European Parliament

The impact of new technologies on the labour market and the social economy

STUDY

Science and Technology Options Assessment

EPRS | European Parliamentary Research Service
Scientific Foresight Unit (STOA)
PE 614.539

The impact of new technologies on the labour market and the social economy

Study

IP/G/STOA/FWC/2013-001/LOT 8/C1

March 2018

Abstract

This study investigates the relationship between innovation, new technologies, employment and inequality. Today, there is an intense discussion on these topics, in particular on the employment effects of new information and communication technologies.

Based on the existing literature and experience from previous technological revolutions, the study strikes an optimistic note about the future. It argues that innovation is labour-friendly: it destroys, but also creates employment. In previous times, the race between job creation through product innovation and job destruction through process innovation has been won by the job-creating effects of innovation.

As a result, the author does not expect that digitalisation will lead to mass unemployment. However, in his view, the costs of digitalisation are unevenly distributed due to the skill-biased nature of technological change. Low-skilled workers, who face a higher risk of job displacement, are therefore particularly likely to bear much larger costs than others. Another group at risk are those whose occupations involve a high share of routine tasks, which is particularly the case in the service industries. The study concludes that the challenge of the future lies in coping with rising inequality as a result of technological change.

PE 614.539

The STOA project 'The impact of new technologies on the labour market and the social economy' was requested by the European Parliament's Science and Technology Options Assessment (STOA) Panel. It was carried out by the Austrian Institute of Technology (AIT) and managed by the Scientific Foresight Unit (STOA) within the Directorate-General for Parliamentary Research Services (DG EPRS) of the European Parliament.

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LINGUISTIC VERSION

Original: EN

ABOUT THE PUBLISHER

To contact STOA or to subscribe to its newsletter please write to: STOA@ep.europa.eu
This document is available at: http://www.europarl.europa.eu/stoa/

Manuscript completed in February 2018

DISCLAIMER

PE 614.539
ISBN 978-92-846-2586-4
doi: 10.2861/68448
QA-02-18-074-EN-N

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Executive Summary

The relationship between new technologies, employment and inequality has gained a lot of attention in recent years. One reason for this interest is alarming reports about possible negative consequences for employment from the widespread use of new information and communication technologies (ICTs), including machine learning, digitalisation of production, robotics and automated vehicles. (Frey and Osborne 2013, 2017, Brynjolfsson and McAfee 2014, Ford 2015).

Innovation and employment

The pessimistic view on the impacts of new technologies is the starting point for a short review of the literature on employment and innovation, analysing the successful creation and commercialisation of new products and processes. On examining the existing literature, we can be optimistic about the future: in the past, innovations were mainly labour-friendly; the literature regards innovation and technology as the main drivers of economic growth and new employment, at least in the long run. A number of scientific contributions show that innovation destroys, but also creates employment. The race between job creation through new products and job destruction from new process technologies has in the past been won by the job-creating effects of innovation. There is no guarantee for a happy end this time; however, an important lesson from the past is that we tend to under-estimate the job-creating potential of fundamental technological transformations, because we lack sufficient knowledge and imagination about the types of jobs that will be created under the new technological paradigm.

New technologies and the demand for skills

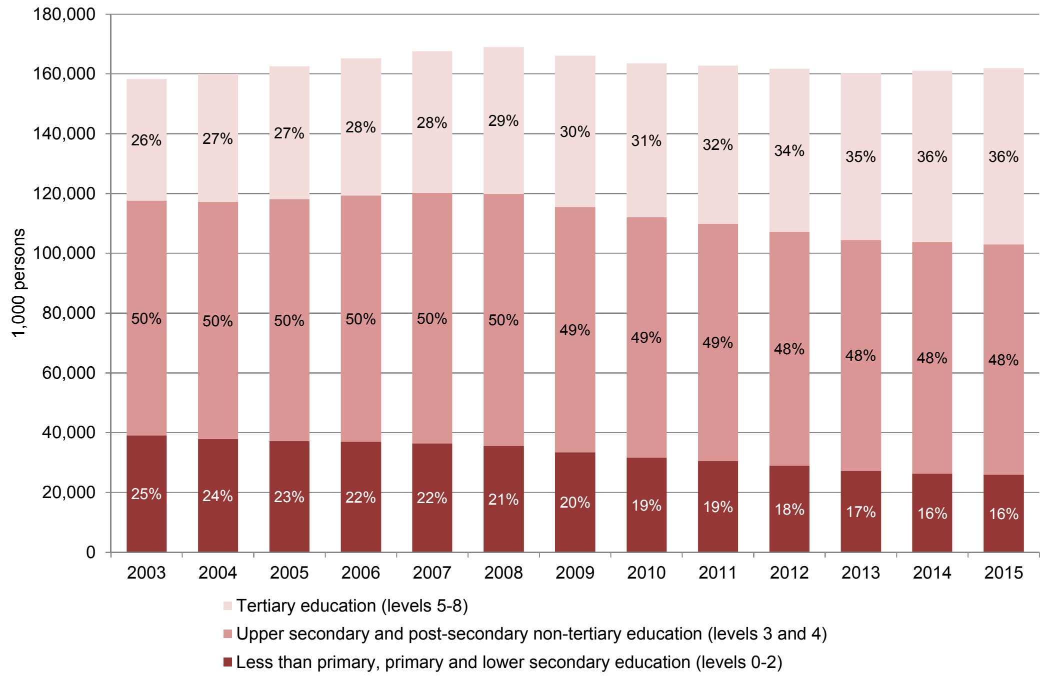
The literature on new technologies and employment also features some worrying findings, in particular, that technological change is not skill-neutral. New technologies tend to favour some particular skills while devaluing and making others redundant, but also lowering the demand for them by firms that use such new technologies. The literature describes this trend as 'skill-biased technological change'. Moreover, some authors have found that new technologies increasingly substitute routine tasks, and have labelled this phenomenon as 'routine-biased technological change'. There is a high share of routine tasks not only in manual occupations, but also in white-collar and administrative ones.

Acemoglu and Autor (2011) show that the demand for routine jobs and tasks has fallen considerably in the US, regardless of whether these jobs and tasks have a cognitive or a manual character. As a consequence, demand for middle-skilled people has decreased, while demand for both high-skilled and low-skilled (paid accordingly) ones has risen. This trend has been labelled 'job polarisation'.

The development of the European labour markets in the last 20 years has followed the path of skill-biased technological change (see the figure below). The number of jobs and occupations that require only low skills has constantly decreased. It is, however, difficult to say if this is due to the introduction of new technologies or to globalisation. There are also some contributions that have identified trends of job polarisation in Europe, but the evidence for Europe is weaker than for the US.

Innovation will create jobs in the future, but they will be in occupations other than those destroyed by technology, and will be characterised in particular by a low share of routine tasks and a high share of tasks that require creative and social skills. This includes many health, education and social occupations.

Employment and skills levels, 1995-2015, EU-28, in 1 000 persons



Source: EUROSTAT, Labour Force Survey.

Technology and inequality

The challenge of the future – besides increasing innovation to spur employment growth – lies in coping with rising inequality as a result of technological change. Skill-biased and routine-biased technological changes are two mechanisms that may increase inequality, because they favour particular groups of the workforce and reduce the employability of other groups, in particular low-skilled workers who already bear a considerable share of the adjustment costs of innovation. The risk of displacement of their jobs is higher, and the number of available jobs that require only low qualification decreases.

Evidence shows that Europe witnessed growing income inequality between the mid-1980s and the late 2000s. In the past 10 years, there has not been any overall increase in income inequality in the EU. However, we find evidence that inequality between people engaged in elementary occupations and others in high-skilled ones has increased. The wage gap between managerial and elementary occupations has widened, which points to the role played by skill-biased technological change with regard to inequality in European economies. Romania, Portugal and Bulgaria reveal the highest inequality between occupations, while Sweden, Denmark and Ireland have the lowest wage spread.

The future organisation of work

Digitalisation is expected to change not only the volume of work and the demand for different skill levels, but also the organisation of work. Individual tasks performed by people will increasingly become tradable over the internet. Experts believe that the share of tasks performed outside the firm and the share of self-employed people who work on a project-by-project basis for various clients will increase ('platform workers'). As a consequence, firms will gradually shift to more project-oriented organisational structures instead of fixed hierarchies. Such a 'platform' or 'gig' economy may lead to more self-determination and a better work-life-balance for employees, but may also result in more insecurity and periods of involuntary unemployment. Moreover, self-employed platform workers often lack legal protection and the various social benefits to which employees are entitled.

Digitalisation and the social economy

How will digitalisation affect employment in the social economy or the third sector, including social assistance services, education and training, or work integration? The social economy provides employment to many people who would not find work in other areas of the economy, because they lack the necessary skills or have special needs. Increased pressure on the job market for elementary occupations will also put strain on the jobs in the social economy. However, the social economy also includes a large number of non-routine tasks in health, social work, education and other areas, which are difficult to substitute by ICTs. Moreover, new ICTs may also provide new tools for the social economy to organise help in a more efficient way.

Policy options

The possible negative consequences of digitalisation for employment have inspired a number of suggestions for policy intervention in recent years.

First, in a world where skill levels are closely related to inequality, it seems essential to invest in education; these investments should encompass all levels of the education system. New results point to the importance of the early years for later learning, which could be a particular focus for policy intervention.

The promotion of research and development (R&D) should be another focus of public policy. Potential returns from R&D are higher at the societal level than at the enterprise level, because other organisations can benefit from knowledge created as well. In addition, Europe should invest in upgrading its internet infrastructure and promote entrepreneurship to transform new technologies into growth.

New types of self-employment, such as platform work, also call for new employment regulations. Policy should review the status of these types of employment and, if necessary, extend social security legislation to platform work. This would also include relying on the owners of platforms for social security contributions.

There may be a need for tax systems to shift from the taxation of labour to a taxation of capital and value added as the main contributor of economic wealth. Machines may also contribute to the financing of social security. Such a shift, however, only seems feasible if the overall tax burden does not increase and the tax burden on labour is substantially reduced. Some experts think that taxing the super-rich may be a way to decrease inequality and raise funds for the state. Piketty (2014), for example, proposes a progressive global tax on wealth of up to 2 %, and additional income taxes. However, he also admits that such a tax is impossible to implement today because it would require a degree of political coordination which seems very difficult to agree on.

Historically, productivity increases generated by new technologies have led to reductions of working time, allowing to bring more people into work or dampen the negative effects of automation on the labour market. Such reductions may also be appropriate when digitalisation leads to further automation. Reductions of working time can be easily implemented, and can be done in small steps.

If the pessimistic scenario of massive job losses and a huge increase in inequality from the economic effects of digitalisation comes true, this may lead to a massive erosion of the income basis of European countries. In such a situation, some authors have suggested to move to a system that provides a basic income for every citizen, regardless of whether they are employed or not. This should prevent the most severe economic inequality and provide the means for participation in society. However, the idea of a basic income is disputed, mainly because many people think that it provides adverse incentives for employment and entrepreneurship, and may create and foster a culture of living on social benefits.

1. Introduction

This report investigates the relationship between innovation, new technologies, employment and inequality. It is a follow-up of a study commissioned by the Science and Technology Options Assessment (STOA) Unit of the European Parliament on the same topic (Krings and Muellner 2007).

Since the predecessor study of 2007, the topic of this report has gained a lot of prominence. This is because of a number of well-received books on the topic (Brynjolfsson and McAfee 2014, Ford 2015), but also due to alarming reports about possible negative consequences for employment from new information and communication technologies, including machine learning, digitalisation in production, automated vehicles etc. This is why the focus of this report is on the effects of information and communication technologies, or digitalisation, on labour markets and inequality.

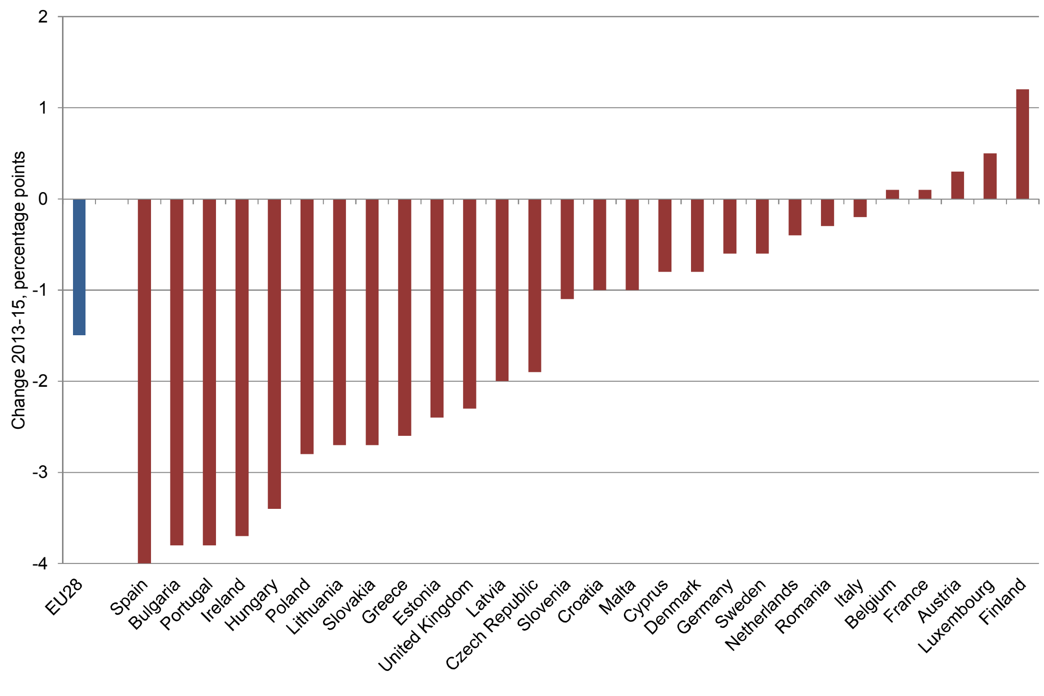
This report will review the literature on information and communication technologies and employment, which has evolved in the last years. Moreover, it will review the academic literature on innovation and employment, and investigate what researchers think about technology and inequality. A special chapter is devoted to the social economy and possible consequences of the aforementioned technologies for it. Finally, a chapter on policy concludes the report.

2. The labour markets in EU countries

The labour markets of the EU member states are in a painfully slow recovery from the recession following the global Financial Crisis of 2008/09. A number of recent reports analyse the status of EU labour markets (for example EUROFOUND 2015; European Commission 2015), so we will only focus on some important facts.

Unemployment in the EU rose from 2008 to 2012, and only stopped rising in 2013. In 2013, unemployment started to decrease in most EU member states (Figure 1 below).

Figure 1: Changes in unemployment, 2013-2015, EU-28 and member states



Source: EUROSTAT, Labour Force Survey

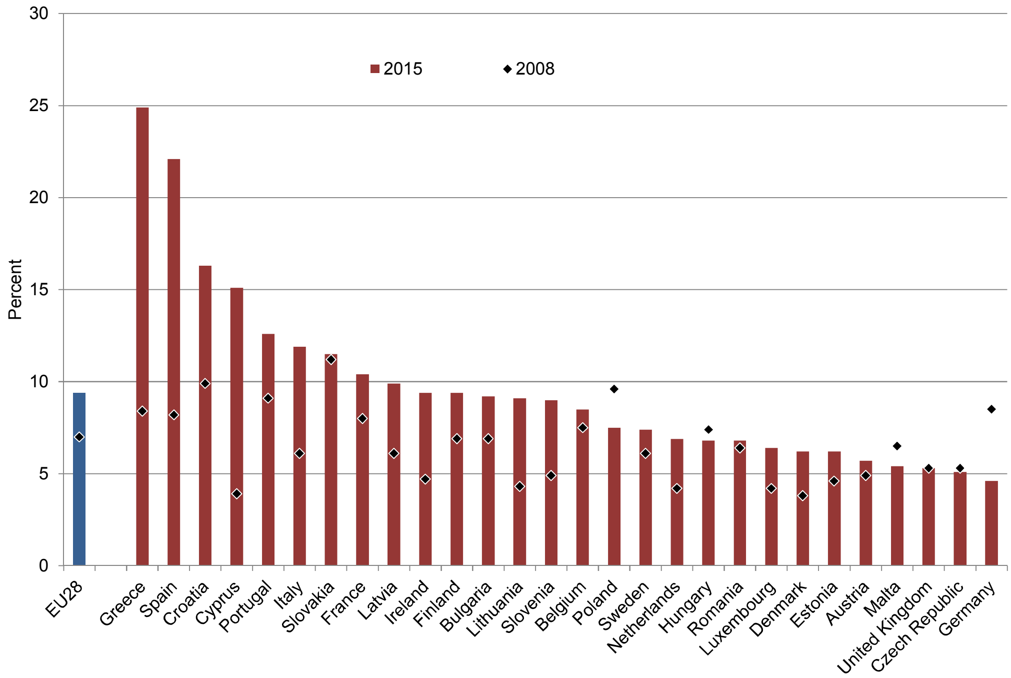
We see the largest decreases in unemployment in some of the countries that were most severely hit by the crisis, including Spain, Portugal, Ireland, and Greece. In other countries with high unemployment, most notably France and Italy, decreases are only small and unemployment persists.

Overall, unemployment in the EU fell from its post-crisis peak of 10.9% in 2013 to 9.4% in 2015. Compared to the development of overall economic activity measured by GDP, the recovery of EU labour markets is remarkably modest (European Commission 2015, p. 12). Unemployment remains high in most EU countries.

The following figure compares pre-crisis (2008) levels of unemployment with the latest annual figures. For the EU, unemployment is still 2.4 percentage points higher than in 2008. We can also observe considerable differences to the year 2008 in Greece, Spain, Croatia and Cyprus. There are only four countries with a lower unemployment rate in 2015 compared to 2008: Poland, Hungary, Malta and Germany.

In absolute terms, on average 22.872 million people were unemployed in the European Union in 2015. The largest number of unemployed people is found in Spain (five million people), France and Italy (three million each), and Germany (1.9 million). Like employment, the number of hours worked has also fallen between 2009 and 2013, and only rebounded in 2013 (European Commission 2015, p. 16).

Figure 2: Unemployment in the EU-28 and EU member states, 2008 and 2015



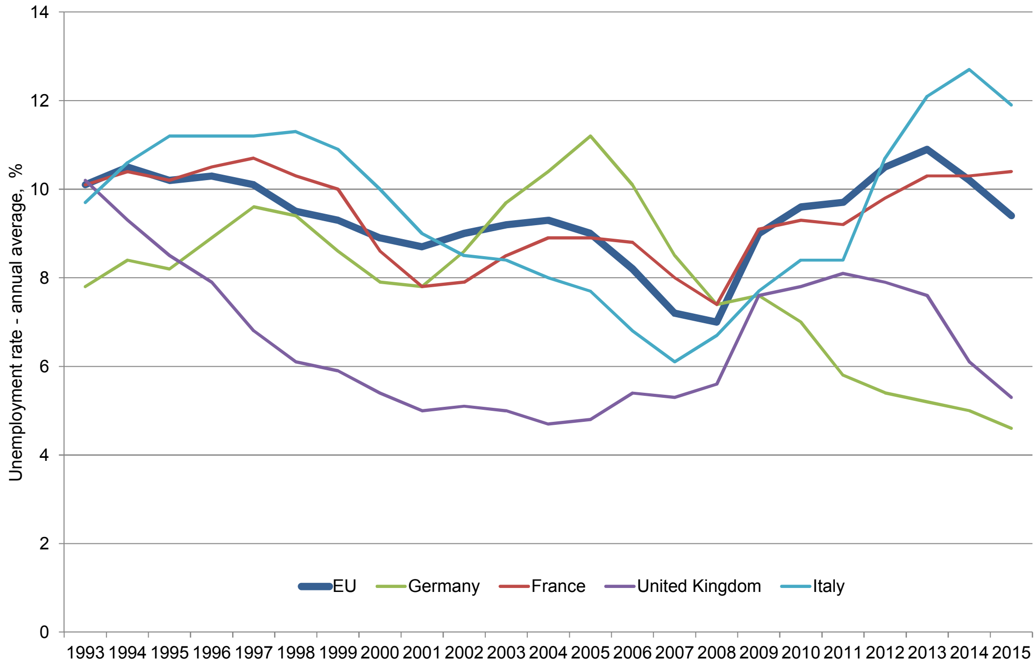
Source: EUROSTAT, Labour Force Survey

One aspect of the painfully slow recovery is the rise in long-term unemployment. The number of people being unemployed for one year or more nearly doubled, from 6.1 million to 12.3 million between 2008 and 2013. In 2015, the number of long-term unemployed was 10.9 million people on average. If we relate the number of long-term unemployed to the total number of unemployed, we see a drastic increase, from 37% in 2008 to 49.3% in 2014. This is a fundamental change in the quality of unemployment. Long-term unemployment is most persistent in Greece, Slovakia, Croatia and Bulgaria, where more than 60% of all unemployed people were out of employment for at least a year. The lowest shares of long-term unemployed are found in Sweden and Finland.

Another worrying aspect of the recent labour market performance in the EU member countries is the high level of youth unemployment. Unemployment among people less than 25 increased from 15.9% (2008) to 23.7% (2013), and dropped in the two following years to 20.2% (2015). We see the highest levels of youth unemployment in Greece, Spain, Croatia and Italy with more than 40%.

Overall, the labour markets of the member states of the European Union show a divergent picture; on the one hand, some countries have held unemployment constant or reduced it considerably in the last years; examples include the UK and Germany. On the other hand, there are countries with persistently high unemployment: France, Italy, Greece, Portugal or Spain. The challenge, thus, is not only to reduce unemployment, but also to deal with a larger degree of disparity in the economic conditions throughout the European Union, a can be seen in the figure below. In the mid-1990s, differences in unemployment rates between the largest EU countries were much smaller than they are today.

Figure 3: Unemployment rates in Italy, France, the UK, Germany and the EU-28, 1993-2015



Source: EUROSTAT, Labour Force Survey

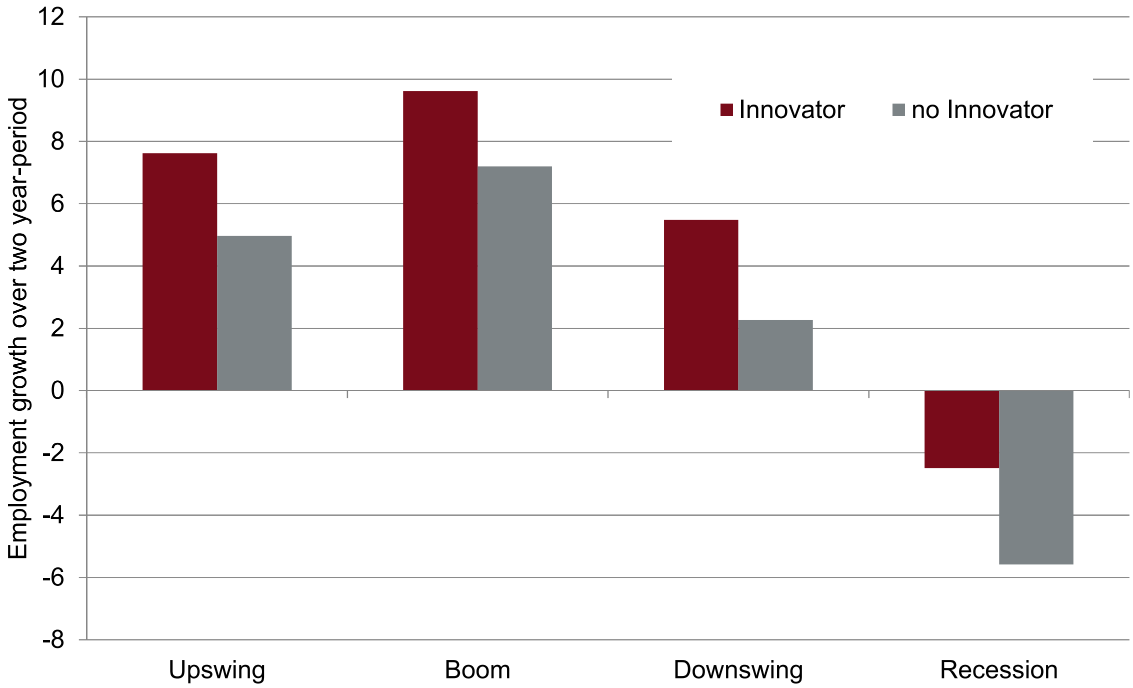
3. The relationship between innovation and employment

What can be done to bring down unemployment? A look in the literature reveals that innovation is seen by many authors as the driving force behind employment growth, in particular in the long run (Freeman et al. 1982; Van Reenen 1997; Edquist et al. 2001; Pianta 2005; Vivarelli 2014).

A first look at the relationship between innovation and employment is given in the following figure. It has been taken from an EU-funded study on the impact of innovation on employment growth at firm level in the EU over the period 1998-2010 (Peters et al. 2014). The figure reveals that in terms of employment growth, innovating firms perform better than non-innovators regardless of the phase of the business cycle; they create more in upswings and boom periods, and loose less employment in recessions[1].

1 Readers should notice that employment growth as illustrated in this figure is the average growth at firm level, not at the level of the whole economy, which is lower The main difference between the two values is the fact that firms which exited the market are not included in the firm level data.

Figure 4: Employment growth of innovators and non-innovators in different phases of the business cycle, manufacturing, 1998-2010



Source: Peters et al. (2014)

3.1. Product innovation, process innovation and productivity

Before we investigate the relationship between innovation on employment in more detail, it is useful to make a few distinctions: first, between **product innovation**, the introduction of new products on the market, and **process innovation**, which is the implementation of new processes for the production of products (OECD 2005). The OECD considers both, product and process innovation, as technological innovations.

In addition, firms may also invest in non-technological innovation such as **organisational innovation** or **marketing innovation**. Whereas process innovations refer to changes in material goods which are improved through technical change, organisational innovations are new ways to organise work (OECD 2005), including the introduction of new business processes and new ways of workplace organisation. Business model innovation also falls in this category (Massa and Tucci 2014).

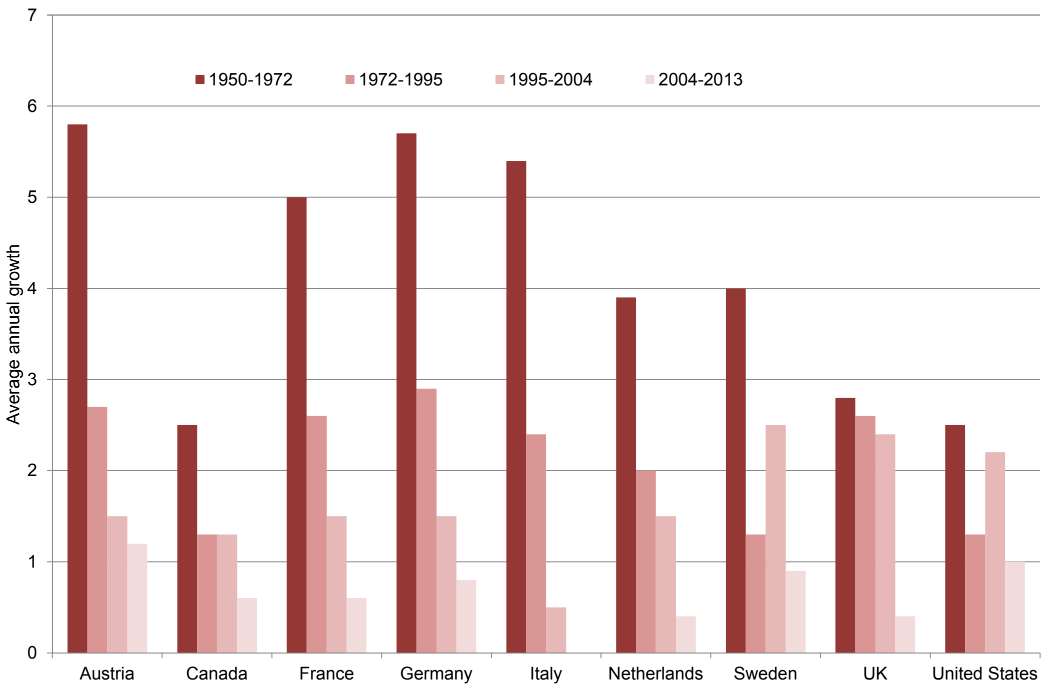
Finally, marketing innovations involve significant changes in product design or packaging, product placement, product promotion or pricing (OECD 2005). We can distinguish between marketing innovations and product innovations by looking at product characteristics; if the function or the way people use the product has changed, then it is product innovation.

The distinction between technological and non-technological innovation says nothing about the economic value of the innovation for the firm and its potential for jobs creation. Organisational and marketing innovations often complement technological innovations and help to unfold their full potential (Brynjolfsson and Hitt 2000).

Another important term related to the topic of this report is **productivity** (Bartelsman and Doms 2000; OECD 2015). Increases in productivity are improvements of the ratio between the factors of production employed and the output of the firm – if a firm becomes more productive, it can produce more with the same inputs. Productivity is central to all discussions on employment and output growth. Empirical evidence suggests that increases in productivity account for a considerable proportion of the employment growth in many sectors in the European Union, in particular in high-technology sectors (Peneder 2009, p. 14).

Unfortunately, productivity growth is slowing down in the long term in Europe and North America, as can be seen in the following figure. It was highest in the post-war period 1950-1972. After the recession of 1972/73, most countries were not able to return to the productivity growth rates of the 1950s and 1960.

Figure 5: Labour productivity growth in the long run, 1950-2013



Source: OECD (2015), p. 16

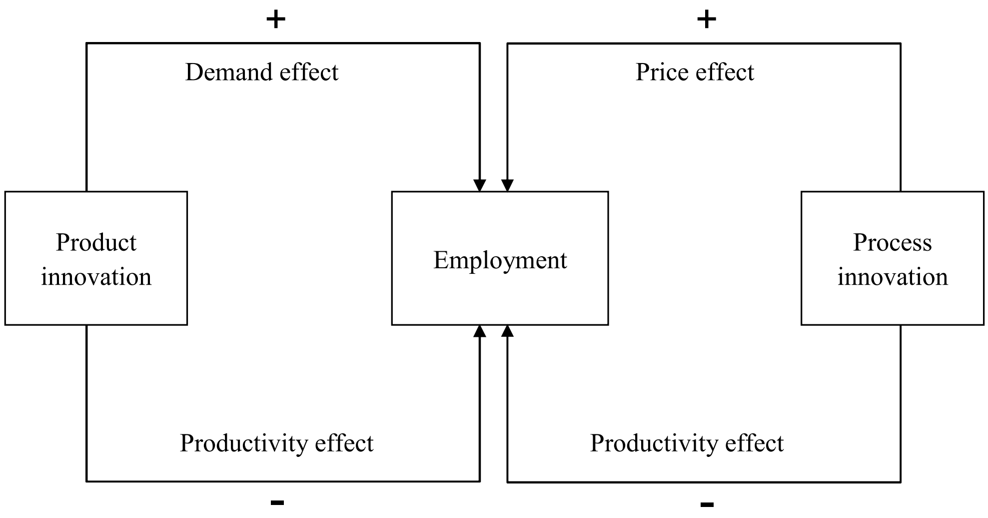
Productivity growth is the link between innovation and employment growth; innovation may lead to changes in productivity, which in turn may lead to employment changes (Hall 2011; Mohnen and Hall 2013). The linkage between innovation, productivity and employment, however, is not straightforward, and different forms of innovation may therefore have different effects on employment growth (Edquist et al. 2001; Chennells and Van Reenen 2002; Pianta 2005; Hall et al. 2008; Harrison et al. 2014; Vivarelli 2014).

3.2. Productivity and demand effects

The following Figure 6 illustrates the relationships between process and product innovation on the one hand and employment changes on the other hand.

We start with the effect of process innovations on employment. Process innovation – for example the installation of new production equipment – usually allows the firm to produce the same amount of output with less capital and/or labour. As a consequence, process innovation most often leads to an increase in productivity and a negative effect on employment (Productivity effect of process innovation, in the lower right side of the figure). The size of this negative effect depends on the current production technology and, thus, the rate of substitution between input factors as well as on the direction of the technological change. This labour-saving effect also varies significantly between sectors (Edquist et al. 2001).

Figure 6: Effects of product and process innovation on employment



Source: Peters et al. (2014), own illustration.

In recent years, a growing literature discussed the labour-saving effects of digitalisation. Some authors (for example Frey and Osborne 2013, 2017; Brynjolfsson and McAfee 2014) predict vast potentials for productivity increases and corresponding employment losses due to the application of information technologies on a wide range of routine activities in manufacturing and services. These predictions will be summarised and discussed in chapter five of this report.

Despite the predictions of vast future employment losses due to process innovation, the empirical evidence on **past** employment effects of process innovations is ambiguous. In the studies of van Reenen (1997) and Entorf and Pohlmeier (1990), the impact of process innovations turns out to be small and not significant at all. Greenan and Guellec (2000) or Lachenmaier and Rottmann (2011), in contrast, report a significant positive effect of process innovations on employment growth. The latter two studies even establish that process innovation creates more new employment at the firm level than product innovation. On contrary, Blechinger and Pfeiffer (1999) find evidence of labour displacement by process innovation, the effect being more pronounced in larger firms.

The second important effect of innovation on employment is the demand effect depicted in the upper left sector of Figure 6. If a firm introduces a new product to the market, this product will create new demand for the firm if consumers and user firms find it useful. The degree product innovation can create new employment depends on the price elasticity of demand and the existence of substitutes or complementary products into our considerations. Altogether, the empirical literature suggests that the demand effect is certainly the most important positive outcome for employment from innovation.

Despite the large number of studies that report employment gains from product innovation, the demand effect is rarely mentioned in current discussions on digitalisation. This may be due to the fact that our ability to imagine the future is limited, which also includes limitations to imagine major future product innovations and their impact on jobs creation. Employment losses due to process innovation, in contrast, seem to be much more obvious from today's perspective because they apply to changes in products and occupations we all know very well.

This lack of clarity is also reflected by current discussions on future prospects for productivity and innovation; the OECD (2015, p. 28) nicely sums up the arguments of techno-pessimists and techno-optimists; the former argue that the current slowdown in growth is a permanent phenomenon caused by the exhaustion of opportunities for significant useful innovation. The latter group, in contrast, sees no evidence for diminishing returns to innovation.

3.3. Other effects

The demand and the productivity effect are two major channels how innovation affects employment; they are, however, not the only ones. Process innovation often allows the firm to manufacture a new product at substantially lower costs than the old one; if the firm passes on this decrease in production costs to their consumers by reducing the price of the product, this step may also lead to overall market expansion and employment growth.

Empirical evidence for this *price effect* is provided by (König et al. 1995), (Greenan and Guellec 2000), or (Lachenmaier and Rottmann 2011). The magnitude of the price effect is determined by the size of the price reduction, the reaction of demand on price changes (elasticity of demand) and the reactions of competitors to the price reduction. Thus, the price effect also shows the importance of competition policy for employment, since we can assume that firms in a competitive market will set prices closer to the new, lower production costs than in a market with only a few competitors.

In addition, productivity effects from product innovation may also enter into the equation (see Figure 6). New products sometimes utilize new inputs, which allow to produce them with less inputs and a higher productivity than the old product (see Harrison et al. 2014). Thus, product innovation can lead to productivity changes, even if product innovation is not associated with simultaneous process innovation. On the other hand, new products may help firms to increase productivity by moving resources from the production of old products to new products with a higher value so that productivity measured in monetary terms increases.

Employment gains from product innovation are a major driver of employment growth; however, they come at a price. New products with a higher utility and/or a lower price will displace existing products offered by the firm or by its competitors. Thus, the demand for a new product may come at the expense of existing 'old' products. Product innovation may incur two types of these negative effects: first, a negative effect to innovator itself (known as the '*cannibalisation*' effect); second, a negative effect to competitors (the '*business stealing*' effect). Both effects may reduce the initial employment-creating effect of product innovation.

We all know these effects from mobile phones, cars or other consumer products; demand for older mobile phones by the same firm or competitors will decrease once a new model has been introduced to the market. Moreover, a new mobile phone with increased functionality may also negatively affect sales of related product categories, for example tablets, digital cameras, digital music players, electronic route guiding systems, etc.

The literature shows that cannibalisation and business stealing effects are frequent: in fact, some cannibalisation is almost inevitable for firms that launch new products, in particular for multi-product firms (Lomax et al. 1997). The degree of these negative effects depends on the existence of substitutes and the reactions of competitors. Exceptions may exist when a new product complements an existing one, or when a new product extends the product range of a firm into new fields, but benefits from the established brand (Lomax et al. 1997).

3.4. Differences between sectors

The linkage between innovation and employment creation is also influenced by the sector of the firm. Industries differ in a number of technology-related factors including the richness of technological opportunities, the cumulativeness of the knowledge base, or the means to protect and appropriate the economic benefits from innovation (Marsili 2001; Cohen 2010; Dosi and Nelson 2010). We can observe the results of these factors in persistent differences in the technological trajectories between sectors and distinct technological regimes that shape the directions of technological search in industries (Breschi et al. 2000; Marsili 2001; Castellacci 2007).

These technological differences also transfer into different employment performances between sectors, as can be seen in the following figure which illustrates employment growth in the EU by technology intensity of the sector[2].

Figure 7: Employment by technology intensity of the sector, EU, 2008 and 2013

Source: (European Commission 2016), p. 301

The fastest growing sector, market knowledge-intensive services, is a diverse sector including water and air transport, but, more important, legal and accounting activities; activities of head offices and management consultancy activities; architectural and engineering activities, technical testing and analysis; advertising and market research; and other professional, scientific and technical activities. Moreover, it also includes employment activities, security and investigation activities. We can therefore imagine very diverse drivers that have fuelled growth of this sector. High-tech knowledge intensive services, the second fastest growing sector, includes the television, music and film industry, telecommunications, commercial R&D services and information and communication technology (ICT) services.

The figure also reveals a considerable gap between manufacturing and service industries in employment growth. All manufacturing sectors perform below average, which high-tech manufacturing performing best. This gap between services and manufacturing is confirmed by macroeconomic data which shows a higher average employment growth in services compared in manufacturing across European countries (Veugelers 2013). The gap has been explained by a higher income elasticity of service products compared to manufacturing products and a higher degree of tradability of manufacturing products that allows a stronger shift of manufacturing towards lower-cost countries and brings a more openness in manufacturing compared to services (Veugelers 2013).

2 Readers should note that Figure 1 relates to the firm level, while Figure 7 relates to the sectoral level. Employment growth cannot be the same for the two figures, since firm-level data do not take into account the effects of firm entries and firm closings.

A second explanation is productivity growth, which is usually considerably higher in manufacturing than in services due to larger opportunities for process innovation (Baumol 2012). There is a long discussion on how innovation in service firms differs from innovation in manufacturing, and if service and manufacturing innovation can be measured with the same metrics (Tether 2005; Gallouj and Savona 2009). From this literature we know that innovation in services is more often non-technical, is based to a lesser degree on the application of scientific and formal knowledge, includes more interaction with clients, requires more of the necessary social skills for interaction, and can be protected less efficiently with formal intellectual property rights than innovation in manufacturing. Moreover, service products are far less standardised than manufacturing products, because services are often the result of user-producer interaction (Tether et al. 2001; Miles 2005). All these factors speak for a lower degree – or at least for different innovation trajectories - in services, and for fewer opportunities for process innovation to raise productivity compared to manufacturing.

If we move from the firm level to the macroeconomic level, another implication of employment change driven by innovation is the reallocation of employment and capital between sectors. The fact that not all firms are successful with their innovation projects implies that some firms and sectors grow fast, while others stagnate or even decrease. Thus, innovation is a major determinant of structural change and aggregate productivity growth, together with firm entries and exits (Caves 1998; Bartelsman and Doms 2000; Krüger 2008; Dosi and Nelson 2010). This reallocation is driven by innovation and the use of new technologies. A famous illustration of long-term structural change as a result of major product, process and organisational innovations is Joseph Schumpeter's (1942) notion of 'creative destruction'.

4. Innovation, Skills and Unemployment

So far, this survey has assumed that no differences exist between people in terms of skills, experience, creativity, etc., so that labour is homogenous. This is, of course a very simplistic assumption.

People have different levels of training and different skills which in turn provide different contributions to innovation. Recent empirical research has shown that a range of different skills (engineering, design, multimedia, graphical arts, software development, marketing research) available in a firm has a positive impact on its innovation activities: the more skills are employed in the innovation process, the more likely is it that this firm brings up new products, and market novelties (Peters 2016).

However, innovation and new products and processes also change the types of skills firms demand. Firms which are based on ICT demand different skills sets than firms based on mechanical technologies. We will discuss this in chapter 4.1 and 4.2. New technologies may also change the way people work and the future organisation of work, as we will see in chapter 4.4.

This linkage between innovation and skills is the background of all estimations of the future impact of digitalisation on employment which will be presented in chapter 5 – what new products will firms offer in the future, and what occupations and skills will the need for this? Can technology take over tasks and occupations where specific skills are needed? What if the development of skills cannot keep pace with technological change? We can be quite sure that innovation will also create jobs in the future, but they will be in other occupations as the jobs destroyed by technology.

4.1. Skill-biased technological change

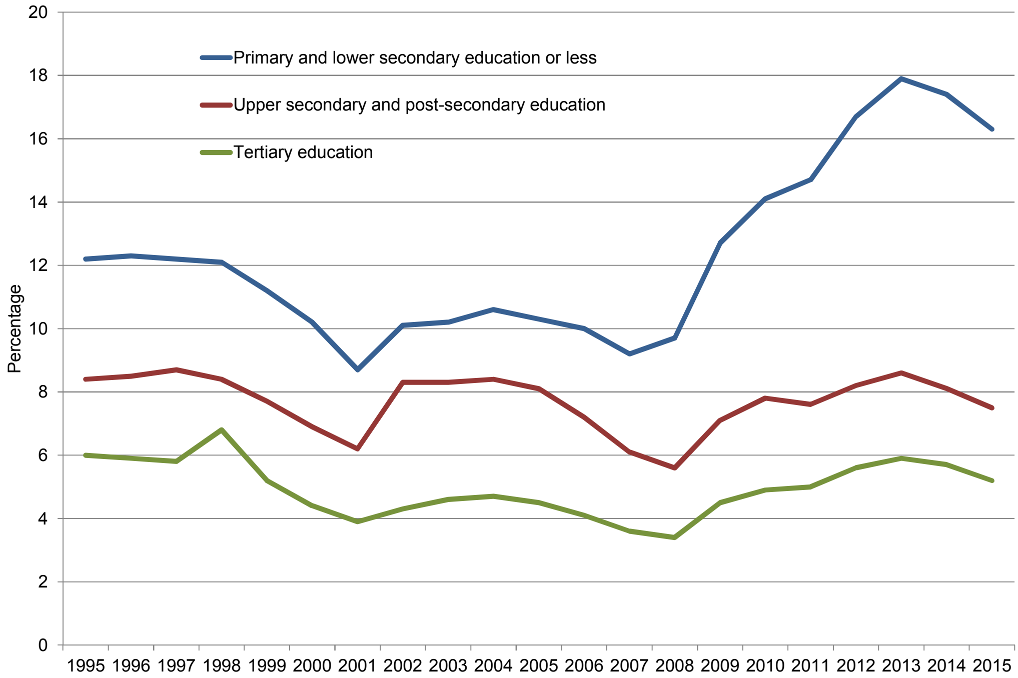
Technology is not skill-neutral, but tends to favour some particular skills, while devaluates other skills and makes them redundant. This has been labelled '**skill-biased technological change'** in the literature (Card and DiNardo 2002; Haskel and Slaughter 2002; Acemoglu and Autor 2011).

The skills bias of technology has been discussed thoroughly in recent years for information and communication technologies (ICTs). Applications of ICTs, such as payroll processing software, barcode scanners, automated inventory software, or word processing, substituted many routine office tasks in the last 30 years and have made them redundant. However, some tasks have also benefited from ICTs because ICTs increased their productivity. Examples include the work of designers, engineers, or managers; ICTs have complemented and augmented skills necessary for these occupations, and increased demand for them.

The following graph gives a first impression of the relationship between skills and unemployment. It shows the share of unemployed with different educational levels as a percentage of the active population in the EU-28 aged 25 to 64.

We see that unemployment is particularly high among people with primary and lower secondary education or less. This group has the highest unemployment rate of all three groups throughout the whole period. Moreover, people with the lowest educational attainment have also suffered disproportionally from the crisis, as can be seen in the Figure. Unemployment in this group nearly doubled during the crisis, from below 10% to 18% in 2013.

Figure 8: Unemployment and skills levels, 1995-2015, EU-28

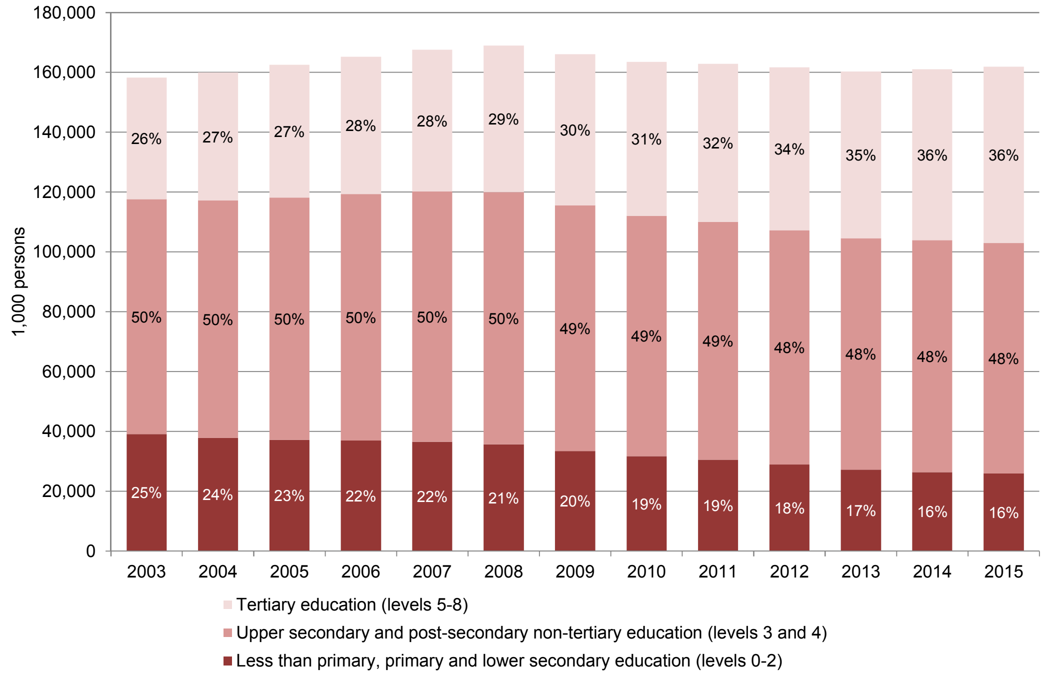


Source: EUROSTAT, Labour Force Survey.

However, employment opportunities for people with primary and lower secondary education or less have decreased long before the crisis 2008/09, as can be seen in the following figure. The share of this group on total employment in the EU decreased from 25% in 2003 (which equals around 40 million people) to 16% (or 26 million people) in 2015. People with tertiary education, in contrast, increased their share on total EU employment by 10 percentage points during this period, from around 40 million people in 2003 to 59 million people in 2015.

The size of the largest share, people with upper secondary and post-secondary education, remained nearly unchanged between 2003 and 2015, both in absolute and relative terms. This group holds a share of about 50% on total EU employment, which equals about 77 million people in 2015.

Figure 9: Employment and skills levels, 1995-2015, EU-28, 1,000 persons



Source: EUROSTAT, Labour Force Survey.

4.2. Routine-biased technological change

Skill levels, however, may still be a too broad category to capture current developments in US and EU labour markets. David Autor (2013) and others suggest to look at **individual tasks** rather than skills. A task is a unit of work activity that produces output (Autor 2013). Tasks can be performed by **labour** (people) or by **capital** (machines, or, in other words, automation). People apply their skills to deliver various tasks (Autor 2013).

The division of tasks between people and machines is fluid: (Autor 2013, p. 186) finds that "novel tasks – those demanded by new products, techniques, or services – are often assigned first to workers because workers are flexible and adaptive. As these tasks are routinized and codified, they become fallow for automation …" A shift of tasks between workers and machines can, of course, also be caused by increases in the capabilities of machines due to technological change.

Chapter 3 discussed that process innovation can destroy, but can also create employment. The tasks approach adds some new facets to this relationship. New process technologies can make some tasks provided by workers redundant, while increase the value and utility of other tasks by increasing their productivity. These tasks include everything related to problem-solving capabilities, intuition, creativity, persuasion, situational adaptability, visual and language recognition and person-to-person interactions (Autor et al. 2003). So, new technologies can either substitute or complement tasks performed by workers (Brynjolfsson and McAfee 2014; Autor 2015).

Acemoglu and Autor (2011) suggest that a distinction of manual vs. cognitive and routine vs. non-routine jobs may be better suited than skilled vs. unskilled. They distinguish between four types of tasks:

- Analytical and interactive non-routine tasks
- Analytical and interactive routine tasks
- Manual routine tasks
- Manual non-routine tasks

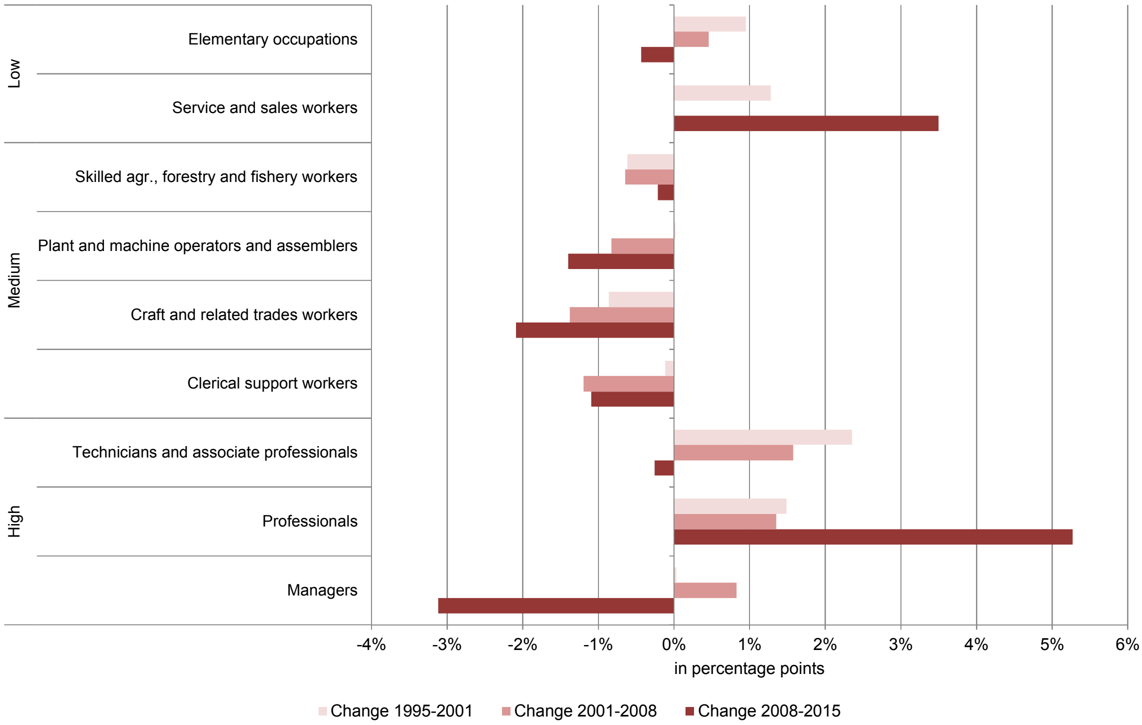
They show that demand for routine jobs and tasks has fallen considerably, no matter if these jobs or tasks had a cognitive or manual character. As a consequence, demand for people with middle skill levels has decreased, while the demand for both high-skilled and low-skilled (and accordingly paid) occupations has risen. This has been labelled '**routine-biased technological change'** and **job polarisation** (Autor et al. 2006, 2008; Goos et al. 2014). ICTs increasingly substitute routine, middle-skilled jobs, but are complementary to less routine high-skilled cognitive and low-skilled manual jobs. This may mean that firms hire more university graduates working in design, development or management, but they may also need cleaning staff, salespersons, etc. An example for such a non-routine task is everything that requires face-to-face communication. An alternative explanation for job polarisation is globalisation, because routine jobs are likely to be more open to offshoring than non-routine jobs.

The figures above do not give evidence for job polarisation. However, if we go at the level of occupations, divergent trends between various groups become apparent. The graph below is taken from the report of Peters (2016). She depicts the changes in shares of eight different occupation groups on total employment for the period 1995-2001, 2001-2008, and 2008-2015. The eight occupation groups are classified into high-paid, medium-paid and low-paid population classes, according to the average wage at European level in each of the groups. Goos et al. (2014, p. 2513) suggest that the routine intensity is highest among the middle-paid occupations. Due to data limitations, the figure only includes data for the EU-15. Developments in the EU-28, however, are similar.

The results (see Figure 10 below) clearly indicate job polarisation; high-paid professionals, but also low-paid service and sales workers could raise their share on overall employment considerably. Medium-paid occupations, such as clerical support workers or craft and related trades workers, suffered the largest losses in terms of employment share. It seems that job polarisation even accelerated since the crisis of 2008/09. Overall, medium-paid occupations lost 4.6 percentage points on overall employment in the period 2008-2012 and nine percentage points in the period 1995-2015. High-paid and low-paid gained 1.3 and 3.1 percentage points in the period 2008-2012 and 9.5 and 5.8 percentage points in the period 1995-2015, respectively. However, there are also exceptions, such as managers, which also lost shares. Evidence presented by Peters (2016, p. 310) based on CEDEFOP employment forecasts suggests that this trend will likely continue in the future.

The European Jobs Monitor (EUROFOUND 2015) comes to a similar conclusion for the three year period between the second quarter 2011 and the second quarter of 2014. During this period, EUROFOUND finds “the largest employment growth in well-paid jobs, some modest growth in the lowest-paid jobs and declining employment in middle of the wage distribution.” (EUROFOUND 2015, p. 1). More recently, employment growth has changed, with more new employment in low-paid and mid-paid segments. This is very recent development, because in its 2014 report, EUROFOUND (2014) writes that “contrary to previous research in this area, a clear association was not found between the routine content of jobs and the polarisation of job structures. While it is true that routine content was negatively associated with employment growth, this effect tended to contribute to upgrading rather than polarisation. “

Figure 10: Changes in employment shares of different occupation groups, 1995-2015, EU-15, percentage points.



Source: EUROSTAT, Labour Force Survey, own calculations.

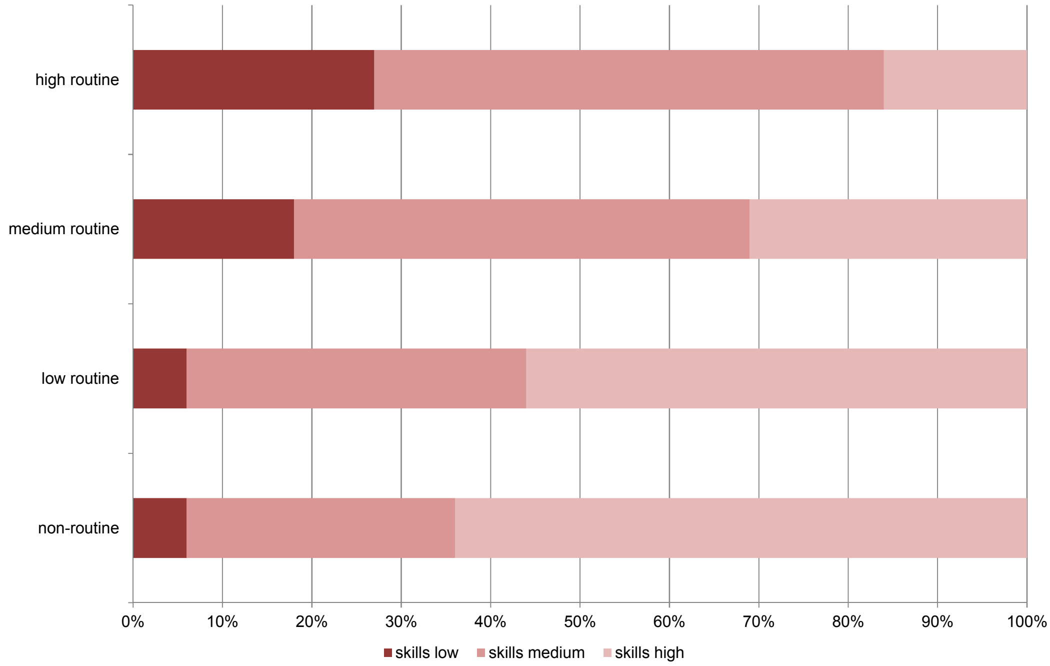
One should note, however, that this analysis of job polarisation and other labour market effects crucially depends on the proper identification of routine and non-routine tasks. Goos et al. (2014, p. 2513) suggest that the routine intensity is higher in the middle-paid occupations. The OECD (Marcolin et al. 2016) brought forward a new classification of routine content based on individual responses to a survey on adult competencies (PIAAC). These results indicate that routine intensity increases with skill levels – the jobs with the lowest skills requirements are also the most routine-intensive ones.

This would – at least partly – bring down the argument of Goos et al. (2014) about routine-biased technological change in Europe. However, Marcolin et al. (2016) also find that medium and high routine-intensive occupations are mostly found in medium skilled employment, simply because there are a lot of these medium-skill jobs around (see Figure 11 below). 73% of all high routine-intensive and 68% of all medium routine-intensive employment can be categorised as medium-skilled. So, the medium-skilled group is the one with the highest affectedness to job polarisation. On average, 46% of the employed work in non-routine occupations or in low routine-intensive occupations.

Marcolin et al. (2016) also provide data on the share of different routine intensity at country level that gives an interesting perspective at divergences in the European Union (see Figure 12 below). Similar statistics are the basis for estimations on the employment effects of information and communication technologies we will discuss in the next section.

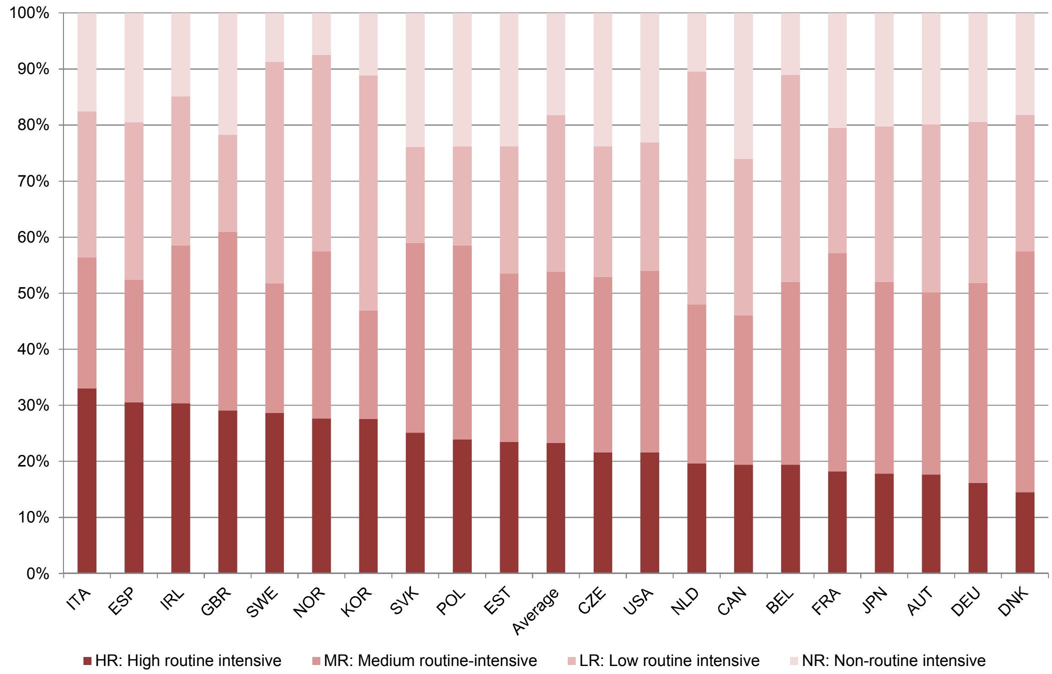
The figure indicates a considerable divide within Europe in terms of routine intensity. Southern European countries such as Italy and Spain reveal the largest share of employees with a high routine intensity, while Austria, Germany and Denmark have the lowest shares in this category. If we sum up the employment shares of medium- and high-routine intensity, the UK and Ireland have the highest degree of routine intensity in the EU, followed by Slovakia and Poland. However, these countries have also the highest shares of non-routine jobs.

Figure 11: Employment by skill and routine intensity, 2011-2012.



Source: Marcolin et al. (2016), p. 23.

Figure 12: Employment by routine intensity in various OECD countries, 2011-2012.



Source: Marcolin et al. (2016), p. 21.

4.3. The role of globalisation

Besides technological change, there are also other economic forces that may reduce employment opportunities for low-skilled people. An obvious candidate is globalisation and the emergence of global value chains. Globalisation can lead to a substitution of domestic low-skilled labour by foreign low-skilled labour, for example when firms offshore production and substitute goods produced in Europe with imports (Grossman and Rossi-Hansberg 2008).

Timmer et al. (2011) show that there is indeed a strong shift towards imported inputs in most global value chains. The output of countries and sectors increasingly depends on imported intermediary goods. However, this does not necessarily mean that domestic low-skilled labour is replaced by foreign low-skilled labour. The authors show for the German automotive industry that the content of domestic low-skilled labour in value added decreased from 7% to 4% of final output value between 1995 and 2008. While the total share of foreign inputs on final output of the German automotive industry increased from 21% to 34% in this period, the share of foreign low-skilled labour on final output remained stable at 4%: Value added is increasingly created by capital and high-skilled labour, and the share of domestic and imported low-skilled labour on output and value added decreases. Thus, the share of low-skilled labour embodied in imported goods cannot be blamed for the decrease of domestic low-skilled labour inputs. The authors report that low-skilled labour inputs decreased in 91% of all combinations of countries and global value chains. So, it is rather technological change than globalisation which is to blame for the decline of low-skilled labour.

However, there are also results that point in a different direction. Becker et al. (2013) show that offshoring is associated with a statistically significant shift towards more non-routine and more interactive tasks, and with a shift towards highly educated workers. Crino (2009) provides more evidence in this direction, so it seems that both, technology and globalisation have its share on the skills-bias we observe in employment statistics. In addition, we have to distinguish between short-term and long-term effects: once firms start to offshore low-skilled jobs abroad, offshoring will raise foreign wages and may change the direction of technological change. Acemoglu et al. (2015) predict that further offshoring may soon induce innovation in less skill-intensive sectors, leading to a shrinking of the inequality gap.

4.4. The future organisation of work

Finally, if information and communication technologies are going to substitute individual tasks, how will the organisation of work look like in the future? A recent foresight study by the German Bertelsmann-Stiftung (Landmann and Heumann 2016) gives some indications for this question. Its main assumption – and also of similar studies – is that individual tasks performed by people will become more tradeable over the Internet. Various experts labelled this a 'platform', 'freelance' or 'gig' economy (Friedman 2014, Kenney and Zysman 2016).

The 'gig' economy has two main consequences:

First, the share of self-employed people who offer these tasks over the Internet will increase, as marketplaces for these services ('platforms') become more widespread. This includes highly skilled and paid experts, but also low-skilled service personnel. As a positive consequence, platform work brings more self-determination for the people offering these tasks, and a better work-life-balance. The downside, however, may also be more insecurity for the platform workers and periods of involuntary unemployment.

Second, as firms gradually rely more on self-employed contractors and independent experts instead of fixed staff, they can increase efficiency and be able to offer their products and services at lower prices because they avoid running idle with their fixed stuff. This means a shift to a more project-oriented organisational structure instead of fixed hierarchies. The boundaries of the firm will increasingly become blurred, and the share of tasks performed outside the firm will increase. Work related to a product or project will more rarely be carried out at the same place and time, but will spread geographically and in time. The office as the place to do work in a pre-defined time of the day will be less important than it is today, and homework will again gain prominence. Crowd working, where many people will take over small pieces of a task, will become more widespread.

The future organisation of work was also one of the main topics of the discussion at the workshop the contractor of this project organized at the European Parliament. Statements by the speakers and from the audience indicated concerns about the gig economy and the 'atomisation' of work relations by platforms. Workshop participants argued that this may have advantages for a few 'superstar' experts, but will bring disadvantages for the large number of people who have few alternatives other than to take up this kind of work. Platform work is already frequent in some sectors like transport and delivery services; in these industries, firms don't have employees, they have associates.

It will be a challenge for social policy to enlarge social security legislation to platform work and other new forms of work that have emerged or will emerge as a consequence of new information and communication technologies. One solution could be a contribution of the platform owners to social security. Moreover, trade unions, as well as the social security system, which both evolved based on the model of wage earners in long-term working relations, will have to cope with these trends. Much will also depend if and how governments regulate crowd working and similar developments.

Another topic related to the future organisation of work is work time reduction. New technologies and the accompanying increases in productivity allowed large reductions in the working time in the past. During the 20th century, work hours shortened by almost half in the United States and Europe. This allowed to keep unemployment low and supported the integration of women in the labour market after the Second World War.

The current technological changes have not created large reductions in working time so far. According to the EUROSTAT Labour Force Survey, full-time employees in the EU-28 worked on average 41.1 hours a week in 2015, only slightly less than 10 years before (41.9 hours). The same is true for part-time employees (20.2 vs. 19.8 hours per week).

Supporters of a reduction argued at the workshop that such a measure may help to dampen the negative effects of new ICTs on jobs predicted by some studies. Moreover, it may also help to increase the quality of life for employees. However, a reduction of worktime while maintaining the same levels of income will inevitably weaken the competitive position of European export-oriented firms, and may even increase labour shortages in areas where firms already find it hard to hire new employees, in particular experts related to ICTs. So, the effects of worktime reduction are not clear, in particular in the long run.

To sum up, there is a tendency that technological change favours high-skilled, non-routine or low-routine occupations, while it reduces employment opportunities in low-skilled and routine occupations. Many of these tasks may be replaced by technologies, in particular ICTs. The development of the European labour markets confirms this skill-biased or routine-biased character of technology. In terms of workplace organisation and organisation of work, experts expect more self-employment, project structures and an increase in the share of tasks contracted and performed over platforms outside the firm.

5. The impact of new technologies on employment: empirical results

This chapter will give an overview on the current discussions of the employment effects of new technologies. This discussion currently focuses on the employment impact of information and communication technologies. An example is the book by Brynjolfsson and McAfee (2014) which paints a rather optimistic picture of the opportunities from the computerisation of physical and intellectual routine tasks. Ford (2015) is more sceptical and points to the need to adjust political, economic and social structures to accompany and smoothen possible negative implications of new ICTs.

5.1. Employment effects of information and communication technologies

Before we begin to discuss possible implications of ICTs on employment it is helpful to consider what particular technologies these authors have in mind when they talk about digitalisation and the social and economic implications of new ICTs. A preliminary, certainly non-exhaustive list includes the following technologies, which are also discussed in a recent STOA study (Van Woensel et al. 2015):

- **Autonomous vehicles:** support and/or substitution of human drivers in private cars as well as in passenger and freight traffic. Autonomous driving could substitute a considerable number of professional drivers.
- **Additive manufacturing (3D-Printing):** a technology that allows production of three-dimensional artefacts by adding successive layers of material. A blueprint at a computer determines the final shape of the object. Additive manufacturing is already used to produce a variety of manufacture.
- **Algorithmic decision-making (Big Data)**: substitution and/or support of human decision-making by algorithms based on large data sets and probabilities. Examples include credit ratings, planning processes, summarising of documents etc. Experts regard algorithmic decision making as one potential tool to substitute a number of routine office occupations.
- **Industrial and service robots:** machines that perform physical tasks without the need for human intervention may take over a number of manual, routine tasks in manufacturing but also in services and substitute workers in these activities.
- **Bitcoin and block chain technologies:** electronic money created by the private sector on the basis of a database that records transactions and ensures ownership titles. This technology could be the basis for a number of new entrants that challenge traditional banks.
- **Digital factory ('Industrie 4.0'):** network connectivity embedded in production equipment allows to exchange production data, a better control of the manufacturing process, a higher degree of customisation of the products and more integration with suppliers and customers along the value chain.
- **Smart home and Active Assisted Living (AAL)**: ICTs provide assistance and/or supervision for people with disabilities. AAL is related to home automation, but also various supervision technologies and also includes rudimentary decision-making, for example in the case of an emergency.

All these technologies are expected to have profound effects on future labour demand because they may substitute routine activities by applications of ICTs. The work of accountants, for example, may be at danger of being substituted because technologies today – and even more in the near future – will be able to correctly recognise invoices and record them according to accounting standards. This may put millions of accountants in Europe and North America out of work.

In recent years, a number of authors have tried to estimate the effects of digitalisation on employment. A tentative list of these studies can be found in the Table below; there are certainly some more on the way.

Table 1: Economy-wide studies on the impact of new ICTs on employment

Source	Result	Period	Remarks
Frey and Osborne (2013)	-47%	10 - 20 years	USA, all sectors
Bowles (2014)	-47 to -60%	10 - 20 years	All EU member states; follows the approach of Frey/Osborne 2013
Bonin et al. (2015)	-12%		DE, all sectors
Boston Consulting Group (2015)	+6%	10 years	DE, manufacturing
Wolter et al. (2015)	less than 1%	25 years	DE, manufacturing, considers also economy-wide compensation effects
Arntz et al. (2016)	-12% to -6%		OECD countries, follows the approach of Bonin et al. 2015

Source: own research.

- With around 800 citations in Google Scholar and another 280,000 search results on Google[3], the work of **Frey and Osborne (2013, 2017)** is certainly the most discussed of these studies. Frey and Osborne identify occupations with the highest content of routine tasks and estimate how many jobs could be replaced by digitalisation. They find that about 47 percent of total US employment is at risk of being substituted by ICTs within the next 20 years. The remaining jobs are characterised by one of these three features: perception and manipulation (for example finger dexterity); creative intelligence (for example the ability to come up with unusual or clever ideas as about a given topic or situation); and social intelligence (social perceptiveness, negotiation skills, persuasion).
- **Bowles (2014)** repeated the study by Frey and Osborne for the European Union and concludes that between 47% (for Sweden - similar to the US) and up to well over 60% (Romania) of the EU work force will lose their job due to ICTs in the coming decades.
- **Bonin et al. (2015),** from the German Centre for European Economic Research (ZEW), expect much lower jobs losses due to ICTs and technological change than the two aforementioned studies. He expects a reduction of 12% for Germany. Here, a main difference to Frey and Osborne (2013, 2017) and Bowles (2015) is that Bonin et al. (2015) focus on tasks **within** occupations, rather than on occupations itself. Occupations include various tasks, routine and non-routine, and require a set of different skills. People apply their skills to deliver various tasks (Autor 2013). It is therefore unlikely that ICTs makes complete occupations

3 Retrieved May 20, 2016

obsolete - which the central assumption of Frey, Osborne and Bowles who estimate how 'computerisable' different jobs are.

- The **Boston Consulting Group** (BGC 2015) studies the impact of Industrie 4.0 in the German manufacturing sector on the basis of expert interviews and statistical data. They find that Industrie 4.0 will have positive impacts on productivity, revenue, employment and investment. For employment, they see a six percent increase or 390,000 additional jobs until 2025. However, they also expect transformations within the workforce with displacement among workers who perform simple, repetitive tasks.
- **Wolter et al. (2015),** from the German Institute for Employment Research (IAB), employ a multi-sector input-output model for the German economy and estimate the economic effects of five aspects of the advance of Industry 4.0, including higher investments in ICTs infrastructure and equipment, changing intermediate demand and changing demand for various occupations. This approach also considers indirect economic effects via demand for investment and intermediate goods.

  They find only a very small reduction in the overall number of employees (-60,000) due to Industry 4.0 until 2030. However, the model also predicts huge structural change within manufacturing and between manufacturing and services: the small total effect of minus 60,000 results from a loss of 420,000 jobs, but also gains of 360,000 jobs in manufacturing.
- Finally, **Melanie Arntz et al. (2016)** follow the approach of Bonin et al. (2015) and consider routine tasks rather than routine occupations. They find that the share of workers who have the highest probability of being replaced by automation is largest in Germany and Austria (12% of the workforce), and lowest in Estonia, Finland and Belgium (6-7%).

Which tasks are favoured or threatened by technology? A closer look at Frey/Osborne

The study of Frey and Osborne ranks 700 occupations according to their potential for automation. This ranking is based on experts' opinions and the description of job profiles. These are the occupations with the highest (99% probability) chances of being replaced by technology:

Data Entry Keyers, Library Technicians, New Accounts Clerks, Photographic Process Workers and Processing Machine Operators, Tax Preparers, Cargo and Freight Agents, Watch Repairers, Insurance Underwriters, Mathematical Technicians, Hand Sewers, Title Examiners, Abstractors, and Searchers, and Telemarketers.

The opposite side of the spectrum consists of occupations with a very low (less than 4% probability of being replaced by technology:

Recreational Therapists, First-Line Supervisors of Mechanics, Installers, and Repairers, Emergency Management Directors, Mental Health and Substance Abuse Social Workers, Audiologists, Occupational Therapists, Orthoptists and Prosthetists, Healthcare Social Workers, Oral and Maxillofacial Surgeons, First-Line Supervisors of Fire Fighting and Prevention Workers, Dieticians and Nutritionists, and Lodging Managers.

The difference between the two groups is obvious: the latter occupations include intensive interaction with persons (mostly patients), and require creative and social intelligence, while the first group does not.

In addition, three other studies with a narrower focus deserve to be mentioned here:

- First, the analysis by Pantea et al. (2014) uses firm-level instead of country-wide data like the studies mentioned above. Firm-level data has the advantage to give an average effect instead of the aggregate effect, which may be distorted by very large or very small actors. The authors come to the conclusion that no negative relationship between employment growth and the intensity of ICT use by firms exists.
- Second, Michaels and Graetz (2015) investigate the impact of robots on employment at industry level for the period 1993 to 2007 for 17 countries. They find a positive effect of increased use of robots in industry on productivity, wages and subsequently on GDP growth. They do not find evidence of a negative effect of robots on aggregate employment, only a negative effect on low-skilled workers and a weaker effect for middle-skilled employment.
- Third, Fraunhofer ISI (Jäger et al. 2015) analyses the impact of robots on employment for the period 2007-2009, but in contrast to Michaels and Graetz (2015) with firm-level data. They confirm the aforementioned result and find neither a positive nor a negative direct employment effect. However, they show that firms using robots reveal a significantly higher productivity. An interesting side result is that firms which use robots have a much smaller probability to offshore production to locations abroad.

Obviously, there is no common opinion in the literature on the future impacts of information and communication technologies on employment. Estimates vary between employment gains and employment losses of nearly half of the workforce, depending on the method and the assumptions used.

Differences in the method employed are most obvious between Frey and Osborne (2013, 2017) and Bowles (2014) on the one hand and Bonin et al. (2015) and Arntz et al. (2016) on the other hand. The latter studies try to break down occupations into various tasks and analyse substitution at the task level. This approach assumes that occupations consist of various routine and non-routine tasks; examples for non-routine tasks are inter-personal group work or anything including face-to-face communication, all things technology is not very good at. So, even if a robot would take over checkout at a supermarket, if may not be the same if a robot or a person wishes you a fine day. Bonin et al. (2015) and Arntz et al. (2016) consider that jobs such as supermarket checkout include routine and non-routine tasks.

It is interesting to have a look at what job profiles are regarded under threat of substitution by the various studies. The occupations with the highest risk of being replaced in Fry and Osborne (2013, 2017) are insurance underwriters, mathematical technicians, hand sewers, title examiners, abstractors, and searchers and telemarketers. Other occupations with a high probability to disappear are tax preparers, cargo and freight agents, data entry keyers, library technicians, insurance appraisers for auto damage, order and brokerage clerks, and tellers. At the other side of the spectrum are recreational therapists, emergency management directors, mental health and substance abuse social workers, audiologists, occupational therapists, healthcare social workers, dentists and oral surgeons, or dieticians and nutritionists.

Such lists are more difficult to identify in the study of Bonin et al. (2015) since they focus on tasks and not occupations, but Arntz et al. (2016) provide examples: people working in the occupation 'Bookkeeping, Accounting, and Auditing Clerks' face an automation potential of 98%. However, only 24% of all employees in this occupation can perform their job without group work or face-to-face interactions; both factors may hamper substitution. Moreover, people working in the occupation 'Retail Salesperson' face an automation potential of 92%. Despite this, only 4% of retail salespersons perform their jobs with neither both group work nor face-to-face interactions. This demonstrates the difference in the two approaches.

Another insight from the comparison of these studies is the fact that new technologies may destroy the demand for certain tasks, but rarely extinguishes whole occupations. This is the main difference between the results of Frey and Osborne (2013) and Bowles (2014) on the one hand and Bonin et al. (2015) and Arntz et al. (2016) on the other hand. ICTs may change the routine content of occupations, but this does not necessarily mean that the whole occupation becomes redundant.

A common weakness of all these studies is that they restrict themselves to the estimation of the **losses** from new technologies based on current employment and occupation structures. There is no information in these studies on future gains from new technologies. As discussed in Chapter 3, technology displaces employment, but also creates new employment via demand for new products, and price reductions for existing products which may levy demand for these products and foster employment. This creation of employment via new products is difficult to assess, because it is basically about products that do not exist so far. This is also a challenge for studies that employ macroeconomic models like the one by Wolter et al. (2015).

We can only rely on the historical evidence from past major innovations, which show that employment losses are more than compensated by employment gains from new technologies. Three effects are responsible for this compensation:

- A minor effect comes from **additional investments** in infrastructure and new machinery for digitalisation, which creates employment in the sectors that produce these investment goods;
- A second effect comes from **decreasing costs** due to ICTs that are passed on by the enterprises to consumers in competitive markets. Lower prices, in turn, generate new demand, and new jobs.
- Third, we may expect a considerable number of **new products** from ICT-based innovations, which will create new demand and also new jobs. However, they may also displace existing products via the business stealing effect.

The result by Wolter et al. (2015) of huge structural changes in the manufacturing workforce brings us back to the tasks approach. Tasks that are not substituted by new technologies benefit from them because these technologies can augment the productivity of non-routine tasks and therefore complement them. This is the reason why Wolter et al. (2015) also predict considerable gains in non-routine tasks which we find in technical and scientific occupations, but also in teaching while machine operators will see large losses. These complementarities between specific tasks part of different occupations and new technologies are a second source of employment growth, besides now products. They may also the reason why the three firm-level studies find no negative effects of ICTs or robots in particular on employment.

There is, however, a big caveat to these considerations. Martin Ford (2015) speaks for many observers when he asks: is this time different? Ford and other authors point out that there are some factors present in the current development of ICTs that have not been in place in previous technological revolutions. A first deviation is the speed of improvement in microprocessor technology, which has been described by Moore's Law. According to Moore's Law, the number of integrated circuits on a chip doubles every 24 months, which also indicates that the processing power grows exponentially.

Exponential growth of power, however, is a feature that was not present in steam power or electrification. As a consequence, costs of processors, sensors, cameras etc. have fallen much faster than did the costs of electrical power or steam power. Nordhaus (2007) estimates that computer performance has improved by a factor of between 1.7 trillion and 76 trillion since manual computing of the Mid-19th century. This could mean that we still underestimate the range of future applications for ICTs, which may raise exponentially just as computing power (Ford 2015).

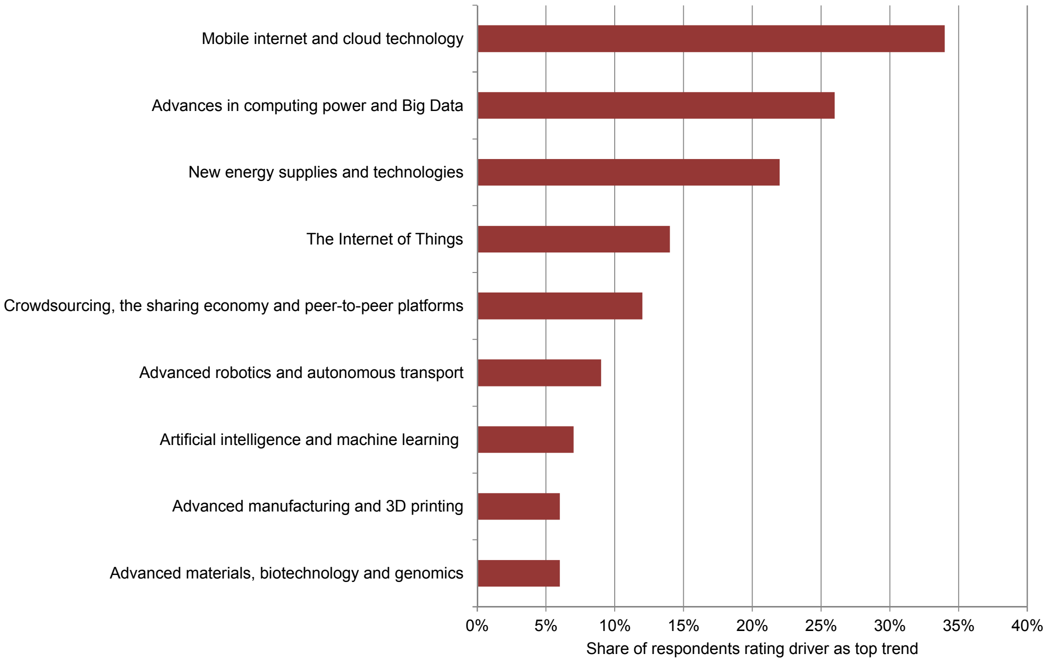
Another implication from this explosive growth in performance is that ICTs are maybe more widespread today than steam power or electricity ever was. This would also imply that ICTs are a part of much more workplaces, firms, and households than steam power or electricity ever were, and that changes related to ICTs are much deeper than with previous technological changes.

Moreover, digital goods such as movies, pictures, online services and any other digitalised information can be reproduced at very little cost, even at zero marginal cost (Brynjolfsson and McAfee 2014). This is a cost advantage very difficult to beat by human labour, even it if became much more productive with ICTs.

5.2. Employment effects of other emerging technologies

Outside information and communication technologies the employment effects of new technologies are hardly an issue for academic research or consulting. The World Economic Forum (WEF 2016) has conducted a survey on drivers of future change in the economy (see Figure 13 below); all but two of these technology drivers are related to ICTs. Respondents see an economic significance beyond ICTs only in advanced materials and health applications of biotechnology.

Figure 13: Technological drivers of change, 2016



Source: World Economic Forum (WEF, 2016), p. 7.

It is therefore not surprising that only very few studies tackle the employment effects of new technologies other than ICTs. Wydra (2011) investigates the employment effects of biotechnology in Germany and finds huge differences depending on the sector where biotechnology is applied. His results also indicate that indirect effects from higher intermediate demand are more important than direct effects. In contrast to ICTs, biotechnology leads only to little substitution of human labour by technology.

Another relevant area is the literature on 'Green Jobs' and the employment effects of environmental technologies. A study by the OECD (2012) summarised the previous literature and provides model estimates for the employment effects of change towards a low-carbon economy. The transition to green growth would first have very diverse employment effects across sectors with huge employment gains for the manufacturers of solar and wind electricity equipment, but also considerable employment losses related to oil and coal mining sectors. Energy generation itself is not labour-intensive and plays only a minor role in these calculations. Since the heavily impacted industries represent only a small share of total employment, these changes do not translate into a large overall reallocation of jobs and total employment would not be affected by mitigation policy (OECD 2012, p. 27). In another survey, Meyer and Sommer (2014) include 23 studies on environmental innovations and come to the conclusion that the majority of them show positive net employment effects for environmental innovations. However, they also point to large differences in the underlying technologies and the competitive position of the firms or sectors.

A particular interesting field for employment effects is resource efficiency, because a reduction of material inputs may lead to less economic activity and less employment. Cooper et al. (2016) investigate this issue for materials efficiency in two case studies on steel consumption in the UK. Surprisingly, they find that more efficiency does not mean less employment. A similar result is found by Sartorius (2015) who investigates the effects of 16 efficiency-increasing innovations for Germany. The International Labour Union points to the opportunities for creating employment from sustainable refurbishment of buildings (Keivani et al. 2010).

To sum up, a considerable literature has evolved on the employment impacts of information and communication technologies. The main message from some of these studies is that we should expect considerable reductions in employment; however, other studies predict much lower employment losses. Since these studies only focus on losses and hardly consider the gains from ICTs, they may overestimate the negative effects of these technologies and underestimate possible positive compensation effects. A second relevant field are studies that examine the employment effects of environmental technologies. A common finding from these studies is that environmental technologies will have only little impact on employment.

6. Technology and inequality

Skill-biased and routine-biased technological change which we discussed in the previous chapter are two mechanisms that can increase inequality, because they favour particular groups of the workforce and reduce the employability of other groups, in particular low skilled workers. Erik Brynjolfsson of the MIT sums up many contributions to the recent debate when he states: 'My reading of the data is that technology is the main driver of the recent increases in inequality. It's the biggest factor'. (Technology Review 2014).

Thus, technology is highly relevant in recent discussions on inequality. Many people see inequality as a big concern in society, and are worried about rising levels of inequality in the US and Europe. These worries are also confirmed by a number of recent major publications (Piketty 2014; Atkinson 2015; Stiglitz 2015).

6.1. The relationship of technology and inequality

Before we have a look at the data we have to clarify some terms regarding inequality. There are many areas where one may find inequality, for example social inequality, inequality before the law, health and mortality inequality, etc. The current discussion mainly deals with monetary inequality.

There are two principal ways to look at monetary inequality: first, in terms of income inequality, second in terms of wealth inequality. The measurement of income inequality is more or less straightforward, by looking at the income of individuals or households before (market income) as well as after public transfers and taxes. Further adjustments to the data can be made to account for part-time or full-time employment, various skills levels, sectors etc.

Wealth inequality is more difficult to measure, despite some progress in recent years. Key challenges in the collection of data on wealth inequality include the assessment of real estate, the treatment of debts, non-response in the wealthiest percentiles of the population, or the assessment of social security claims. New empirical evidence for Europe came from the Eurosystem Household Finance and Consumption Survey (ECB 2013), a project co-ordinated by the European Central Bank. This is why there exist only very few data – except the ECB study – which allow a cross-country comparison of wealth and wealth distribution. We will therefore stick to income data, which also allows to link measures of inequality to occupations and sectors.

Despite current discussions which regard technology as a driver of inequality, there are numerous examples from the past where new technologies **reduced** inequality. A common pattern in the history of technology is that technological change made products and services - which were previously reserved only for a small group of people - available for a large part of the population. This is basically the story of the mass production of textiles, pottery and other household goods during the First industrial revolution, mass transport and electricity during the Second industrial revolution, or advances in medicine in the 20th century (Freeman and Soete 1997).

A modern example how new technologies create equality are mobile phones in developing countries. Aker and Mbiti (2010) report that the introduction of mobile phone services has reduced communication costs and increased access to vital information such as prices for agricultural products. Thus, mobile phones help to overcome the information asymmetries between farmers and traders and produced tangible economic benefits, improving agricultural and labour market efficiency and producer and consumer welfare (Aker and Mbiti 2010).

Technology also contributes to equality by freeing up time and money that can be saved for other activities. The washing machine is perhaps the best example for the fact that time-saving contributes to equality because it liberated women from one of the most time-consuming household activities (Cardia 2008).

However, the literature has also identified various ways technology and innovation increases inequality. These effects are at the centre of today's discussions of technology and equality. A first channel is differences in skills or tasks. New technologies require various sets of skills and/or replace various types of tasks, which are unevenly distributed in the workforce; we have discussed **skill-biased** and **routine-biased technological change** in Chapter 4. New information technologies, for example, complement skilled labour and shape demand for unskilled and skilled labour in favour of the latter; they substitute routine tasks, and make them increasingly replaceable. Skill-biased and routine-biased technological change may contribute to a higher inequality, which may *multiply* when negative scenarios of digitalisation and technological unemployment become reality.

Another way how innovation may increase inequality is the degree innovators are able to reap the economic benefits from their innovations (also called appropriability). Today, some economists find a tendency towards **winner-take-all markets**, a market where a small number of people or firms gain most of the income or sales available in this market (Rosen 1981; Frank and Cook 1995). Winner-take-all markets contribute to more income and wealth inequality because they allow that the profits of one sector are mostly or even entirely appropriated by one or a small number of firms. This is a sharp contrast to markets where one firm holds only a small or medium fraction of the global market. Winner-take-all markets can be seen as a type of natural monopoly where new technologies create cost structures that lead to one firm taking the whole market.

Krueger (2005) explains this development which is fuelled by new technologies by citing Alfred Marshall's explanation why a gifted opera singer in the 19th century was paid less than a superstar salary: “But so long as the number of persons who can be reached by a human voice is strictly limited, it is not very likely that any singer will make an advance on the £10,000 said to have been earned in a season by Mrs. Billings at the beginning of the last century ...”

Technological change, from the gramophone to online streaming services has removed such barriers and multiplied the number of people the opera singer can reach at a time. The same happened for actors, writers and directors with the advance of cinema, television, DVDs and streaming, and also in other sectors (examples are software, social networks, internet services etc.). The market share of the second largest search engine on the internet is only a tiny fraction of Google's market share.

Brynjolfsson and McAfee (2014) identify three developments that make winner-take-all markets more common today:

- The digitalisation of information, goods, and services makes the reproduction of them very cheap;
- Improvements in telecommunications and transport and the global economic integration increase the number of consumers a firm can potentially reach;
- Standards, networks and network effects become increasingly important.

A surprising fact about winner-take-all markets is that the factors that promote their emergence can also lead to their decline. Digitalisation of information, goods and services not only reduces the marginal cost of their reproduction to almost zero, but also considerably lowers fixed cost and therefore entry barriers for new entrepreneurs (Brynjolfsson und McAfee 2014). New market entrants may therefore have a better chance to overcome monopolies in these markets than in other parts of the economy.

A third way how innovation creates inequality is the **business-stealing effect** described in a previous chapter. New innovations compete with old products and make them obsolete. The business-stealing effect leads to structural change in the economy, and creates growing and declining sectors with increasing and shrinking employment. The automobile made horse-powered transportation redundant in the early 20th century, and we see similar examples in other fields today. Unemployment in these declining sectors may be a major source of inequality in the society, if employment is not re-allocated from declining to increasing sectors – which is often not easy because of different skills requirements between industries.

Some economists argue that inequality from innovation is the price we have to pay for technological progress. This has already been pointed out by Joseph Schumpeter (1911): The main incentive for entrepreneurs to introduce new products is the reward of gaining market power and monopoly rents. A new formulation of this thought is presented by Mankiw (2013). He confirms that the incomes of individuals at the top, especially in the top one percent, have grown much faster than average since the 1970s in the US. Mankiw defends the top one percent and points out that these high earners have also made significant economic contributions to growth and income of many other people. He asks if society would be really better off without their achievements, and admits that many of these questions are rather in the sphere of political philosophy than economics.

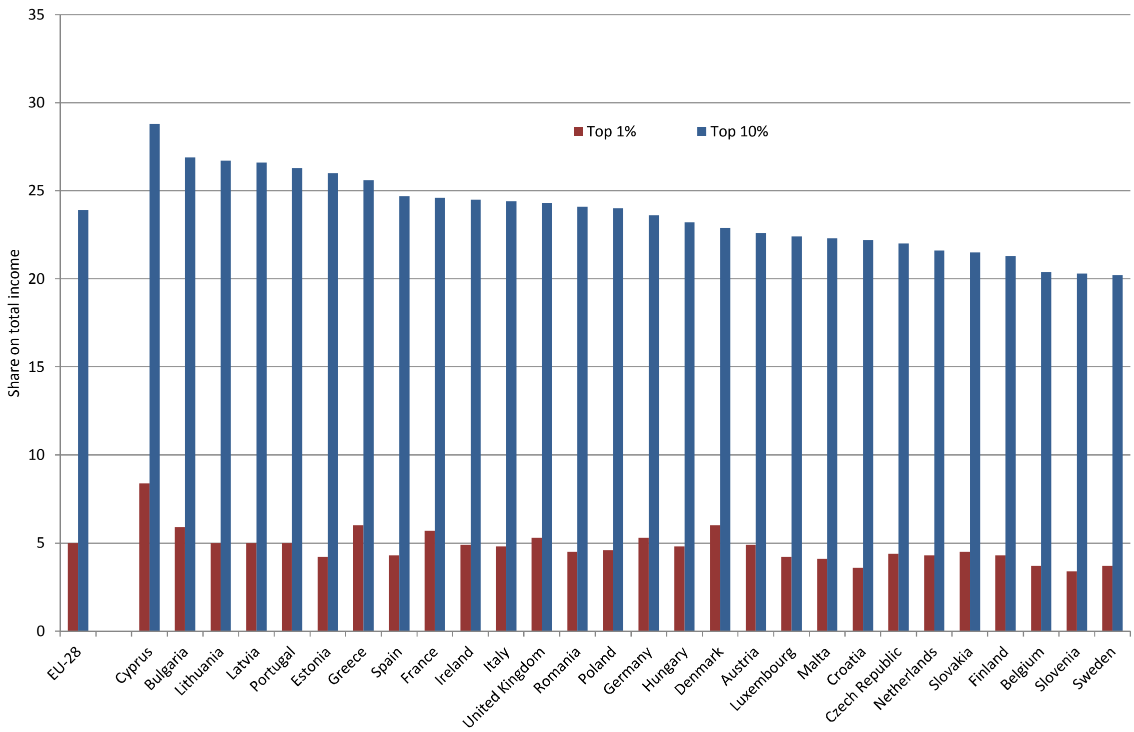
Public debates on employment often distinguish between 'good', well-paid and secure jobs and 'lousy' jobs with low pay and insecure employment conditions. Will technological change create good or lousy jobs in the future? From the perspective of skill-biased technological change is seems quite clear that technology will create more good jobs in the future, simply because they are complementary to the productivity-enhancing characteristics of new technologies. From the perspective of routine-biased technological change the picture is more differentiated. Lousy jobs can also thrive in times of technological change if they have a low routine content. This may be the case for platform workers, self-employed in transport and delivery services, cleaning, health services etc. So, technological change does not inevitably push back lousy job. There is, however, a clear tendency that they become less frequent.

6.2. Evidence for inequality in Europe

What is the evidence for a growing degree of income inequality in Europe? For the period between the mid-1980s and the late 2000s, the evidence clearly points to rising inequality (OECD 2011). In this report, we focus on the last 10 years.

A first, well-known measure of inequality is the share the top one, five, or 10% of the population have on income. We find the largest degree of income inequality for this indicator in Cyprus, Bulgaria and Lithuania, and the lowest degree of inequality in Sweden, Slovenia and Belgium. In 2006, Portugal revealed the highest degree of inequality, while in 2010 it was Lithuania. However, there is a certain degree of consistency between the Top one percent and Top 10% rankings, and also a large overlap with other rankings. Rankings based on the Gini coefficient measure the overall concentration of income across the income distribution. The countries with the smallest Gini coefficient and the most equal income distribution in the EU are Slovenia, the Czech Republic, Sweden and Finland, while the most unequal countries are Latvia, Lithuania, Bulgaria and Cyprus. This is also the picture revealed by the Figure below.

Figure 14: Income share of the Top one percent and top 10% of the population, EU-28, 2014

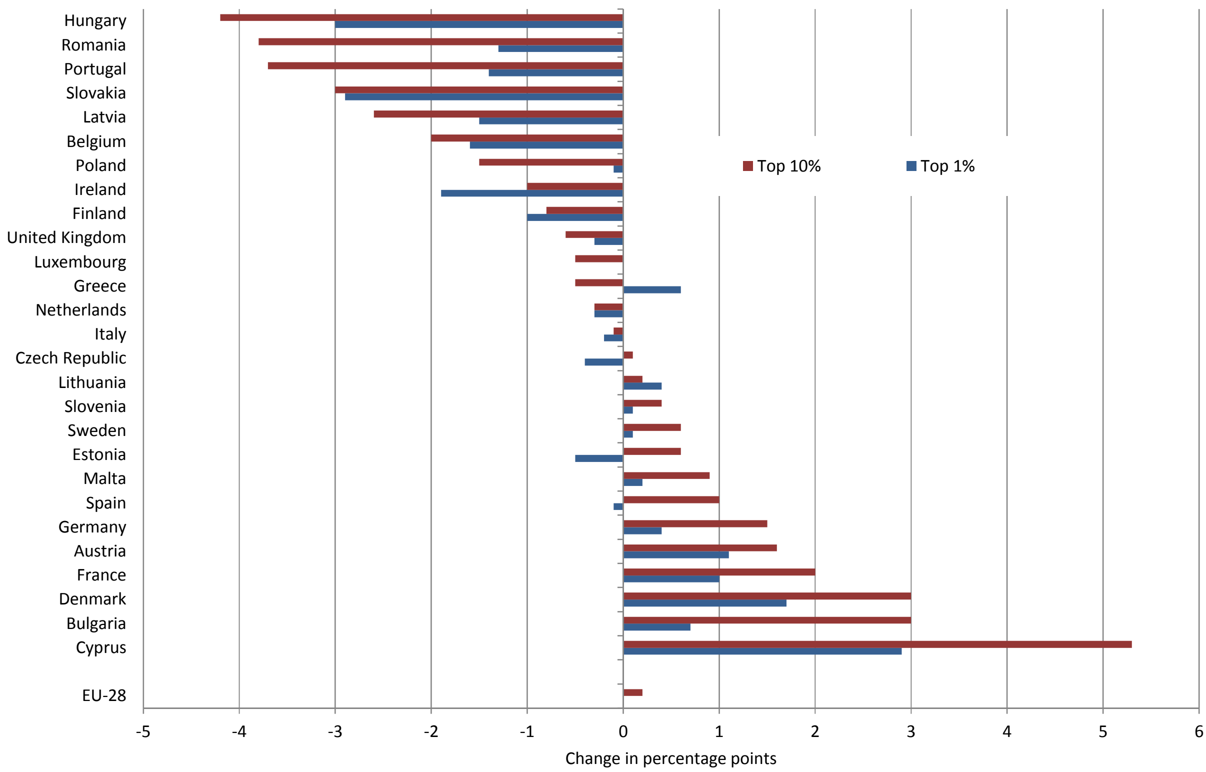


Source: EUROSTAT, Community Statistics on Income and Living Conditions (SILC).

The income shares of the Top one percent and Top 10% of the population were quite stable in the period 2006-2014. At the EU-28 level, there is no change in the income share for the Top one percent, and only a small gain of 0.2 percentage points for the Top 10%. However, we find much more movement at the member states level (Figure 16). The largest increases in inequality can be found in Cyprus, Bulgaria and Denmark, while inequality decreased in Hungary, Romania and Portugal. Portugal was the country with the highest degree of inequality in 2006, while Denmark was one of the most equal countries in those years in the EU.

The development in large member states which considerably influence overall EU development was unequal; a rise in the income shares of the Top one and 10 percent in Germany and France, a decrease in Poland and the UK. Spain saw a rise in the income share of the Top 10%, but a decrease in the income share of the Top one percent. There is also very little movement in the median values for the Top 10% and Top one percent across all EU member states. Altogether, there is no evidence that income inequality has changed in one or the other direction in the EU during the last nine years. There is some evidence of rising inequality in the period before, but we are mainly concerned with the most recent period since this is the time where effects from technological change may have materialised.

Figure 15: Changes in the income share of the Top one percent and top 10% of the population, EU-28, 2006-2014



Note: Data for 2006-2009 without Croatia

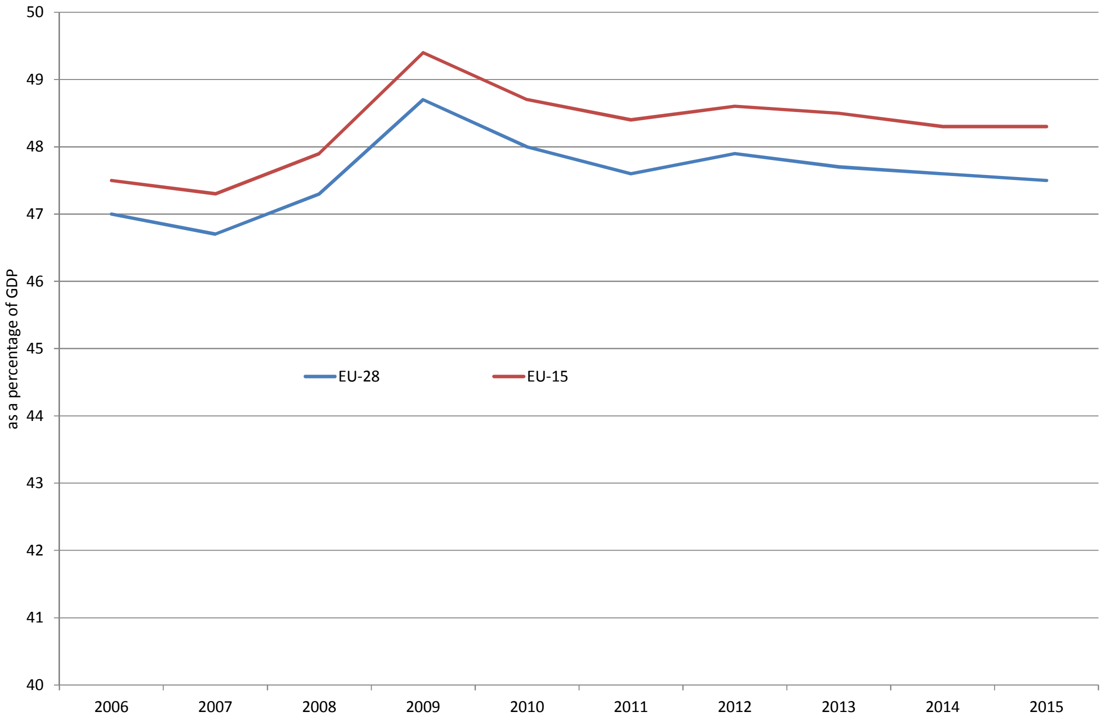
Source: EUROSTAT, Community Statistics on Income and Living Conditions (SILC).

The argument above about inequality and automation was that automation replaces workers by machines, which in turn leads to unemployment and to a shift of economic benefits from workers to the owners of capital. So, we have to look at the distribution of income between workers and capital owners. A first measure for this distribution is the share of the compensation of employees (wages, social security contributions by employers) on gross domestic product (GDP). A falling share would indicate that capital owners appropriate a higher share on GDP, which may be due to a higher automation and a substitution of labour by machines.

This was, however, not the case, as the figure below indicates. The indicator remains quite flat at a level of 47-48% throughout the period. At country level we see the largest decreases in the United Kingdom (-2.9%), Portugal (-3.6%), Ireland (-5.1%), and Romania (-5.8%). The reasons for this decrease may be related with the crisis and high unemployment. The US also saw a declining share of employees' compensation on GDP and other measures (Lawrence 2015).

However, there are also countries in the EU where the labour share has increased, most notably Bulgaria, Estonia, Sweden and Austria. Germany, as the largest economy in the EU, also witnessed an increase in the labour share, as France and Italy. So it would be wrong to say that employees lost shares on GDP during the last nine years.

Figure 16: Compensation of employees as a share of gross domestic product, 2006-2015



Source: Eurostat, national accounts

We now look at the level of sectors to find more evidence for the development of the wage share over time. The following table shows the share of personnel costs on value added at factor costs for different sectors and their development over time. The value added of all sectors adds up to gross domestic product, however, we do not provide data for value added from governmental activities here.

The picture at sectoral level is similar to the aggregate picture, as we do not have an indication for a decrease in the share of employees, measured by personnel cost, on value added. There are some sectors where we indeed find a decrease (construction and transport), but the overall share is rather increasing than decreasing. Trade has rising personnel costs and a stagnant value added, resulting in a rising labour share.

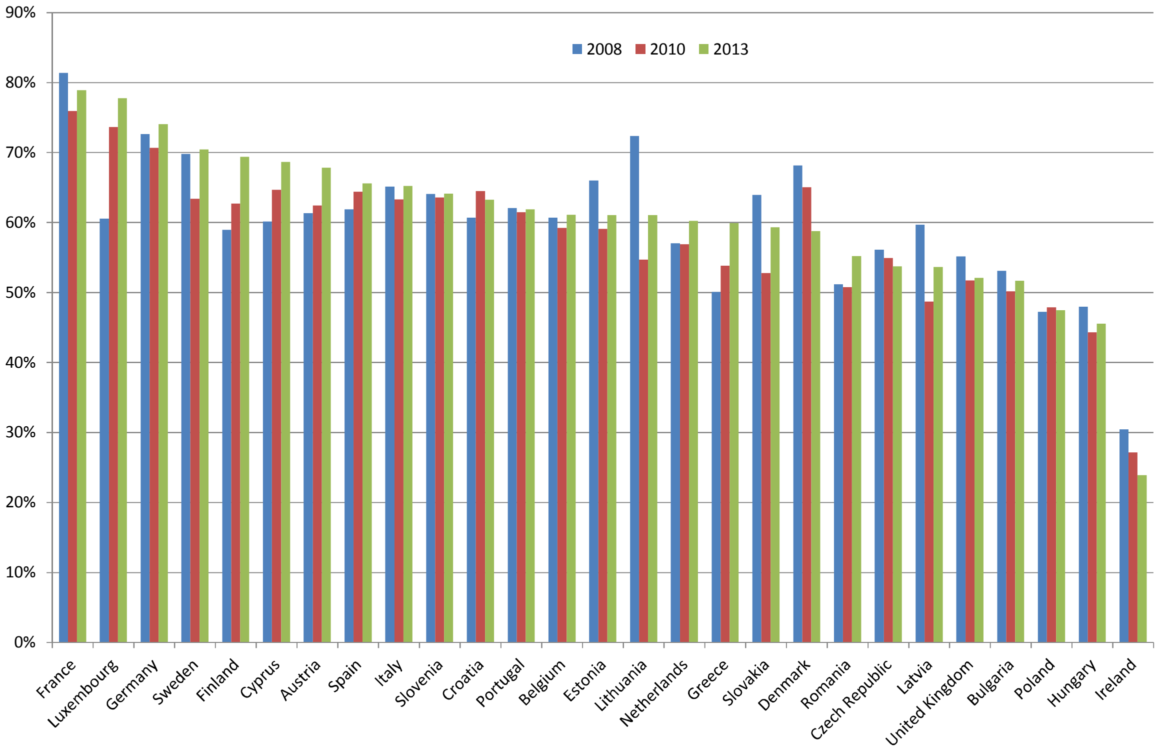
Table 2: Share of personnel costs on value added in various sectors, 2013 and change between 2008 and 2013, EU-28

Sector	Share 2013	Change 2008-13
Tourism	68.9%	2.5%
Manufacturing	65.9%	1.6%
Construction	65.8%	-0.5%
Trade	64.8%	5.5%
Transport	63.5%	-1.0%
Professional, scientific and technical activities	61.7%	2.5%
Information and communication	54.7%	2.6%
Total business sector	60.3%	2.4%

Source: Eurostat, Structural Business Statistics, own calculations

An increase in the personnel costs on value added can also be seen in most countries, with only some exceptions. The overall development of the EU is, of course, driven by large countries, which all – with the exception of the UK - show rising or at least stagnant personnel costs as a share of value added. So, there is no indication for more inequality between workers and capital owners in the EU.

Figure 17: Personnel costs as a share of value added at country level, 2008, 2010 and 2013, EU-28



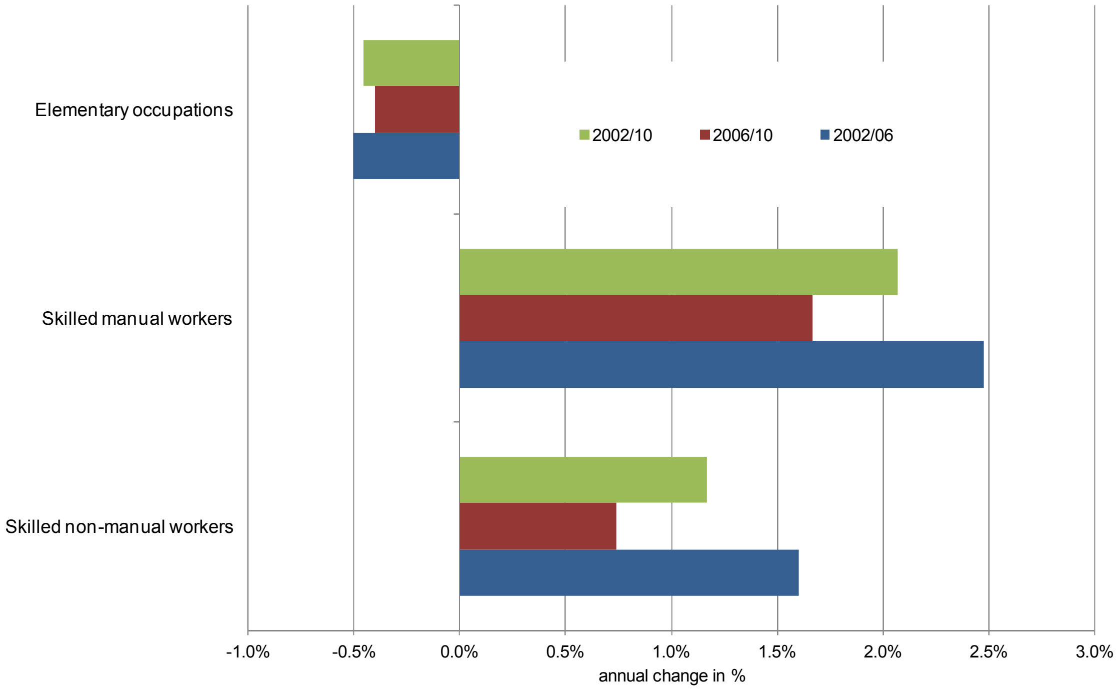
Source: Eurostat, Structural Business Statistics, own calculations

The literature reviewed above points to differences between various occupations and skills levels in their income over time, so we will, in a next step, look for rising inequality within the labour force between different skills levels.

The following Figure indicates that inequality between different occupational classes - which also resemble different skills levels - has indeed increased. It shows the annual average change in hourly wages for three broad occupational groups in the business sector between 2002/06, between 2006/10 and for the full period 2002 to 2010.

There is clearly wage dispersion with average losses for elementary occupations of around 0.5 percent a year and wage increases for skilled manual and non-manual workers. A decrease of 0.5 percent annually adds up to minus 1.6 percent between 2006 and 2010, or minus 3.6 percent between 2002 and 2010. Total hourly wages increased on average between 1.6 and 1.8 percent per year, so skilled manual workers (e.g. plant and machine operators, craft workers) had a favourable wage development compared to the average worker. This can be taken as an indication for skilled-biased technological change in European labour markets.

Figure 18: Average annual change in hourly wages for three different occupational groups, 2002 – 2010, EU-28

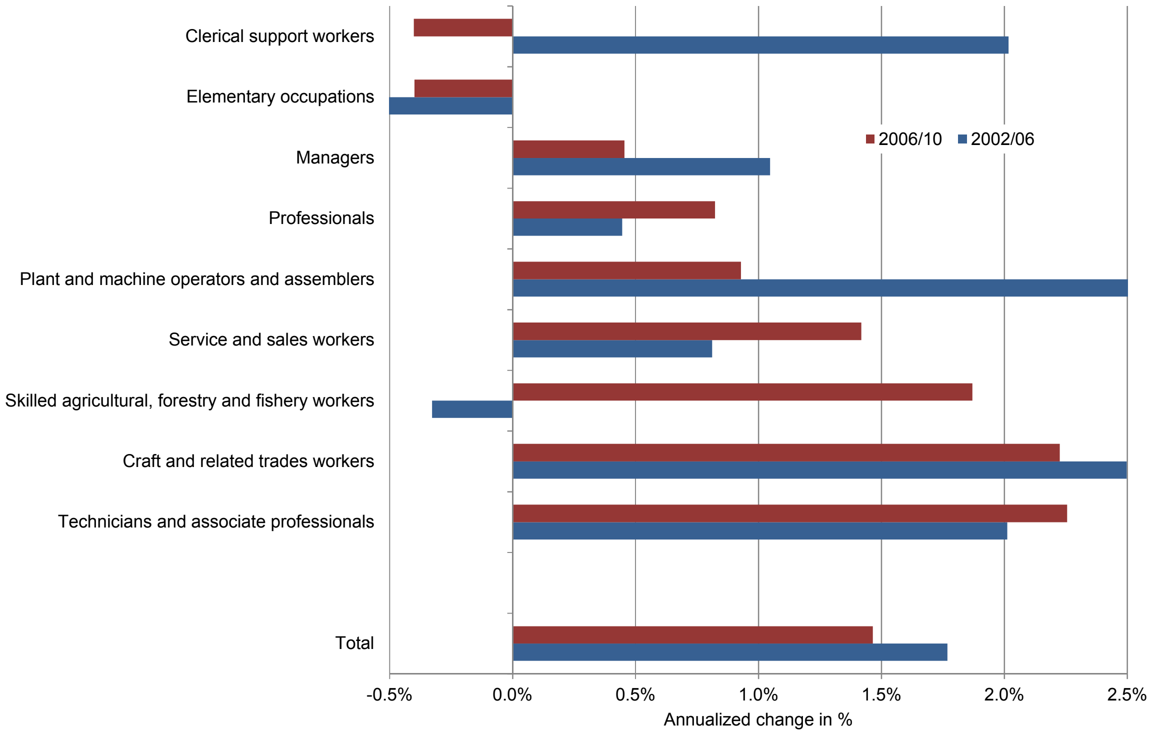


EUROSTAT, Structure of earnings survey, own calculations

A more detailed picture of the development gives the following Figure 19. We see the decrease in wages for elementary occupations we already know from the previous Figure. In addition, the data also show a decrease in the wages for clerical support workers for the period 2006-2010, which was not the case in 2002-2006. This may be a first indication for the jobs-destroying effects of digitalisation in white-collar professions. Managers have by far the highest average hourly wages - around double the wage of the average worker - but also saw below-average wage increases during this period. Craft workers and technicians had the best wage performance.

Finally, we can also measure inequality due to skills differences by calculating the wage of the occupation with lowest hourly wage as a percentage of the occupation with the highest hourly wage, this is, managers. Inequality has also increased in this indicator between 2002 and 2010: in 2002, the average hourly wage of elementary occupations was 35.1% of the average hourly wage of managers; in 2010, this value decreased to 31.9%. Inequality was even higher if we look at annual wages instead of hourly wages. Here, full-time employed people in elementary occupations only gained 31.8% of managers in 2006 and 29.8% in 2010. Unfortunately, data on annual wages are not available for 2002.

Figure 19: Average annual change in hourly wages for different occupations, 2002–2006 and 2006-10 EU-28



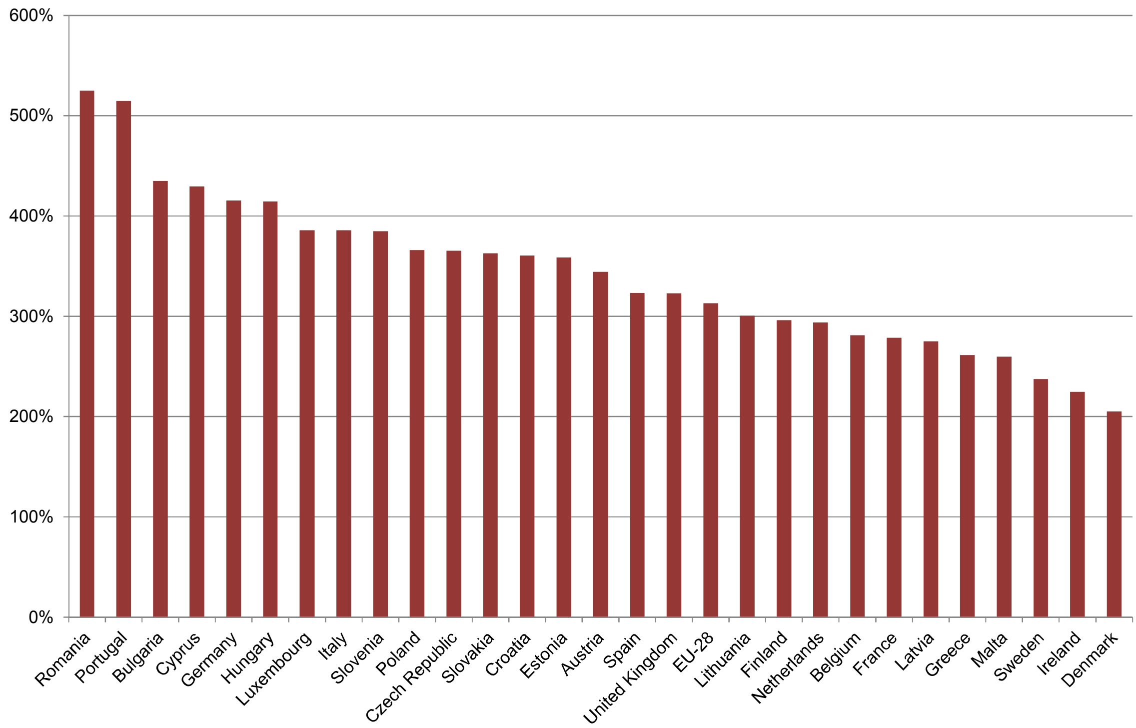
EUROSTAT, Structure of earnings survey, own calculations

Differences between the wage of the occupation with lowest and the highest hourly wage can also be used to compare countries (Figure 20). It turns out that the countries with the lowest degree of inequality between occupations are Sweden, Denmark and Ireland, while Romania, Portugal and Bulgaria reveal the highest degrees of inequality. This confirms the result of the comparison of the Top one percent and Top 10% income earners (Figure 14).

It should be noted, however, that the average hourly pay of a manager in Romania (7.14 EUR) is only a third of the average hourly wage of a worker in an elementary occupation in Denmark (21.46 EUR). Moreover, the very high average wage for elementary occupations in Denmark raises some doubts about the comparability of the data. The corresponding value for Sweden is only half (13.43 EUR), which is nevertheless still two times the wage for managers in Romania.

To sum up, there is evidence for a growing degree of income inequality in Europe between the mid-1980s and the late 2000s (OECD 2011), but not for the last 10 years in the EU, although there are some countries where income is more unequal distributed today than it was 10 years ago. There is no sign that capital owners would acquire a larger share on economic welfare, either. However, we find evidence that inequality between workers in elementary occupations and in skilled occupations has increased. The wage gap between managers and elementary occupations has widened which points to skill-biased technological change in European economies.

Figure 20: Wage of the occupation with the lowest hourly wage as a percentage of the wage of the occupation with the highest hourly wage, EU-28, 2010



EUROSTAT, Structure of earnings survey, own calculations

The previous chapter came to the conclusion that digitalisation is unlikely to destroy a large number of jobs. However, based on the results of this chapter, there seems to be an uneven distribution of the **costs of digitalisation**: ow skilled workers are likely to bear the brunt the adjustment costs of innovation, because the risk of automation and displacement of their jobs is higher. Another group with a potentially high burden is medium-skilled white collar occupations with a high share of routine tasks that can be found in particular in service industries. Therefore the likely challenge of the future lies in coping with rising inequality from technological change.

7. ICT, employment and the Social Economy

We now move our focus to a specific sector of the European economy, the Social Economy or the Third Sector (Monzón Campos and Chaves Ávila 2012; OECD 2013). The Social Economy consists of firms and organisations organised as co-operatives, associations, mutuals and foundations. Hence, experts also see the Social Economy defined by certain organizing principles rather than economic activities (OECD 2013, p. 16):

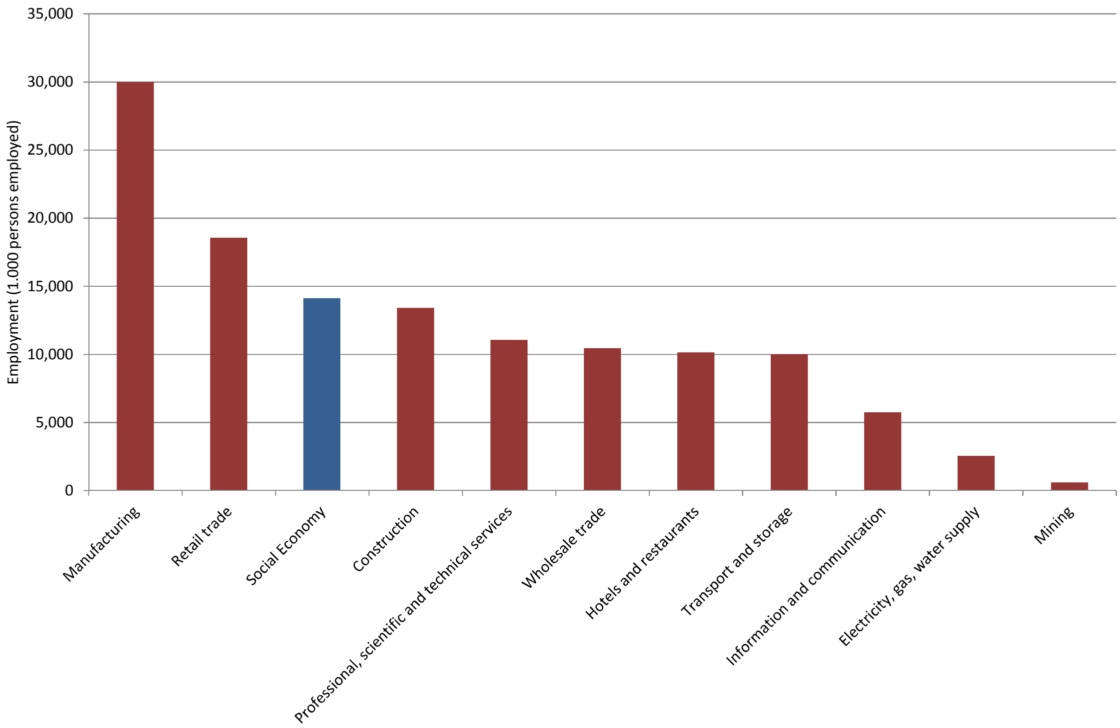
- Placing services to its members or to the community ahead of profit
- Autonomous management
- A democratic decision-making process
- The primacy of people and work over capital in the distribution of revenues

A related concept to the Social Economy is also social innovation (Howaldt et al. 2015). Some authors see the Social Economy as the main field for social innovation (Moulaert and Nussbaumer 2005), and the aforementioned principles also as relevant for social innovation. The meaning of social innovation, however, is ambiguous (Reinstaller 2013), with changing emphasis on the social aspects of technological change, on social entrepreneurship, innovation for the poor in developing economies, etc. There seems to be a consensus that social innovation should lead to positive social change. Caulier-Grice et al. (2012) define social innovation in the following way: 'Social innovations are new solutions (products, services, models, markets, processes etc.) that simultaneously meet a social need (more effectively than existing solutions) and lead to new or improved capabilities and relationships and better use of assets and resources. In other words, social innovations are both good for society and enhance society's capacity to act.'

Another common goal of both social innovation and the Social Economy is employment and the improvement of employment for vulnerable groups. This is why both concepts have received increasing attention from policy in recent years.

The following Figure 21 gives an indication of the share of the Social Economy compared to other sectors in the EU-27 (excluding Croatia). With a total number of more than 14 million people employed, the Social Economy is indeed a relevant actor, even at the European stage. The sector has about the same size as the construction industry.

Figure 21: Employment in various sectors of the economy and in the Social Economy, EU-27, 2009-2010



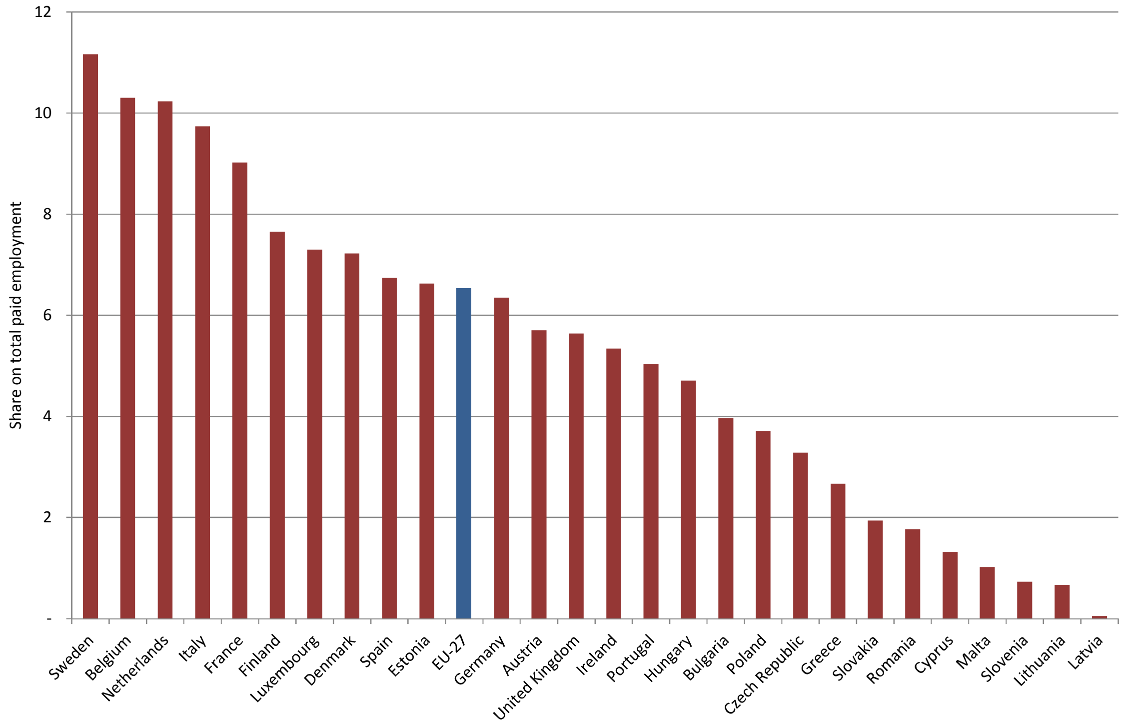
Note: Employment figures for all sectors except Social Economy are persons employed for 2010. Social Economy is 2009-10

EUROSTAT, Structural business statistics, Monzón Campos and Chaves Ávila (2012), own calculations

Monzón Campos and Chaves Ávila (2012) estimate that the Social Economy equals 6.53% of total paid employment in the EU, with the highest shares in Sweden, Belgium and the Netherlands, and the lowest shares in some Southern and Eastern European member states.

We also get a good impression about the Social Economy if we look at the fields where the organisations of the Social Economy are active in. From a large-scale case study project on the Social Economy, the OECD (2013, p. 27) reports that these organisations are mainly active in social assistance services (26%), education and training (21.1%), work integration (19.6%), culture and recreation (16.2%), and health and medical services (7.8%). Just 4.4% of the cases they analysed are active in manufacturing, another three percent in construction. Sources of revenue are the sale of goods and services and subsidies to a similar degree (around 30% each).

Figure 22: Share of the Social Economy on total paid employment in EU member states, 2009-2010



EUROSTAT, Monzón Campos and Chaves Ávila (2012), own calculations

What are the relations between the Social Economy and innovation, ICTs and employment? They are not obvious at first sight.

A first relation between these topics is given by the criteria for routine tasks provided above, which are, in the opinion of various experts, in danger of getting displaced by machines. From the list of sectors where Social Economy organisations are active in, it seems that most of them are in sectors that are highly non-routine. Social assistance services, education, work integration, culture, or health services are associated with non-routine activities (Autor 2015), and require a great deal of human interaction and social perceptiveness. Thus, we may assume that the Social Economy will be one of the sectors least affected by the jobs-destroying effects of digitalisation. Technology may have a supporting, not a displacing role in these sectors in the future. Like many service industries, they require a direct involvement of employees in the production of their output. **It seems unlikely that involvement and human interaction in the Social Economy can be replaced by ICT-enabled services.**

Second, an important part of the employment-creating activities of Social Economy organisations is also related to vulnerable groups. The OECD study finds that over three-quarters of the organisations surveyed worked with vulnerable individuals. A lack of employment opportunities in the wider labour market, but also a lack of skills are main obstacles for more employment in this group. Main employment sources for vulnerable people are routine occupations, so there may be some danger that digitalisation will make this particular part of the activities of Social Economy organisations more difficult in the future.

However, this does not mean that ICTs have no use for the Social Economy. Social internet technologies such as social networks or newsfeeds have been adopted at very high speed in recent years, and organisations in the Social Economy are beginning to make use of them (Chui et al. 2012).

The main opportunities of these technologies for the Social Economy lie in **improving communication and co-operation within groups and between people**.

An example is Austria, when around 90,000 refugees arrived in the country until the end of the year 2015. The involvement of volunteers outside professional social organisations was mainly organised by using social networks like Facebook and Twitter. Registered volunteers were called in on a day-to-day basis, depending on actual demand for support. This system has been institutionalised as 'Freiwillige Soforthilfe'[4]. People who register themselves are contacted by SMS or email when their skills are needed.

But the opportunities of social networks for the Social Economy go beyond one-way communication and mobilisation. Since social networks allow two-way communication, new forms of organisations in the Social Economy may emerge which go beyond the centralised approach of many established organisations. Moreover, social networks may also facilitate the claim for a democratic decision-making process in Social Economy organisations. Social networks may therefore open Social Economy organisations to many of the new forms of innovation described by (Leitner et al. 2012) such as Innovation Communities, Crowd sourcing, User Innovation or Open Innovation.

8. Workshop summary

A panel of experts from academia, industry and the trade unions took up the issues discussed in this report at the STOA workshop 'How is digital technology changing the labour market?'. The aim of the workshop was to discuss further the topics and findings of the report together with the audience. The workshop confirmed the relevance of the topics of the report.

The workshop took place on October 11th 2016 at the European Parliament in Brussels and was chaired by Georgi Pirinski, MEP and STOA Panel Member. Susanne Giesecke from the AIT Austrian Institute Technology was the moderator of the workshop.

Bernhard Dachs (AIT Austrian Institute of Technology) summarised the results of the study. He pointed out that innovation was in the past the answer to unemployment, at least in the long run. However, today some observers believe that the labour-friendly character of innovation has changed. Moreover, he pointed out that we cannot be sure that new technologies still contribute to a reduction of inequality, like they did it in the past when they made consumer goods, transport or electrical energy accessible to large parts of the population.

Jari Kuusisto (University of Vaasa, Finland) observed a deep transformation at all levels in European manufacturing firms. This transformation is driven by digitalisation, with the aim to increase production efficiency and competitiveness, and reduce costs. In his presentation, he regarded a skilled work force, a good education system, and a capable infrastructure as the strengths of Finland and other European countries in this transformation. He illustrated his point with the example of the company ABB in Vaasa, Finland; ABB hired several engineers at PhD level and a number of engineers at Master and Bachelor level, but only one welder in 2015; this shows the importance of skills for future manufacturing. However, disruptive innovation often happens outside Europe, and platforms which may be decisive in the future evolve outside Europe.

Zelko Pazin (European Engineering Industries Association, Belgium) agreed that European manufacturing is currently in a deep transformation. However, from his perspective, European manufacturing still looks healthy and is one of the most important economic sectors, accounting for 20% of employment, 67% of exports, and 65% of R&D expenditure in the business sector. One of the strengths of European manufacturing is its diversity; the competencies of the EU manufacturing industries are distributed over a broad range of subsectors, which is not the case for their US and

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Japanese competitors. He saw more R&D, investment in skills and the establishment of favourable framework conditions as necessary to cope with future challenges. Europe needs to stay on the top of technological development and quality of the industrial workforce in order to master the transformation.

Marco Vivarelli (Catholic University of Milano, Italy) explained that the academic debate on technological unemployment is very old, but inconsistent: the promise of economics is that job losses are compensated by new employment from higher overall production due to new technologies. However, in the real world, non-competitive markets, price rigidities, and pessimistic expectations may severely hinder and delay the compensation of the initial job losses. Today not only agricultural and manufacturing employment appears at risk, but also employees in services - including occupations that mainly rely on cognitive skills - are no longer safe. Vivarelli saw that R&D leads to job creation, but this effect is often limited to high-tech sectors, while low-tech sectors struggle. As a consequence, he stressed the need for social safety nets, and to train the unskilled.

Christine Jakob (European Public Service Union, Belgium) pointed to the need for an inclusive transition towards good and fair digital work. She also saw a need for upskilling, and more assessment of the social impacts of ICTs. Current public discussions are scattered, and there are many different approaches at sectoral and member state level; what we need is a comprehensive approach and a discussion.

Plamen Gochev Dimitrov (Confederation of the Independent Trade Unions in Bulgaria) identified in his statement a trend in the current industrial transformation of transferring the risk from employers to workers. He saw several new digital divides, including one between Eastern and Western European countries and within the group of EU member states in Middle and Eastern Europe. For example, the Digital Economy and Society Index by DG Connect reports a considerable gap between the Baltic States and the Czech Republic on the one hand and Bulgaria and Romania on the other hand.

Dimitrov pointed out that the new member states are more at risk of job losses due to digitalisation than old member states. Moreover, digitalisation may widen the gap between various groups of employees, including, in his own words, 'superstar workers' and 'digital galley slaves'. He agreed the need for new regulation to counter the effects of atomistic labour markets.

Discussion

The relevance of the topic could be seen from the number of statements and questions from the audience of the workshop. Several people from the audience picked up the topic of the **transformation of working conditions**. A main concern was the worsening of working conditions for 'gig' workers - people offering their services via platforms on the Internet. Platform work is indeed frequent in some sectors; in these sectors, firms do not have employees, they have associates. The speakers and the audience agreed that social security legislation is not prepared for it. The speakers stressed the need to give platform workers some of rights of employees. Maybe it is time to think about corporate digital responsibility, as one participant suggested?

More generally, the discussion raised the question **what exactly employment means today**. This question has very much to do with how work is performed today, and how working rights are evolving. Moreover, it was also questioned if trade unions are up to the task of reacting to the challenges. There is not unified view on issue related to digitalisation, platform work, etc. in trade unions across the EU.

There was a consensus in the discussion that we cannot stop new technologies but must **adapt our frameworks to it**; at the moment, there is a regulatory mess. There is also a lack of data on new forms of employment related to ICT, and we need these data to allow a better informed policy.

The discussion also raised the issue of a **new industrial policy**, which was seen as a necessity by the audience, but, of course, without the old mistakes. Compared with the old industrial policy, much more focus should be laid on research, development and innovation, and on the development of skills.

Finally, another topic of the discussion was the **reduction of working time**. Statements from the audience pointed out that productivity increases in the past were accompanied by a reduction of work time, which is not the case today. In this perspective, the current industrial revolution is different from previous revolutions, because they have all produced something better. So far, it is difficult to see what the digital revolution turns for the better. Maybe the productivity growth from new technologies will allow a basic income in 10, 15 years.

To sum up, there was a consensus among in the audience that there is a need for change. This need coming from the technology side, is based on the changes evidenced in the business sector and in labour relations brought forward by new forms of employment. Education and skills are key for managing this change. The challenge today is to look for different jobs for the people – good, decent jobs. There was also a consensus that we need also some additional mechanisms to compensate the losers of digitalisation.

9. Policy options

The final chapter will present options for policy. The future is uncertain, so we will depict three small scenarios – positive, negative, and regional divergence - how digitalisation and new information and communication technologies may shape employment dynamics and income equality in the next 20 years. The scenarios are based on the literature reviewed in the previous chapters.

These scenarios do not intend to present a complete set of drivers, critical factors and impacts of future developments; they rather serve as the framework of how policy can react if things evolve in a particular direction. These reactions in the form of concrete measures are discussed in the final section of this chapter.

9.1. Industrial renaissance in Europe

Looking back from 2036, it turns out that digitalisation complements Europe's strengths to a large degree. In particular, digitalisation was a good match to the competences of European firms in many manufacturing industries. Manufacturing firms took up new production technologies fast because they complemented many of their traditional strengths. European firms learned very quickly to combine the skills of their workforce with the technological opportunities of digitalisation.

This has led, for the first time in decades, to a considerable boost in productivity and new jobs. Productivity gains lead to a re-shoring of production activities back to Europe, because productivity-adjusted wage advantages of Asian locations decreased, and production in Europe close to many key clients is much more capable to take up the advantages of flexible production from digitalisation.

There was also jobs destruction from digitalisation, in particular in service firms of the banking, insurance, and professional services sector. A number of middle-skills jobs in these firms and in administrative were replaced by machines. However, many of these losses were compensated by new jobs where non-routine skills are augmented by digitalisation. This was also due to large investments in data infrastructure and in education in EU member states beginning in the second half of 2010s, which started to pay off in 2020-25. Another source of growth was Europe's traditional strength in culture, which became the basis of many new services. New information technologies lowered fixed cost and entry barriers in many fields of services and offered new opportunities for a number of entrepreneurs.

Economic growth and prosperity made it easier for European policy to dampen tendencies towards economic inequality. Education and a 'no child left behind' policy are seen as the main instruments to fight economic inequality in the long term. In social policy, one guiding principle is still flexicurity and enhancements of this concept, which help employees and employers to cope with the raising need for flexibility due to digitalisation.

Economic growth also helped to balance public budgets, ease the burden of public debts and continue a policy of social equilibrium in Europe. Taxes on income and indirect consumption taxes are still important in 2036, but are gradually complemented and substituted by environmental taxes and taxes on value added, as contribution of capital to the creation of economic wealth increases, and the labour share decreases.

9.2. Europe's industrial misery

Looking back from 2036, economic nightmares come true: digitalisation wiped out considerable parts of employment in Europe, as forecasted by some employment studies from the 2010s. Economic growth has virtually stopped, and we can witness the economic decline of regions and even whole countries. In retrospect, it seems that many people had grave difficulties to compete with new technologies based on their acquired skills, which seemed outdated when compared to the productivity of machines.

European firms also suffered from fierce competition by Asian firms and the resurgence of the United States in manufacturing and services. US banks, insurance companies and software firms are the technology leaders in Big Data applications. In retrospect, it seemed that the US economy was able to benefit much more from digitalisation than Europe, which some blame to a lack of flexibility and entrepreneurship in Europe.

Jobs destruction appears in all sectors of the economy, but is most pronounced in administrative and office occupations. The argument that job losses are compensated by new jobs turned out to be wrong; new information technologies created much less new jobs than destroyed existing employment because of two reasons; first, technological progress in ICTs went much faster than many expected, leading to a much larger number of tasks which could be replaced by machines and software; second, absolute cost advantages of services provided by ICTs turned out to be so huge that firms preferred machines over people even if they have to forego some non-routine tasks provided by employees. This resulted in a large number of highly automated services in the economy of the year 2036. These automated services may lack a 'human touch', but can nevertheless be produced at virtually no marginal cost. There were also attempts to re-bundle tasks within occupations by concentrating non-routine operations in a small number of all-around occupations which are still performed by people. Employment and economic activity declined.

One consequence of these developments is that markets with winner-takes-all characteristics are much more common in 2036 than 20 years ago. This has led to a considerable number of firm closures and market exits in many manufacturing and service sectors, and to a higher concentration of value added and wealth in a few firms and individuals in the economy. Unemployment has increased to levels not known since the 1930s. These two developments also raised economic inequality to levels not known for a long time in Europe.

The developments described above had also serious consequences for public households in Europe: on the one hand, tax revenues came under pressure as a consequence of shrinking employment and the economic downturn. A stronger progression in income taxes with a higher tax burden for the superstars of the winner-takes-all economy provided only limited relieve for tax revenues. On the other hand, raising inequality and high unemployment forced governments to more social policy interventions. Countries escaped this difficult situation by reducing social policy to measures to prevent absolute poverty, rather than providing a differentiated system of social security. Some countries experiment with the introduction of an unconditional basic income which replaces all or most other social monetary transfers. Nevertheless, social and political stability is fragile, and the opposition against 'everything digital' has been growing.

9.3. Europe's growing double digital divide

Digitalisation turned out to have very different effects on the Member States and regions of the European Union. In the economic centres and the metropolitan areas, digitalisation has led to renewed growth, a vibrant entrepreneurial culture and growing incomes. In rural areas, digitalisation had hardly a positive economic impact, and economic divergences between metropolitan and rural areas have deepened.

This development is, at first, due to the fact that digitalisation has strongly augmented the clustering of creative people in cities, which has already been described by Richard Florida in the 2000s. It may be true that digital workers can do their projects from everywhere; however, they also want to socialise, exchange ideas and enjoy an appealing cultural surrounding. These preferences created entrepreneurial ecosystems with a variety of specialised services in many metropolitan areas of Europe which were very competitive internationally and well-connected to similar city regions outside Europe, but with very little relationships to their surrounding rural regions which stayed behind.

Regional disparities were first welcomed and seen as an indication that metropolitan areas develop into 'beacons' of digitalisation, entrepreneurship and economic dynamism. However, there was no trickle-down of the economic benefits of this growth to rural areas, and the development was partly self-enforcing, by substantial movements of educated people from the rural to the metropolitan regions who found much better employment opportunities and income there.

As a result, the divide between metropolitan and rural areas widened. A growing divide can also be observed at EU member states level, between the Nordic and some Western and Eastern European countries on the one hand which could benefit much more from the opportunities of digitalisation, and Southern and Eastern European countries on the other hand which adapted only slowly to digitalisation. The divide between Northern and Southern EU members started to widen after the economic crisis of 2008/2009 and the sovereign debt crisis of 2010. Both developments deprived Southern member states of the means for investments in education, infrastructure and R&D to prepare for digitalisation. There are some isles of digitalisation in Southern Europe as well, but they are much smaller and fewer compared to Northern Europe.

Public households got into trouble from this development, at least in federal states. A growing divide between metropolitan and rural areas lead to higher transfers from the wealthy to the poor regions. A growing divide also poses a dilemma for policy: should policy invest money in stagnating regions to increase overall coherence of living standards and infrastructure, or put money into the metropolitan regions to ensure the future competitiveness of these regions? A growing disparity between poor and rich regions also shifts the economic powers, and finally also the political powers in favour of metropolitan regions.

9.4. Measures for policy

What are adequate policy responses to digitalisation and the developments described above? In the following, we will present some conclusions for policy related to the three scenarios described above. As a general remark, it does not seem adequate – and also impossible– to slow down or even hamper the diffusion of the technologies described in this report to avoid possible negative consequences. This would basically mean to cut off Europe from technological change happening in other parts of the world. To our knowledge, there is no case in history where such an experiment did succeed. Isolating Europe from the rest of the world in terms of technological change would also imply to take away the means to stay competitive on foreign markets from European companies. So, technological isolation of Europe would also lead to and require economic isolation and de-globalisation. Countries which followed such a policy in the past, such as China and Japan in the 18th and 19th century, paid a very high price in the form of economic decline and political dependence, before they decided to end isolation and start catching-up policies (Ferguson 2011). So, Europe cannot escape the consequences of new technologies, be they good or bad.

- Education

In a world where skills levels are closely related to inequality, because skilled-biased technological change continuously increases the demand for skilled labour, it seems essential to **invest in education**, regardless what future will became reality; this is why education should also be the top priority for policy. A more flexible education policy will make it possible both for younger and older people to adapt to the new working conditions. Depending on the difference in skills between jobs destroyed and created, the time and cost of individual adaptation will differ. Historical experience has shown that by increasing the supply of skilled labour, policy can compensate the unwanted effects of skilled-biased technological change on inequality (Goldin and Katz 2008).

Investments in education should encompass all levels of the education system. More specifically, recent research shows that early childhood is an important period for shaping cognitive and non-cognitive skills and for forming the basis for learning and the acquisition of skills in later years (Heckman 2008, Heckman et al 2013). A critical time is from birth to age five, when the brain develops rapidly to build the foundation of cognitive and character skills necessary for later success in school, health, career and life.

Early childhood education fosters cognitive skills along with attentiveness, motivation, self-control and sociability (Heckman et al 2013). Moreover, it is also a form of social policy, because children from a disadvantaged background are less likely to get such support, and are in danger of staying behind in early years, if they come from families that lack the social and economic resources to provide the early developmental stimulation. So, efforts should focus on the first years for the greatest efficiency and effectiveness. This is why early support of children in Kindergarten, pre-school and elementary school is essential, and policy intervention should in particular focus on this age with higher investments in education.

A second question related to education is which skills should be taught. This is even more important when we move away from early childhood and the basic skills mentioned above. From the literature on skills, ICTs and employment, it seems most relevant to foster non-routine skills. These skills are, on the one hand, related to human interaction and social perceptiveness, and, on the other hand, complement ICT applications, so that technology can augment human abilities. The problem with this approach, however, is that digitalisation is moving fast, and there are some abilities of machines that were far out of range in the opinion of most experts only a few years ago. In a new book, McAfee and Brynjolfsson (2017) tell the story of how a computer programme prepared by the deep learning unit of Google managed to beat a human master player in the game of Go, a game which was thought to be too complex to be mastered by computers. The point McAfee and Brynjolfsson (2017) make is that it is difficult to identify skills that are 'safe' of automation, because the underlying technologies are progressing even faster than experts assume. Computers today challenge human superiority in so many fields, including pattern recognition, language, intuition, judgement, and prediction.

McAfee and Brynjolfsson (2017, see also Brynjolfsson and McAfee 2014) give an answer by suggesting to focus on everything related to the ability to come up with creative and unusual ideas on a given topic or situation – even if computers today can do more and more things that meet most definitions of creativity, including composing music, painting, designing objects, or developing scientific hypotheses. However, computers are still not good in experiencing the world like humans do, and in understanding and predicting human behaviour. This is why work that requires empathy, teamwork, coaching or other types of human interactions will continue to be done mostly by humans. It consists of a second part of skills, besides creativity, that cannot be replaced by machines, at least in the short and medium term.

If we believe the literature, a focus on memorising facts should not be the first priority of future curricula. This may be a big change for some education systems. Brynjolfsson and McAfee (2014) stress the fact that education systems of many Western countries still include many features of 19th century education systems with their focus on three basic skills: good handwriting, good reading, and multiplication, division, addition and subtraction in the head. Clerks were the computers of the Victorian times, and these three skills were essential for their well-functioning. Therefore, not only a change of the contents, but also reform of the educational system as such should be on the agenda.

- Research and development

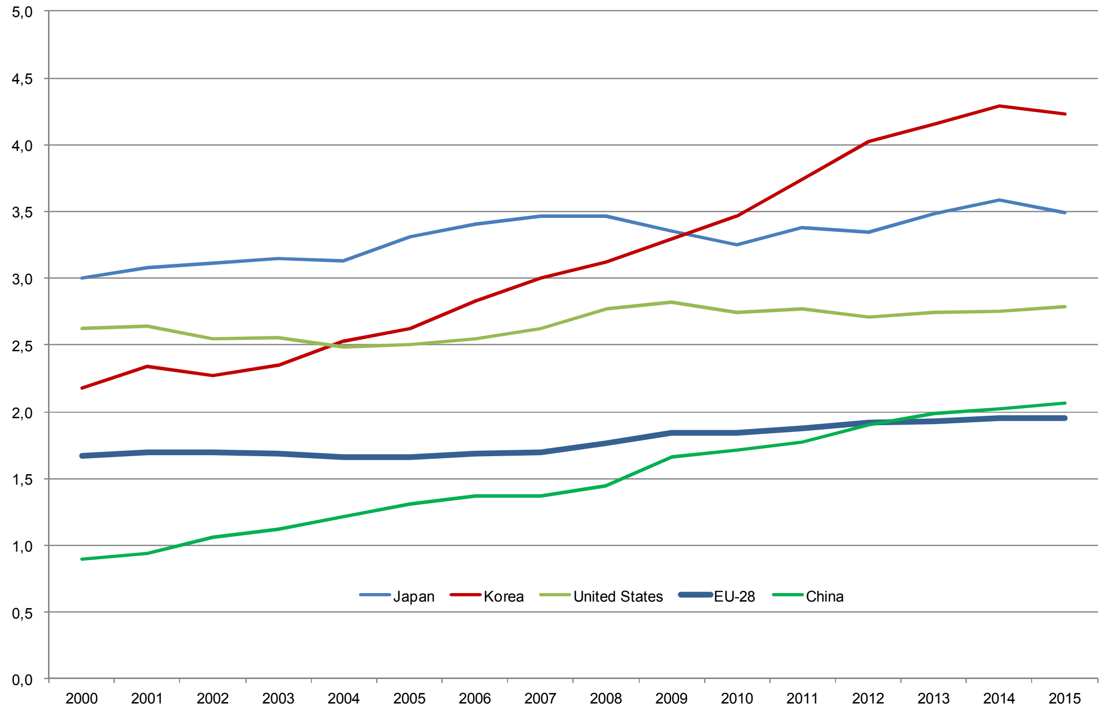
Research and development is a second key area of policy with respect to digitalisation. It closely related to education, in particular at tertiary level. Investments in R&D help firms to build up competences and are therefore an important driver of competitiveness and employment growth, at least in the long run (Peneder 2009, Peters et al. 2014).

Another common feature of education and R&D is that the potential returns to investments in education and R&D at the societal level are higher than at the level of individuals or firms. This is because also other firms and individuals are benefitting from more knowledge of one individual or firm, for example by knowledge spillovers which is the voluntary or involuntary transfer of knowledge between firms. Knowledge spillovers exist because knowledge can often be given away without any loss of knowledge to the sender (Foray 2004). As a consequence of the difference between the private and the social returns of R&D, firms often invest too little in R&D, because they cannot fully reap the benefits of their R&D investments. This is one important reason for policy to support R&D of private firms (Steinmueller 2010).

Economists estimate that the social rate of return from research and development - this is the yield from R&D in the form of economic growth and a higher GDP - is between four and eight percent (Ugur et al. 2014). Hence, the social return from R&D today is considerably higher than the current interest rates for public debt, a good argument for public investment in R&D.

Despite these favourable characteristics of research and development, the European Union lacks behind the US in terms of R&D investments (OECD 2016a). According to the OECD, China, South Korea and the US have expanded R&D expenditure faster than the European Union in recent years, so the gap between the EU and these countries has widened, not closed. China has surpassed the European Union in gross R&D expenditure as a percentage of GDP. The figure below shows this development and China's catching up since 2000.

Figure 23: R&D expenditure as a percentage of Gross Domestic Product (GDP), EU-28, USA, Japan, China, Korea, 2000-2015



Source: OECD Main Science, Technology Indicators 01/2017

There are also some qualitative deficits of European R&D that should worry policy: publications of EU researchers are cited less frequently than publications by US researchers (Dosi 2006, Sachwald 2015). In Sachwald's interpretation, this is an indication for less relevance and quality of European research. Similar findings are also presented by the European Commission (2016, S. 61).

Sachwald (2015) also points to some deficits in the sectoral composition of the EU economy which relate to R&D: in addition to a higher R&D intensity, the US also has a much stronger basis in some scientific fields with a high relevance for innovation, in particular ICT and health. This makes Europe's deficits even worse if we consider the innovation perspective. The structural deficits of Europe's science system are also a main concern for Moncada-Paternò-Castello who is affiliated to the European Commission's JRC (Moncada-Paternò-Castello et al., 2010; Moncada-Paternò-Castello, 2016a). By structural deficits, Moncada-Paternò-Castello means a lower share of some R&D intensive sectors, in particular the ICT sector. For him, these differences explain a lot of Europe's slow growth in high-technology sectors and the lower overall R&D intensity of Europe.

There are some signs that Europe's comparably low level of R&D is related to funding, not to a lack of capabilities. For example, the European Commission (2017) reports in its mid-term evaluation of Horizon 2020, the main instrument of the European Commission to fund R&D in Europe, that the available funding in Horizon 2020 is too small to provide support for all high-quality proposals received. In other words, Europe is wasting good ideas.

These are all good arguments to **increase R&D expenditure** – regardless what scenario may become reality. The arguments even gain weight when we consider that interest rates for public debts are currently at very low levels, considerably below the social rates of return for R&D which are between four and eight percent. Europe should invest in R&D at all levels, from basic research to applied development. Basic research has a considerable training effect for scientific and technological staff. This would include higher budgets for universities, and more public funding for R&D in firms.

In recent years, indirect public funding of R&D via tax credits has gained importance in the policy mix of many countries (Appelt et al. 2016). Tax credits also faced some criticism, because they may be more advantageous for large firms or do not target specific technologies. Nevertheless, policymakers should consider to balance tax incentives for business R&D with the use of direct support measures to foster R&D and innovation in areas such as ICT or health where Europe has deficits compared to the US.

Another important question with regard to the design of R&D policies is the degree recipients of public funding are free in the topics they want to research. In recent years, a number of governments earmarked funds for R&D in topics related to global or societal challenges. A recent report by the OECD (2016a) lists a number of these challenges or megatrends related to demography, resources and energy, climate change and the environment, health, and the economy. In topics related to global societal challenges, direct instruments may be more appropriate than tax incentives because direct instruments allow the government to provide directions for R&D. However, one may argue that government not necessarily have better knowledge about future technological requirements than firms do who are under pressure from markets to bring up new products that find acceptance from consumers because they satisfy demands.

- Entrepreneurship

R&D needs **entrepreneurs** who transform new scientific findings into growth and new employment. A recent report by the OECD (2016b) shows that a considerable amount of new jobs is created by small, newly-found enterprises. The same report demonstrates that Europe is lacking behind in the growth of young enterprises. Moreover, Cincera and Veugelers (2013) demonstrate that the lower R&D intensity of the EU compared to the USA we discussed above is, to the largest part, due to a lower R&D intensity of EU young innovating firms compared to their US counterparts. The emergence of information and communication technologies in particular has been very much shaped by start-ups in the past, and some of these start-ups reached a considerable size in very short periods of time. So far, European entrepreneurial ecosystems have not generated an equivalent to Amazon, Facebook or Google. Technological change proceeds fast in ICTs, and the knowledge bases of these technologies provide only low entry barriers for new firms. Thus, ICTs provide considerable opportunities for new ideas and new firms.

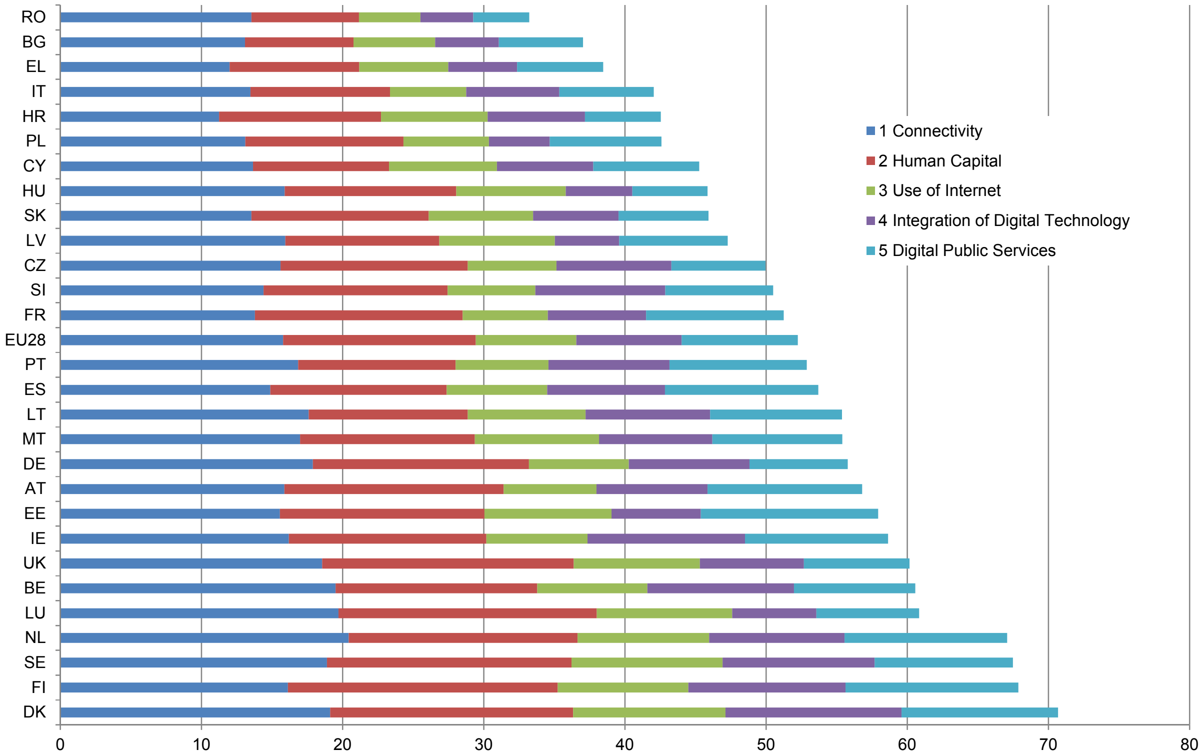
In another study, Moncada-Paternò-Castello (2016b) demonstrates that the gap between the EU and the US in R&D is not because there are fewer young firms in the ICT sectors in the EU, but because the younger, R&D-intensive ICT and biotechnology sectors are smaller in the EU, being dominated by the early entrant and subsequently growing US companies. This is why Europe needs more support for new firms in the field of ICTs and biotechnology. Besides soft measures such as training and consulting for people who want to start a business, this may also include measures to increase the available amount of venture capital. European countries still have a considerably lower supply of VC as a percentage of GDP compared to the US, but also compared to Israel or Canada (OECD 2016b). On average, Nordic countries in the EU are better equipped with venture capital than Southern member states. However, it cannot be the task of the government to provide venture capital. States should rather generate incentives for individuals to invest more in start-ups and small firms and strengthen capital markets in Europe.

- Infrastructure

Investment in infrastructure is crucial if Europe wants to keep pace in the ICT revolution. Policy can use digitalisation for modernising the welfare state since it provides a digital infrastructure that could be used by businesses as well as the whole of society, for education, health and wellbeing services.

In particular, Europe should invest in **upgrading its Internet network infrastructure**. An active role for policy is needed for maintaining a balance between city regions – which are likely to get a lot of private investment – and rural areas, which may lack behind in terms of infrastructure. Moreover, there is also a danger that imbalances in internet infrastructure between Eastern and Western European member states, as well as within the group of Middle and Eastern European member states may deepen. According to the Digital Economy and Society Index 2017 of DG Connect (see Figure below), Bulgaria and Romania are currently lagging behind all other EU countries, while Estonia, Lithuania Slovenia and the Czech Republic established themselves at the EU average or even above average.

Figure 24: The Digital Economy and Society Index 2017



DG Connect

Looking at digital infrastructure, it is clearly a task for the European level to ensure equal access to connectivity. It seems evident that a further deepening of this digital divide in Europe has to be avoided. The European Commission has already taken steps to upgrade infrastructure in Europe with the European Fund for Strategic Investments (EFSI), an instrument to relaunch investment and restore EU competitiveness. On focal area of the EFSI, besides energy and research, development and innovation, are digital technologies. A European programme for broadband on a European scale could be a first step in that direction.

- Employment regulations

Social security systems will face some challenges from the developments described in this report. In all scenarios, Europe will be well served to stick to the concept of **flexicurity** described in detail in a previous study for the European Parliament (Krings and Muellner 2007). This concept, on the one hand, meets the strong demand to make labour markets, employment and work organisation more flexible. On the other hand, it also meets the equally strong demand for providing security to employees – especially vulnerable groups – and for preserving social cohesion in European societies.

The flexibility aspect of the flexicurity approach matches with predictions in the positive scenario that self-employment and more flexible working arrangements will increase in the future due to

ICTs, while the security aspect is needed to enable secure transitions of people from job to job and cope with structural change in the future. This is why flexicurity is an important element for future labour market policies to cope with technological change as it is already an important piece of the European Employment Strategy.

More specifically, new types of self-employment such as platform or gig workers also call for **new employment regulations**. These new forms of employment offer some opportunities for more self-determined and more flexible work; however, opportunities for more self-determination should not come at the price of more uncertainty, or undermine goals of promoting full employment, and rising and stable incomes. Platform employment can also create a new 'precariat' of isolated individuals living from job to job, without lasting financial or social connections to workplaces or to other workers. Policy should review the status of these types of employees, and, if necessary, enlarge social security legislation, but also health and safety regulations, to platform work. This would also mean that owners of platforms should contribute to social security. However, policy should avoid to move from current non-regulation to over-regulation.

Historically, productivity increases generated by the new technologies have led to **reductions of working time**, and allowed to bring more people into work or dampen the negative effects of automation on the labour market. Such reductions may also be appropriate when ICTs lead to further automation. The reduction of working time is a very flexible instrument which can be easily implemented, and reductions can also be done in small steps. Thus, a shortening of work time may be a more moderate form of re-distribution than the introduction of a basic income with may have some unintended side effects described below.

Work time reduction, however, also means an increase in labour costs, which may have negative consequences for the competitiveness of export-oriented firms if productivity does not increase in the same way. However, just like the universal basic income discussed below, work time reduction may be the right measure if the goal is to reduce inequality caused by a new unemployment.

- Tax and social security policies

In the positive scenario, economic activity will remain vibrant and growth will even speed up. Tax revenues will remain stable or even grow, which allows governments to maintain the welfare state and invest in education, R&D and infrastructure. However, there may be a need for a shift in the tax systems of European countries from labour as the main source of revenue to a **taxation of capital** and **value added**, if these components become the main contributors to economic wealth due to digitalisation. Machines may also contribute to the financing of social security. A shift in taxation away from labour towards value added and capital may seem even more important in the negative scenario where economic activity is decreasing due to digitalisation.

Such a shift seems only feasible if overall tax burden does not increase, and only if the tax burden on labour is substantially reduced. Otherwise, this move would mean an increase in overall tax burden. Moreover, it has to be kept in mind that a higher tax on the means of production basically means taxing one of the potential future sources of comparative advantage of European firms. Higher taxes on value added or on investment goods may reduce the willingness of European firms to utilize digital technologies and may be an obstacle for future competitiveness.

The designers of tax policies should also bear in mind that capital is more mobile than labour. The shift away from labour towards capital and value added may lead to distortions and even to movements of firms out of countries that lean too much on taxation of these factors. Therefore, the shift from labour taxation to capital taxation has to be co-ordinated between countries, at least at the level of EU member states.

Empirical evidence presented by Thomas Piketty (2014) and others suggests that the concentration of wealth in the hands of a few very rich individuals has dramatically increased in recent decades.

Globalisation and new technologies have disproportionately benefited the rich by rewarding capital more handsomely than labour. There are experts who believe that digitalisation will further increase this concentration because of the winner-takes-all principle and the stronger role of capital in value added creation compared to labour.

Thus, **taxing the super-rich** – by higher income taxes, a stronger progression in income taxes or wealth taxes - is seen by many as a way to decrease inequality and raise financial means for the state. Moreover, it may even have a greater psychological impact than a financial one, because it may reduce a feeling of injustice and discrimination among ordinary tax payers who frequently are confronted with reports of tax avoidance.

There have been many propositions in recent years to tax the super-rich. Thomas Piketty (2014), for example, proposes a progressive global tax on wealth of up to 2%, and additional income taxes. However, he also admits that such a tax is impossible to implement today because it would require a degree of political co-ordination with seems very difficult to agree on today. This is a main problem of taxing the super-rich (but also of taxing capital): wealth is very mobile, and may find a 'safe harbour' where it is out of reach for the taxation of their home countries. A solution to this dilemma can only lie in international cooperation.

- The idea of an unconditional basic income

If the pessimistic scenario of massive job losses and a huge increase in inequality from the economic effects of new ICTs comes true, some authors (for example Ford 2015) have suggested to introduce an unconditional **basic income** for every citizen. Unconditional basic income means that all residents or citizens of a country receive a certain sum of money from the government regardless of they are employed or not. This should prevent the most severe economic inequality and provide the means for participation in society.

The idea of a basic income has generated wide interest in a number of countries, and is actively discussed by several political parties. In a recent briefing for the European Parliament, Karakas (2016) discusses the main arguments in favour and against a basic income: proponents of a basis income point to the fact that it provides people with more independence in their education and professional choices, contributes to poverty reduction, may be a step towards more employment and may help to deal with an economic crisis, because it stabilizes demand. With respect to digitalisation, an unconditional basic income appears for many to be a sound approach for redistributing the gains from automation. Advocates of a basis income hope that it will be an effective measure to avoid that many people fall into poverty. Moreover it should avoid a concentration of incomes in the hands of large enterprises and their owners which benefit disproportionally from digitalisation and winner-takes-all effects. Thus, basic income has to be accompanied by a new tax policy that focuses on capital gains and the benefits of automation and digitalisation instead of labour.

However, the idea of an unconditional basic income is also disputed. First, there are moral arguments against a basic income. It may foster a culture of living on social benefits, and people should be paid for working (and not for not working). The political process may also be influenced by steady demands to increase the basic income if the majority of the voting population receives it. Second, critics think that an unconditional basic income provides adverse incentives for employment and entrepreneurship. This may lead to lower employment, less economic activity, and may even drive the economy into a recession rather than stabilize growth. Moreover, they argue that a basic income for every citizen is way too expensive to implement as it will require massive tax increases to finance it. Moreover, there are also practical problems with the implementation, for example how to calculate the level of basic income in a fair way.

It is difficult to assess the relevance of the arguments of the advocates and critics of a universal basic income, because there is only limited empirical evidence that would back up the points they make in favour or against it. Karakas (2016) reports some experiments with the basic income and concludes that these experiments reveal positive effects on reducing poverty and inequality. However, the economy-wide implementation of a basic income would be at a completely different level than isolated experiments: it seems a big social experiment with uncertain outcome. Moreover, once the unconditional income has been implemented in a country, it seems impossible to reverse this decision. Therefore, we argue that less revolutionary measures such as changes in taxation or a reduction of work time may be more appropriate than a basic income.

To sum up, it does not seem feasible to stop digitalisation, but policy has many options to influence and steer the process, by investing in education, infrastructure, and R&D, and adapting labour legislation and tax and social security policies to digitalisation. Perhaps most important is to think of digitalisation not as a threat, but as a chance to increase welfare, opportunities and social cohesion for all European citizens.

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11. Annex

Calculation of Value added at factor costs:

- turnover (+);
- capitalized production (+);
- other operating income (+);
- increases (+) or decreases (-) of stocks;
- purchases of goods and services (-);
- other taxes on products which are linked to turnover but not deductible (-);
- duties and taxes linked to production (-).

= Value added at factor costs

This study – through examining the relationship between innovation, new technologies, employment and inequality – investigates the potential employment effects of new information and communication technologies.

The study reviews the existing literature and experiences with previous technological revolutions, and argues that the race between job creation through new products and job destruction from process innovation was won in the past by the job-creating effects of innovation.

It concludes that there is an uneven distribution of the costs of digitalisation because of the skill-biased nature of technological change so the challenge of the future lies in coping with rising inequality from technological change. The study also proposes a set of policy options for dealing with the employment effects of digitalisation.

This is a publication of the Scientific Foresight Unit (STOA)
EPRS | European Parliamentary Research Service, European Parliament

PE 614.539
ISBN 978-92-846-2586-4
doi: 10.286/68448
QA-02-18-074-EN-N