT-related skills. Those at risk of unemployment or exclusion are usually 'basic' users of ICT, as opposed to 'specialist' or 'advanced' users of ICT. ICT skills can enhance a person's employability profile, particularly when combined with other skills and attributes, and can be a catalyst for learning further skills. However, some ICT skills may also become increasingly routinised and less in demand as ICT gets better – much as driving started as a skilled profession but became a skill that most adults could easily acquire as cars improved and their use became ubiquitous.

This underlines the importance of other, ICT-complementary skills, including context-specific literacy and numeracy skills as well as communication and entrepreneurial skills. All these skills allow individuals to make use of new technologies in genuinely beneficial ways. The fast pace at which new technologies develop leads inevitably to 'shortening life-cycles' of ICT skills, and so continuous learning and up-skilling (CEPIS, 2006) are essential, both for businesses and for the employability of individuals.

Both young workers and older workers may face specific challenges in re-skilling or up-skilling. Although young people are typically seen as 'digital natives', there is little evidence that their ICT skills can be directly translated into employability skills. They may need further support in the form of career guidance and digital skills development. Older people are more likely to lack ICT skills than young people, but they may have other complementary knowledge and experience, which, once they have acquired ICT skills, can be used more strategically. For this group, e-Inclusion training which provides access to ICT and support to engage with it is crucial.

ICT skills by themselves do not guarantee employability at any age; they need to be complemented by other skills, attributes and behaviours. A holistic approach that focuses both on ICT skills and complementary skills is more likely to be successful in finding and maintaining employment.

3.2.1. The distribution and availability of digital skills within the EU population and workforce

According to the New Skills Agenda (European Commission, 2016), in the near future nearly all jobs will require some level of digital skills and some will require very high levels of professional ICT skills. The Commission therefore sees the acquisition of digital skills as vital for employability, jobs, innovation, competitiveness and growth.

Evidence suggests that more than 20% of the EU population have no digital skills and less than 30% have digital skills above the basic level.

Chart 4.6 brings together three Eurostat indicators on ICT skills. For most EU countries, in 2014, the percentage of individuals in the active labour force with basic or above basic digital skills ([86]) was over 75% (right axis); it was very low only in Romania (36.6%). Nordic countries ranked high, in the upper part of the band. Nordic countries also had significant proportions of individuals in the active labour force who were able to write a computer programme using a specialised programming language: 29% in Finland and 25% in Sweden. This compares with the EU average of 11.8%. Conversely, in Finland and Norway – perhaps as a result of the high ICT standards expected there – about 29% of the active labour force judged their current ICT skills to be insufficient to enable them to change job within a year. This perception is stronger only in Italy (33%), Latvia (32%) and Iceland (30%).

According to the New Skills Agenda Factsheet on Digital Skills, 39% of companies report difficulties in finding suitably skilled ICT professionals. It is estimated that by 2020 there will be 756,000 unfilled vacancies for ICT professionals in the EU and 578,000 already in 2017. The Commission proposed a "Skills Guarantee" in the New Skills Agenda for Europe to help low-skilled adults acquire a minimum level of literacy, numeracy and digital skills and progress towards an upper secondary qualification. This has been endorsed by the Council on 21 November 2016 in the Recommendation "Upskilling pathways: New Opportunities for Adults".

The PIAAC (Programme for the International Assessment of Adult Competencies) ([87]), often called the Survey of Adult Skills, can be used to analyse the distribution of digital skills within the EU population. One of the key and innovative features of the OECD Skills Survey is its skill assessment module. After answering the background questionnaire, survey participants are asked to take a test of their competence in three skill domains: literacy, numeracy and problem-solving in Technology Rich Environments (TRE), which is a useful proxy for the e-skill levels of the participants. The interviews for the first survey ([88]) were conducted between the summer of 2011 and the spring of 2012 in 24 countries.

Problem solving in TRE refers to the ability to solve specific problems using modern ICT tools, typically a personal computer and its associated functions. Examples of the type of questions that are asked in this module include searching books in the archive of an electronic library and finding the quickest route between two locations on an online map. In order to take the PIAAC test on competences in TRE, individuals need to have some basic ICT skills. Otherwise they are excluded from the test.

([86]) An individual has basic digital skills if they are able to perform at least one 'basic' activity in each of the four main domains defined by the Digital Competence Framework.

([87]) PIAAC is a broad research and policy programme managed by the OECD in collaboration with the governments of the participating countries and a number of other international organisations. Sampled individuals complete a very detailed, but otherwise relatively standard, background questionnaire collecting information on family composition, employment, incomes and, interestingly, a battery of questions on the use of skills at work. The survey uses nationally representative samples for the adult population aged 16 to 65 in each participating country. The samples are constructed according to harmonised guidelines designed to guarantee the comparability of data across national boundaries. OECD (2013) provides a wealth of detail on the structure of the test.

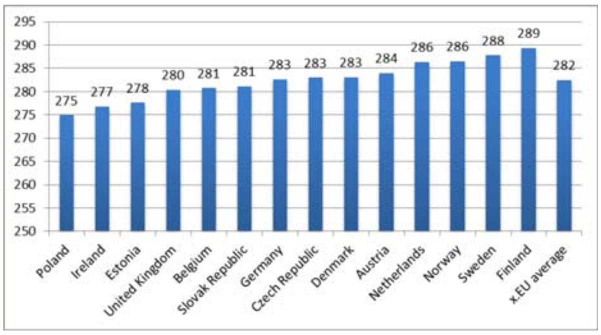
([88]) OECD is finalising the report on the second survey, but at the time of writing the data are not yet publicly available.

The PIAAC data show a clear generational gap: 54.3% of those who did not have prior computer experience were in the age group 55-65 and only 1.5% in the age group 16-24. The data also suggest an education divide. When looking at the surveyed individuals who have no ICT skills, those with low educational attainment (less than upper secondary schooling) made up the biggest group (56%) of individuals with no ICT skills, followed by those who had completed upper secondary and post-secondary non-tertiary education. Only 3.6% of those who had no ICT skills have completed tertiary education. Almost all (92.3%) of those with no computer experience were in elementary or semi-skilled occupations.

Chart 4.7 presents the assessment scores for problem-solving in TRE for the EU countries for which PIAAC provides data. The mean scores range from 275 in Poland to 289 in Finland, with an EU average of 282.

For all countries together only a minority of respondents achieved the highest proficiency level (level 3) of TRE (e-skills). The vast majority were in levels 1 and 2. However, there were large differences across countries, with some countries clearly showing better test results. In particular, Finland, Norway, Sweden, the Netherlands and Austria had above-average test outcomes and larger than average percentages of level 3 test scores. The largest percentages of adults with test outcomes below level 1 were found in Poland (24%), Estonia (19.6%), Belgium (18.8%), Ireland (18.7%) and the UK (18%).

Chart 4.7: Mean problem solving in technology rich environment (PS – TRE)



Source: PIAAC data (OECD), calculations by European Commission, DG Employment, Social Affairs and Inclusion

Click here to download chart.

In answer to the question: "*Do you think you have the computer skills you need to do your job well*?" the data show large cross-country differences. While the EU average for positive answers was 7.54%, country-specific values range from 16.2% in Norway, 11.1% in Finland and 9.9% in Denmark, to only 3.2% in the Czech Republic.

A lack of computer skills may not only affect productivity and efficiency at the workplace, it may also affect the possibility of getting a job, getting a promotion or a pay rise. In answer to the question: "*Has a lack of computer skills affected your chances of being hired for a job or getting a promotion or pay rise?*" 5.4% of EU respondents reported that lack of computer skills had affected their career. The percentage of positive answers to this question was highest in Poland (9.5%) and lowest in the Netherlands (3.6%).

Overall, EU respondents with lower education qualifications were more likely to be affected by their lack of computer skills than those with higher education qualifications. For those with the lowest educational attainment there were wide cross-country differences in the perceived career disadvantages of lack of computer skills - from Cyprus (22.3%) to the Czech Republic (3.2%), with an EU average of 8.76% ([89]).

In this context, the Digital Skills and Jobs Coalition aims to improve ICT skills in the EU ([90]). The new Coalition, launched on 1st December 2016, expands the Grand Coalition for Digital Jobs, which trained over 2 million people over a three year period (2013-2016). It brings together a broader variety of stakeholders, beyond those from the ICT sector, to include ICT-using sectors, training organisations, academia, social partners, Innovation Hubs and, crucially, Member States.

([89]) Pellizzari et al. (2015).

([90]) https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition

In this context, Member States have been called upon to develop national digital skills strategies and to set up national digital skills coalitions with a board set of stakeholders through which to implement them.

The Commission's Digital Competence Framework for Citizens (DigComp) identifies, defines and describes the digital skills needed by all citizens as part of the key competences for lifelong learning (Ferrari, 2013). DigComp version 2.0 has recently been released to update the conceptual reference model, the vocabulary of terms and the competence descriptors to reflect recent changes (Vuorikari et al., 2016) ([91]).

DigComp has already been included in Europass as a self-assessment tool for job-seekers to self-evaluate their digital competence and have it described in their CV. At national and regional level, DigComp is being used as the reference for self-assessment tools for employability (Basque Country and Andalusia in Spain), for the development of strategic policies (Italy, Malta, Navarre in Spain, Poland and the United Kingdom), for the assessment of education and training content and student performance (Estonia, Flanders in Belgium, Region Emilia Romagna in Italy and Slovenia) as well as for teachers' professional development ([92]) (Croatia, Lithuania and Spain) ([93]).

DigComp has also been used to develop the Commission's Digital Skills Indicator to measure citizens' digital competence, showing that 45% of the EU population lack a sufficient level of basic digital skills of which around half of them have none at all.

3.2.2. General skills and adaptability: addressing skills gaps

The knowledge economy and the digital revolution require a labour force that not only has specialised e-skills and competences, but also possesses the skills necessary to ensure complementarity between human capital and technology. New ways of working, increased independent and contract-based work and more frequent job changes (by necessity or opportunity) call for skills that can be transferred by individuals across contexts in daily life, study or work. What level of literacy, numeracy, science and technology (S&T) and entrepreneurship skills do adults and students in the EU possess?

According to OECD's PISA survey, around 20% of 15-year-olds in the EU have low reading and numeracy skills. And according to PIAAC, 20% of adults show low literacy skills while 24% have low numeracy skills.

In some countries (Luxembourg, Cyprus and the Netherlands) the proportion of tertiary graduates in S&T is rather small. However, in Austria, Denmark, Finland, France, Ireland, Portugal, Spain and the UK in 2014, more than one fifth of graduates had been enrolled in S&T courses.

Entrepreneurship skills are also important because the labour market of the future will need more complex skills that can drive/support creativity and innovation. People need the mind-set, skills and knowledge to generate creative ideas, and the entrepreneurial initiative to turn those ideas into action. Yet less than a quarter of students have had an entrepreneurship experience by the time they finish school (Eurydice report, 2016) ([94]). Entrepreneurship in Education is a pillar of the EU Strategic framework – Education & Training 2020 ([95]) and is about inspiring entrepreneurial potential.

For the past ten years the Commission has been promoting the take-up of Key Competences (as described in e.g. the 2006 Key Competences Recommendation ([96])) by supporting a range of initiatives, including the development of reference frameworks for an initial set of key competences.

The Entrepreneurship Competence framework (EntreComp) defines the competences that make citizens entrepreneurial, capable of developing initiatives that create cultural, social or commercial value for

([91]) Vuorikari et al. (2016).

([92]) The Commission is currently working on the definition of a specific digital competence framework for teachers (DigCompTeach) which is expected to be ready by the end of 2016.

([93]) European Commission website, "Being digitally competent – a task for the 21st century citizen", Joint Research Centre.

([94]) The Eurydice network supports and facilitates European cooperation in the field of lifelong learning by providing information on education systems and policies in 38 countries and by producing studies on issues common to European education systems.

([95]) http://ec.europa.eu/education/policy/strategic-framework/index_en.htm.

([96]) http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:c11090 others. EntreComp aims at creating a common understanding of entrepreneurship as a competence and its learning outcomes, and establishing a Europe-wide reference set of knowledge, skills and attitude statements reflecting different level of proficiency. The EntreComp was published last June (Bacigalupo, et al. 2016) and is already being taken up in many contexts. The Ministries of Education of Finland and Greece are translating it, and Finland has decided to use it as part of their forthcoming national evaluation of entrepreneurship education and competence at all stages of education and schooling. The Portuguese Ministry of Education is also revising the framework in the light of their development of a national framework. Beyond the EU, Ukraine, supported by the ETF, has embarked on a pilot adaptation of the EntreComp. The Ministry of Employment and Vocational Education of Madagascar, with the technical support of UNIDO, is also adapting the framework to fit the needs of their Vocational Education and Training curricula ([97]).

Work is also ongoing within the 2020 Education and Training Strategic Framework for European cooperation on education and training (ET 2020) to modernise education systems and promote digital skills and competences for teachers and learners. A dedicated ET 2020 working group on digital skills and competences brings together representatives from ministries of education and education stakeholders to share experience and best practice.

Skills mismatch and skill shortages appear to be present in the labour market – even if at a lower level than often believed ([98]) - and guaranteeing high employment rates and decent wages has become more challenging with the development of the digital revolution. There is a risk of a drop in demand for routine workers and of resulting job displacements. A coordinated policy response to these challenges is therefore necessary. While forecasts of skill needs (such as those provided by Cedefop) are very important, especially in the short-medium run, long-run estimates of the future demand for skills/occupations tend to be less accurate, especially at the level of occupational profiles.

4. CONCLUSIONS

Previous industrial revolutions have created profound structural changes in the organisation of our societies. In the same way, the velocity, scope, and impact of the technological innovations at the heart of the fourth industrial revolution have the potential to cause a major transformation of the current social and economic systems governing our lives. The transformative power of key technological breakthroughs such as artificial intelligence, robotics, Cloud computing, 3D printing, digital platforms, and algorithms (described in more detail in the Annex, Box A1.1) may well demonstrate that we have entered a new path of development in human history.

Economic theory identifies two main effects of technological change on employment at firm level: the effect of substituting capital for labour (the substitution effect) and the employment-generating effect (the compensation effect). Through the compensation effect, technological progress can and has led to job creation through product innovation and the commercialisation of new products and demand for new equipment.

While new jobs are likely to be created, the composition of employment may nevertheless change. Process and organisational innovation typically alter the skill composition of labour demand, and in the case of ICT and digitalisation this is likely to favour the highly skilled, with potential consequences for skill mismatch, unemployment and ultimately growth. The evidence suggests that ICTs can have a positive impact on labour productivity. The effect of ICT development on employment appears to be neutral if not positive – though this does not necessarily mean that there are no effects on the composition of employment, or on particular sectors and occupations. The evidence also shows the complementarity between ICT, organisational capital and human capital.

Therefore, digitalisation of the economy and the possible disruption of jobs should prompt a rethinking of education policy. To maximise the benefits of digitalisation and to create new entrepreneurial

([97]) Bacigalupo et al. (2016).

([98]) Pellizzari et al. (2015).

opportunities it is fundamental to invest in raising the analytical and creative abilities of the workforce. Flexibility and adaptability to new forms of work will require individuals with skills transferable to different sectors. Job polarisation, which seems to be arising as a consequence of technological innovation, means that more jobs will be created at the bottom and top end of the workforce while employment for middle-earners in the labour market will decrease. For example, workers providing in-person service may not see their jobs change; workers in routine jobs such as accountants may see machines replacing them; and highly skilled workers such as surgeons may expect to see their productivity increased.

The availability of ICT infrastructure is also an essential pre-condition for exploiting the full potential of the digital economy. But, although much progress has been made in recent years, some aspects of infrastructure coverage and use have not developed at a uniform rate in all EU countries. It is vital for European companies to recognise the potential of ICT development and digitalisation. This underlines the importance of implementing existing policy initiatives such as the Digital Single Market.

This chapter has also investigated the link between the development of new technologies and the rise of a new economic phenomenon, the collaborative economy. The available data shows that this phenomenon represents a non-negligible proportion of employment in some EU countries. The collaborative economy represents a new form of production of goods and services at both the global and local level. It has grown in importance thanks to technological innovations such as smartphones, new types of algorithms, and powerful broadband connections. Important components of this new economy are platforms, which function as online marketplaces that facilitate transactions in a wide range of services.

While concerns about the quality of work and social protection of individuals employed in this economy remain, online platforms have the undeniable advantage of functioning as a multiplier for job opportunities. For instance, online platforms can match people and jobs which might or might not be found in local labour markets; they can create new marketplaces where people can access services or provide work without the high costs sometimes found in traditional economic sectors; they may also help traditional firms hiring and managing talent; they can increase the share of formal employment by diverting workers from employment in the informal sector; and they can reveal trends in the demand for skills, which in turn can help to shape decisions about new education and training curricula.

At the same time, while taking steps to encourage economic growth, governments around Europe may need to take steps to minimise the adverse consequences that the digital revolution may bring, for example as regards working rights, access to social protection and protection of personal data. In this context and in various forums and actions ([99]), including the ongoing consultation on a European Pillar of Social Rights ([100]), the European Commission is exploring with Member States and different stakeholders the opportunities and the risks associated with technology change, the future of work and the potential need to adjust regulation to a phenomenon that, by its very nature, transcends national boundaries.

In future, the features that characterise employment relationships and business activities may be different from today's, reshaping the way in which policy-makers and researchers approach employment issues. In this context, it seems worthwhile to make more use of social dialogue, perhaps in additional forms, as a means of discussing and resolving social and economic issues related to the emergence of new jobs.

It will be crucial to identify good practices that ensure a friendly environment for start-ups to develop their business using new technologies, and for companies who invest substantially in innovation in order to create new services and products. These companies can give Europe a competitive advantage relative to other industrialised economies, therefore they should be helped to prosper. At the same time, it will be important to identify practices that can ensure fair and well-functioning labour markets and welfare systems. As the European Pillar of Social Rights consultation asks: Which best practices and lessons from social innovation should be actively encouraged?

([99]) "Recommendation No. 204 concerning the Transition from the Informal to the Formal Economy": labour standard adopted in 2014 http://www.ilo.org/ilc/ILCSessions/104/texts-adopted/WCMS_377774/lang--en/index.htm.

([100]) http://ec.europa.eu/priorities/deeper-and-fairer-economic-and-monetary-union/towards-european-pillar-social-rights/public_en.

Relevant data needs to be drastically improved. Currently there are no direct employment measures of occupations in the collaborative economy, so that it is necessary to rely on indirect or proxy measures. An important problem for European statistics is the lack of a clear picture of how many service providers are freelancing; whether service providers are voluntarily or involuntarily pushed into atypical working arrangements; and whether this activity is their main source of income or an extra economic activity to top up their salaries from other occupations. It has been difficult to assess these issues because of the wide variety of working arrangements. These include incorporated freelancers and other self-employed people without employees; independent contractors; full-time employees who also do undeclared work; and others who participate in digital platforms but do not consider this as a proper job, and thus do not mention or admit to it when surveyed.

Designing appropriate measures to capture the employment expansion encompassing the different economic activities originating from the digital revolution is one of the important challenges that statistical agencies, both at the national and European level, need to address. To harness the full potential of the technological revolution it is crucial to have access to robust statistics, including on the type of employment and on earnings. Data would then support the design of policy programmes aimed at supporting social inclusion and economic growth in this new era of digital revolution.

More research is needed and should be encouraged, to improve understanding of how the nature of work and jobs is changing and whether the digital economy in general - and the collaborative economy in particular - will produce a new workforce predominantly of genuine high-income independent mini-entrepreneurs free from the "9-to-5 grind", or a new class of service providers mainly dependent self-employed in low-wage, insecure occupations, with limited access to social protection. Universal social insurance/protection would make issues relating to (bogus) self-employment less critical.

Devising and applying effective strategies to transform the opportunity presented by the 4th industrial revolution into long-lasting economic growth will be one of the challenges that will define the future of the EU.

ANNEX: ICT AS A KEY DRIVER

A.1. Are ICTs triggering a fourth industrial revolution?

There is much debate among academics about whether societies are currently undergoing a fourth industrial revolution. An industrial revolution has been described as involving "not simply an acceleration of economic growth, but an acceleration of growth because of, and through, economic and social transformation" (Hobsbawm, 1999). As Table A1.1 shows, the first industrial revolution (1784-1830) was caused by the steam engine, which was the basis of the development of cotton spinning, railroads and intense maritime transportation. The second industrial revolution (1870-1970) originated with two major technological breakthroughs: electricity and the internal combustion engine, and the advent of running water with indoor plumbing. The third industrial revolution (1970-today) saw the development of electronics, IT and automated production.

Many commentators argue that the current scope and speed of digitalisation is evidence of a fourth industrial revolution taking place, associated with the mass diffusion of ICTs (a General Purpose Technology, just as the railway, electricity, the steam engine and the internal combustion engine were), with the potential to transform society's entire system of production, management and governance.

The fourth industrial revolution is driven by a complex array of technologies, some of which have not yet reached their full capacity. Examples of these technologies are: smart machines, advanced computer processing, artificial intelligence and networked communication.

Box A1.1 describes these and other key technological breakthroughs, which are digitalising many aspects of people's economic and social life, changing the world of work and generating significant growth in the global economy. They are creating opportunities for new jobs and new business, but also challenging some current tasks and jobs.

ICT development and digitalisation are generating an economic transformation that is affecting all industries on a scale comparable to the steam engine during that first industrial revolution. Almost every aspect of daily life is being influenced in some way by digitalisation, and some argue that the pace of change is faster than ever before.

Digitalisation has already caused important changes in the world of work. Industry 4.0 (Schwab, 2016) and the robotisation of manufacturing are some examples. Alongside the effects on labour productivity and employment, traditional models of value creation are also being challenged by new business strategies and new technologies. ICT development has already contributed to increasing access to new markets and, therefore, facilitating/encouraging the starting up of new businesses. Nowadays, a firm that provides a digital application to the Apple app store gains worldwide access to over 500 million app store account holders (The World Bank, 2013).

Digitalisation, smart machines and advanced computer processing can transform the world of work by making many work-related (but also private) activities 'mobile', with all the attendant risks and opportunities. They can generate new business opportunities and make 'offering anything as a service' (Renda, 2016; Claffy and Clark, 2013) a reality, as evidenced by the range of services that are already being traded on line via platforms. ICT-based innovations (such as internet shopping) can change consumption patterns and consumer behaviour and therefore the scale and nature of the demand for goods and services.

Furthermore, in the field of advanced manufacturing, the merging of digital technology, the internet and conventional industry are estimated to provide efficiency gains in manufacturing of between 6% and 8% (ACATECH, 2015). In Germany alone it is predicted that the 'fourth industrial revolution' will bring 390,000 more jobs and contribute 1% per year to GDP growth over a ten-year period (BCG, 2015).

The automation of processes and robotisation is expected to increase flexibility in production: different products will be produced in the same facility, with a net gain in terms of cost reduction and decreasing

Table A1.1: The path to the fourth industrial revolution

Revolution	Time periods	Key Technologies
First	1784 – mid 19th century	Water and steam powered mechanical manufacturing
Second	Late 19th century – 1970s	Electric-powered mass production based on the division of labour
Third	1970s-Today	Electronics and information technology drives new levels of automation of complex tasks
Fourth	Today –	Presence of high-speed ubiquitous Internet, increased functionality and capacity of the network, leading to the "The Internet of Everything"; Availability of Big Data(1) and of the technology capable of analysing them; Open Cloud and Cloud computing; Developments in Artificial Intelligence, robots, and machine learning (e.g. the Watson Computer, the driverless car); Additive manufacturing and 3D printing; Advances in simulation methods; Advances in systems integration; Blockchain.

(1) A term for data sets that are so large or complex that traditional data processing applications are inadequate.

Source: created by European Commission, DG Employment, Social Affairs and Inclusion

Click here to download table.

need for production outsourcing. At the same time, the speed at which products and services can be improved is expected to create 'mass customisation', increasing firms' ability to adapt to customer-supplied specifications and drastically reducing the time between the design of a product and its delivery, or, in the case of digital platforms, between the demand for a service and the opportunity to access it (Davies, 2015).

In manufacturing, data-driven supply chains can more than double the speed of production processes in terms of time needed to deliver orders, and reduce by 70% the time needed to get products to market (European Commission, 2015).

In a time of slow economic growth, ICTs offer an important opportunity for industries and companies to innovate and create new jobs. ICTs' penetration of our daily lives is a reality. For instance, mobile phone subscriptions (7.4 billion in 2015) approach global population figures: 69% of the world population is using at least a 3G mobile broadband network (ITU, 2015). In this environment, the competitiveness of economies increasingly depends on their ability to leverage new technologies (The World Economic Forum, 2013).

European countries have accepted the opportunities and challenges brought about by ICT development and digitalisation and have taken important policy initiatives as highlighted for example in the EU Digital Agenda for Europe (101). In Italy the 'Fabbrica del Futuro' project (2011-13) has supported research initiatives to generate the knowledge needed to support the creation of new industry and smart production processes.

Germany has launched the 'Industrie 4.0' initiative to develop smarter factories, putting together best practices from both private and public experiences. The aim is to create a strategic plan to best apply digital technologies to business. France launched in 2015 the 'Factory of the Future' programme as part of a larger framework programme called 'Industry of the Future'. The intention is to help small and medium enterprises to get loans to invest in new technologies such as robotics, big data, and high performance computing. The UK has created 'catapult centres' which aim to facilitate companies' access to research and expertise in specialised areas such as advanced manufacturing and process innovation.

A.2. Is ICT accelerating the rate of change? The importance of ICT in the EU economy

It is generally agreed that ICT development and digitalisation have improved productivity and economic growth. For example, the majority of researchers agree on the important role played by ICT in the US growth resurgence observed from 1995 to 2006 (102). The Digital Single Market initiative for example aims to induce productivity and economic growth through the diffusion and adoption of ICT in the EU (103).

(101) See https://ec.europa.eu/digital-single-market/en/digital-agenda-europe-key-publications.

(102) Jorgenson et al. (2008) estimate that the proportion of US growth performance attributable to ICT goes from 43% for the period 1971-1995 to 59% for the period 1995-2000, with an almost doubling of the contribution from increased investment in ICT capital (ICT capital deepening) and a more than twofold increase in Total Factor Productivity (TFP), both inside and outside

This section looks at the importance of ICT and ICT investment in the economy. Current adoption and usage rates show that almost all businesses in the OECD area rely on ICT – in 2014, 95% of all enterprises in the OECD area with more than ten employees had a broadband connection. However, web presence in SMEs ranges from 90% and above in Denmark, Finland and Switzerland to less than 50% in Latvia and Portugal. This shows a significant divide in ICT uptake between different EU countries.

Moreover, firms in Europe have a relatively low adoption rate for supply chain management or enterprise resource planning (ERP) software ([104]) even where European companies are highly integrated in supply chains, both upstream and downstream ([105]). Such software, intended to manage business information flows, is often associated with improvements in firms' productivity. In 2014, 31% of European companies used ERP applications. There are noticeable differences in adoption rates between countries (Belgium, Austria, Sweden and Denmark leading, Latvia, Iceland and the UK lagging behind) and between firms of different sizes (a larger proportion of bigger companies use ERP).

The value of the ICT sector ([106]) in the EU, measured in terms of value added (VA), appears to be closely linked to the size of the economy (Figure A1.1) ([107]). The largest EU economies, i.e. those with the highest shares of EU GDP, also have the highest shares of ICT value added in the EU: Germany (19.7%), the UK (17.6%), France (15.2%), Italy (9.4%) and Spain (6.5%). Together, these five countries represented 68.5% of EU ICT value added in 2013.

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the ICT producing sector. For the post-2000 period, the authors find that the contribution of ICT investment to growth has been reduced and that TFP growth in the ICT producing sector has gone down (from 0.58 for the 1995-2000 period to 0.38 for the 2000-2006 period). On the other hand, the role of TFP outside the ICT producing sector (and hence in ICT-using sectors) has increased. Overall, in the period 2000-2006, ICTs are estimated to account for about 38% of the US output growth.

([103]) See https://ec.europa.eu/priorities/digital-single-market_en.

([104]) Enterprise resource planning is a process to manage and integrate the important parts of the business in a company by connecting different technologies used by each individual part in order to eliminate duplicate and incompatible technology, reducing costs and increasing efficiency.

([105]) See ILO (2016), page 14 at http://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_468097.pdf.

([106]) PREDICT project (https://ec.europa.eu/jrc/en/predict) provides comparable ICT sector data adopting the OECD 2007 classification of the ICT sector. It consists of five ICT manufacturing sectors (ISIC Rev. 4 classification), two ICT trade sectors and five ICT services sectors.

([107]) Figures elaborated by Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) are taken from last PREDICT report (De Panizza, forthcoming).

Box A1.1: Key technological breakthroughs

Artificial intelligence has been defined as 'the construction of intelligent agents - systems that perceive and act in some environment'. Recently artificial intelligence has developed a technique called 'deep learning'. With deep learning, artificial neural networks learn - through examples supplied by a vast database - to improve their performance of a specific, mainly cognitive task. The expansion of artificial intelligence has the potential to influence virtually all sectors of the economy using computers. Artificial intelligence is used by the Google search engine to find the most relevant reference for particular queries, by Amazon to provide shopping recommendations, and by Google and Tesla to develop self-driving cars. With its expansion, it will be important to improve the robustness of these systems, optimise their impact on the economy, adapt relevant regulation and address ethical considerations.

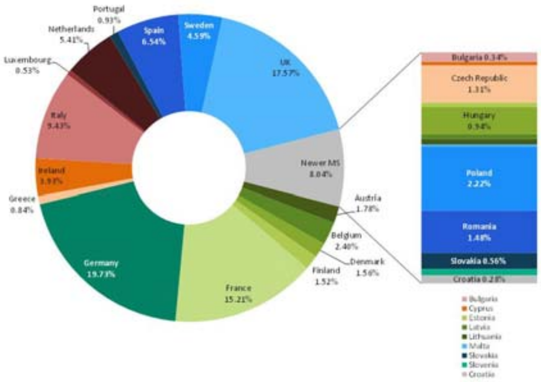
The use of **robots** in the manufacturing sector is not new. However, the number of robots used in workplaces and homes continues to increase, as does their physical dexterity and ability to learn. Recent technological breakthroughs – for example, increased computing power and cheaper sensors – have allowed more versatile and collaborative robots to be developed. Most professional service robots are collaborative by design. Offices, homes, laboratories, warehouses, farms, distribution centres and healthcare facilities all make some use of service robots. Collaboration between robots and humans has the potential to improve labour productivity on challenging tasks. In a human-machine study conducted at BMW, it was demonstrated that hybrid teams of humans and robots can be more productive than teams of either humans or robots alone.

3D printing - also known as additive manufacturing in its industrial version – produces items of different shapes on the spot. Like traditional printers applying ink on paper, 3D printers build objects based on the data delivered to the 3D printer. But whereas traditional manufacturing uses a subtractive approach - grinding, forging, welding – a 3D printer is additive; it produces an object in a single act, building it up layer by layer. This reduces the amount of waste, thereby lowering the cost of the manufacturing process and reducing the environmental impact of production. There are numerous possibilities for this technology in, for example, prototyping or in the healthcare industry (building prosthetic devices, creating organs, tissues and bones for transplantation).

Digital platforms connect providers with users and facilitate transactions between them using the internet. They have contributed to the globalisation of labour markets, a phenomenon that gained importance in the 1980s when large multinationals started to outsource and offshore whole chunks of activities such as IT services or call centres to countries offering comparatively cheap labour costs. While SMEs and smaller companies could not afford such outsourcing and offshoring solutions, platforms now fill this gap, allowing even very small companies to outsource work.

Blockchain - the technology underpinning the digital currency Bitcoin - is a technology that permanently records transactions in a way that cannot be erased later but can only be sequentially updated, in essence keeping a never-ending historical trail. The technology creates and maintains a global database open to anyone, where everything with a value can be managed and stored securely and privately. It is like a digital ledger of transactions, agreements, contracts - anything that needs to be independently recorded and verified as having happened. However this ledger is not stored in one place, but distributed across thousands of computers around the world. Blockchain can potentially change the way transactions are made, data is stored and assets are moved. It could replace powerful intermediaries like banks, governments and technology companies, by building mass peer-to-peer systems of collaboration and clever code. Several concerns would need to be addressed for blockchains to deliver fully on their potential. Among these concerns are large energy consumption, high initial capital costs, regulatory uncertainty, security and privacy.

Figure A1.1: ICT sector measured in value added and its distribution in Europe – Year 2013



Source: JRC-IPTS calculations and estimations based on EUROSTAT data, PREDICT project

Click here to download figure.

According to Chart A1.1, in 2013, the ICT sector's value added as a share of GDP ranged from 12.7% for Ireland to about 3% or less for Lithuania and Greece. Some of the Member States that acceded in 2004 have ratios of ICT value added to GDP that are above the EU average, while the ratio is below the EU average for 9 out of the 15 Member States that joined before 2004. Romania was the Member State with the highest increase in ICT value added as a share of GDP.

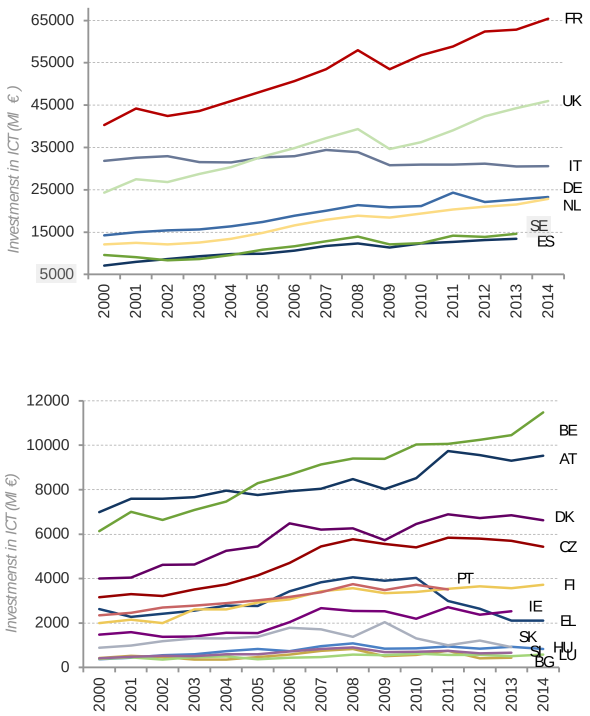
The increasing importance of ICT development is attested by growing ICT investment. In recent times when overall investment contracted, ICT investment grew, or remained steady, in many countries.

Chart A1.2 shows gross investment in ICT since 2000 in millions of euro. Investment in ICT is calculated as the flow in three different types of fixed assets: computer hardware, computer software and databases and telecommunications equipment. Steady growth can be observed for almost all the countries, notably France, UK and Belgium. The trend only turned negative in Greece and Hungary (there is some evidence of a negative trend also for the Czech Republic and Denmark).

The rising trend remains visible for most Member States when considering ICT investment as a proportion of total investment. In 2013, this reached 17.8% in Netherlands and 16.7% in Sweden, but was only just over 4% in Hungary.

Chart A1.3 shows the share of ICT investment in 2000, indicated on the horizontal axis, and the share of ICT investment in 2013 [108] on the vertical axis.

Chart A1.2: ICT investment by Member State and by year

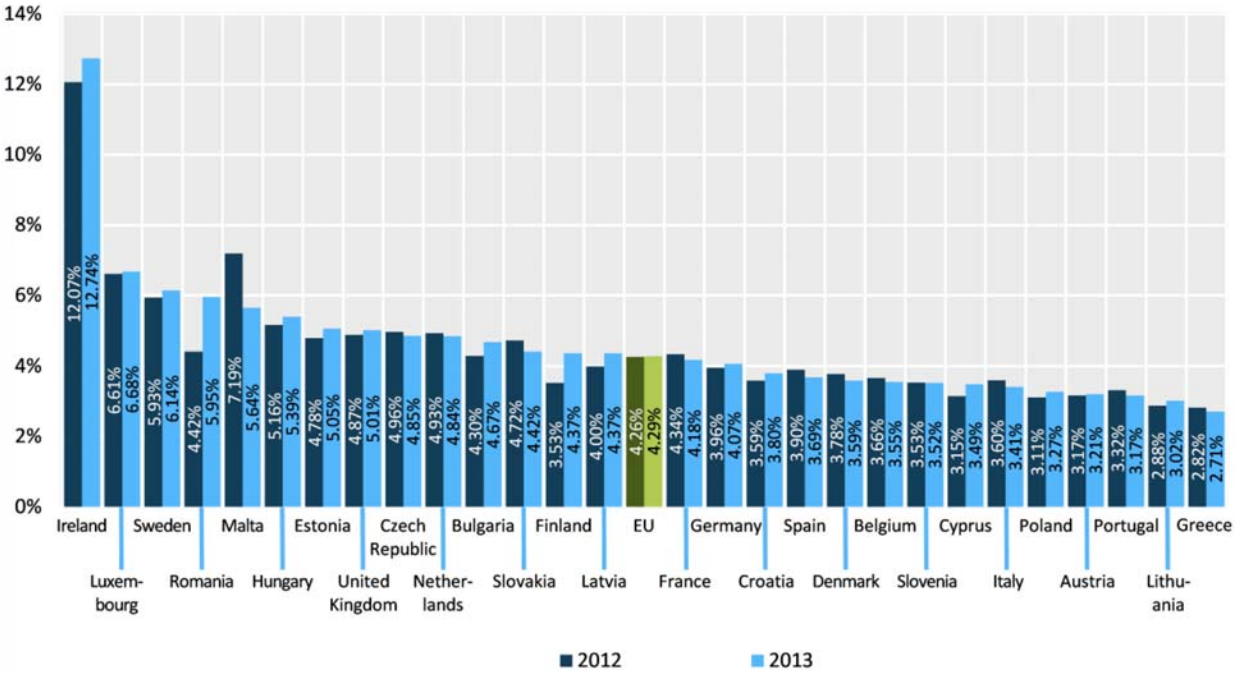


Source: Eurostat, elaborated by European Commission, DG Employment, Social Affairs and Inclusion

Click here to download chart.

([108]) Year 2013 is chosen for the comparison due to the poor availability of data for 2014.

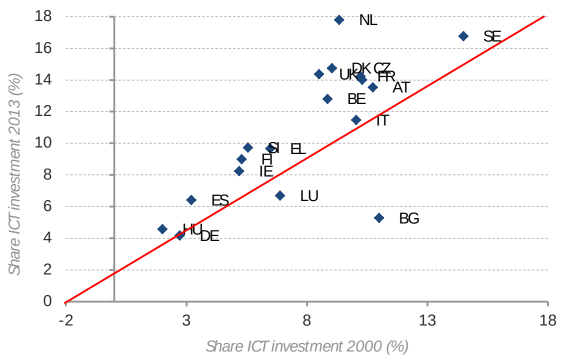
Chart A1.1: ICT sector (VA) as share of GDP by Member State (2012, 2013)



Source: JRC-IPTS calculations and estimates, based on EUROSTAT data, PREDICT project.
Click here to download chart.

Countries above the diagonal line show an increase; those below it (Luxembourg and especially Bulgaria) show a decrease. It can be seen that for nearly all the EU countries for which data are available the proportion of ICT investment has increased.

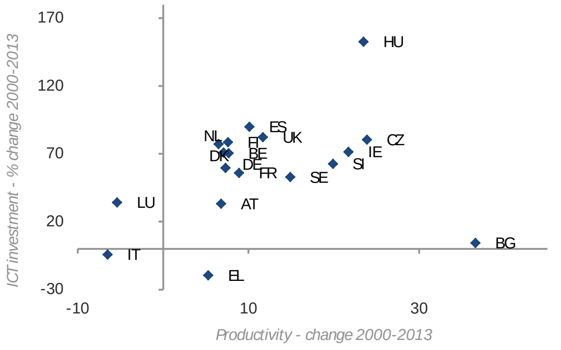
Chart A1.3: ICT investments as a proportion of total investment in 2000 and 2013



Source: Eurostat, elaborated by European Commission, DG Employment, Social Affairs and Inclusion
Click here to download chart.

Chart A1.4 plots the change in productivity between 2000 and 2013 against the change in ICT investment during the same period. The correlation between these two variables is positive (Bulgaria appears to be an outlier).

Chart A1.4: ICT investment and productivity – Changes 2000-2013



Source: Eurostat, elaborated by European Commission, DG Employment, Social Affairs and Inclusion

Click here to download chart.

The ICT sector shows higher labour productivity than other sectors: 69.1% higher than overall productivity (Predict project). From 2007 to 2013 labour productivity growth in the ICT sector was always higher than that for the total economy. In addition, labour productivity is 26.6% higher in the ICT services sector than in ICT manufacturing, also presenting a less cyclical pattern. Since 2009, ICT services productivity has always shown growth, though growth rates declined from 3.9% in 2010 to 1.2% in 2013. ICT manufacturing productivity fell sharply in 2012 (-9.3%), but returned to growth in 2013 (10.3%).

A.3. Micro review of the impact of ICT on productivity

Productivity evidence at company level shows that companies in the USA outperform European companies in terms of productivity. There are at least three reasons for this EU-US labour productivity gap (Biagi, 2013):

- the USA has a higher productivity growth rate in the ICT sector, thanks to improvements in technological equipment improvements;
- investment in ICT capital (i.e. ICT capital deepening) has been higher in the USA than in the EU;
- total factor productivity (TFP) in the service sector has been growing faster in the USA than in the EU (except for the Netherlands and the UK).

ICT investment has been crucial in helping a variety of European companies to increase their chances of survival in the global economy. ICT's substantial positive effect on productivity and efficiency at the company level has been demonstrated in a number of studies. For example:

Van Reenen et al. (2010), studying firms in 13 European countries in 1998-2008, found that a 10% increase in ICT capital is associated with an increase in output of between 0.9% and 0.23%, confirming the importance of ICT for growth.

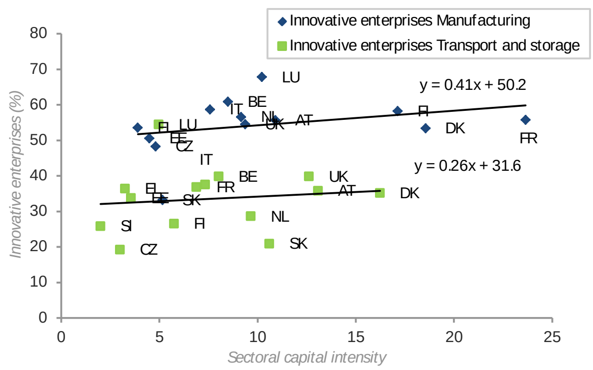
- Broersma et al. (2003) found that computers contributed positively to productivity (real output), even after accounting for firm-specific factors such as labour quality.
- Doms et al. (2004) found evidence of a significant relationship between ICT investment intensity and sales per employee for large firms.
- Mendelson and Pillai (1999) and Biagi (2013), using data on the computer and electronic industry, found a positive relationship between digitalisation and business success (as measured by profitability and growth).
- Brynjolfsson (2003) and Bloom et al. (2012) suggested that ICT investment has a greater positive effect on productivity when coupled with investment in complementary assets, such as organisational and human capital.

ICT has also been found to foster innovation in several sectors. In both the manufacturing and transport and storage sectors ([109]), there is a positive correlation between ICT capital intensity ([110]) and the percentage of innovative enterprises ([111]) (Chart A1.5).

Other studies have suggested, however, that:

- ICT investment alone has a positive but low impact on productivity;
- the impact of ICT investment becomes large and positive only when it is coupled with organisational change (which itself may also have a small positive impact);
- due to the complementarity between ICT investment and organisational change, some lag is to be expected between the time of the investment in ICT and the time the positive impact on productivity is observed, due to the organisational change that a firm has to go through if it wants to reap the full benefit of ICT investment;
- the distribution of skills among the workforce and the level of human capital are also important in determining the impact of ICT investment and organisational change; and
- not all firms can benefit in the same way from ICT investment since not all firms can implement organisational change successfully.

Chart A1.5: ICT intensity and innovative enterprises in 2012 - Manufacturing and Transport and storage



Source: Eurostat-CIS2012, elaborated by European Commission, DG Employment, Social Affairs and Inclusion

Click here to download chart.

([109]) These charts use available cross-sectional data at country level for year 2012.

([110]) ICT capital intensity is measured, at sectoral level, as fixed stock in ICT divided by number of employees.

([111]) Firm level data provided by Eurostat - Community Innovation Survey 2012 (CIS2012). Innovative enterprises include enterprises with abandoned, suspended or ongoing innovation activities. CIS2012 considers four different types of innovations: product, process, organisational and marketing.