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# THE EUROPEAN LABOR MARKET AND TECHNOLOGY: EMPLOYMENT, INEQUALITY, AND PRODUCTIVITY

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# EXECUTIVE SUMMARY

Since the start of the Great Recession in 2008, the unemployment rate in the euro zone and in the EU as a whole has grown by more than 50%. The latest data suggests that an economic recovery in Europe is finally gaining traction and this brings hopes that the unemployment rate can be rapidly reduced to the pre-recession level. But it may not be the case.

In recent years, technological progress has led to a wholesale **destruction of middle-level jobs** and a substantial **rise in income inequality.** Although controversial, there are a number of tell-tale signs that **an era of high structural unemployment** driven by rapid technological change is quite possible**.** If real, this would greatly affect the fundamentals of our labor market – and might severely shake the social structure and stability of our society. In short, this constitutes a major risk and challenge that **cannot be ignored by policymakers**.

Technological innovation over time has brought immense benefits. It is the most important factor driving improvements in living standards. Innovation is essential for dealing with grand societal challenges, and is key in maintaining a competitive edge in the global competition that the Netherlands faces in many economic sectors.

Yet rapid and all-encompassing technological changes always disrupt traditional ways of doing things and bring new challenges. Worries that technological progress makes many jobs redundant have been with us since the outset the Industrial Revolution in England. The interest to this topic has spiked from time to time, often coinciding with the periods of high unemployment.

Recent years mark another period of heightened concerns regarding technological unemployment. These concerns are particularly prominent in

the United States, where a tepid pace of job creation over the last few years (a 'jobless growth phenomenon') and rapid technological advances (the rise of smart machines) have led many observers to conclude that these two phenomena are indeed closely connected. In the euro zone, where the unemployment rate reached a record high 12.2% in September 2013, such worries seem to be more muted as it struggles with more immediate threats of the euro crisis and double-dip recession. However, as these threats recede, the labor market disruptions brought by the Digital Revolution are certain to move to the top of policymakers' agenda.

Examples of technology replacing human workers are often highly visible. Automatic kiosks at airports, hotels, and supermarkets are increasingly common. ATMs have replaced most bank cashiers. Telephone information lines at banks and other service providers now often employ software in the form of interactive voice response systems instead of people. Even a few years ago, many of the skills and jobs that we see disappearing now were considered practically impossible to automate. In short, it does not require a leap of imagination to start worry about the impact of technology on the future prospect of many types of jobs.

Our review of academic literature suggests that the main negative impacts of technology on the labor market can be summarized as **more inequality** and, potentially, **more unemployment**. The cross-country empirical evidence demonstrates a strong relationship between technological change and higher inequality. The role of technology in increasing structural unemployment is more speculative and has not been clearly demonstrated. However, such a risk clearly exists. The importance of these impacts for policymakers is also obvious: if left unchecked, they could put existing societal structures under severe stress, and might threaten political stability in European countries.

For a better understanding of these trends it is important to separate them into more specific impacts. The first two impacts are different sides of growing income inequality. The last two describe different aspects of the mismatch between supply and demand in the labor market, including its main outcome – unemployment.

1) Academic literature provides strong evidence that technological progress has led to **job polarization**. While employment of high-skill workers has strongly increased, middle-skill occupations have experienced substantial job losses. Many such occupations involved routine jobs which proved to be replaceable by computers and robots. The effect of technology on employment of low-skill workers carrying out non-routine manual tasks has been broadly neutral in Europe. Similar trends have taken place in all OECD countries. Job polarization has been one of the most important drivers behind the growing income inequality.

2) Another trend that has taken place in almost all OECD countries since the 1980s is the **declining share of the labor income in the national economy,** which also contributed to higher inequality**.** Technological change has been one of the major factors explaining this trend along with globalization and several other.

3) It seems intuitively obvious that the rapid pace of technological progress should lead to acceleration of **skill obsolescence** and to **increasing skill mismatches**. Skill mismatches in Europe have indeed increased in recent years but the role of technological change in this process has not been clearly demonstrated yet. The need for the constant upgrading of workers' skills, however, is quite obvious.

4) **Higher structural unemployment** (i.e., technological unemployment). This is a controversial issue. Most economists posit that there has been an increase in structural unemployment in recent years, but they attribute this to the recession and overall macroeconomic weakness. The role of technological progress in this rise is uncertain. Nevertheless, it seems that rapid advances in technology might have contributed to higher structural unemployment rates in recent years. Most job losses during the recession have been in routine occupations, manufacturing and other economic sectors exposed to foreign competition (they are called 'tradable' sectors). The growing mismatch between jobs and workers is another indirect indicator of how technological progress renders workers' skills obsolete.

The effects of the Digital Revolution on the labor market underscore the importance of three big challenges facing policymakers. These challenges are not listed in any particular order, but rather should be tackled together as different sides of one broader challenge. They are closely interlinked and involve essential trade-offs, and sometimes push policies in opposite directions. This is why addressing them is not straightforward.

First, the **Employment challenge**. In the years preceding the financial crisis of 2008, the EU had made substantial progress in increasing employment. Many EU member states have introduced substantial labor market reforms aimed at increasing flexibility and encouraging people to join employment. Statistical data demonstrates that the labor force participation ratio increased, while the unemployment rate declined substantially prior to the crisis. In short, the EU had enjoyed a job rich growth. However, the economic crisis reversed many of these achievements. The unemployment rate has increased substantially. Now, the fear is that further rapid progress of ICT will lead to more and more 'creative destruction' of jobs, which will result in higher structural unemployment.

One of the main reasons for prioritizing higher employment rate as a policy goal is that the European population is getting older. This is expected to place additional pressure on sustainability of social protection schemes. Putting more people to work will help to lessen such pressures. Overall, the employment challenge is the most familiar to policymakers, and European countries do have a rich experience in using a multitude of policy instruments to promote job creation. Many of these instruments are applicable irrespective of the reason for unemployment – whether it is technological change, international trade or shifting consumer preferences.

Second, the **Inequality challenge**. The replacement of middle-skill jobs with jobs that require more education is largely a positive trend. However, this trend also brings higher inequality overall. Societies differ in their perception and tolerance of inequality. But generally speaking, a substantial increase in inequality does not bode well for political stability. This puts pressure on the social cohesion and social fabric of European societies. The rise of populist parties in many European countries is likely to be one indication of such pressures. Another is isolationist and protectionist tendencies, which are clearly on the rise. Income inequality also impedes equality of opportunity.

Third, the **Productivity challenge**. The EU faces a strong imperative to increase its labor productivity. The rising old-age dependency ratio implies that this is needed just to keep living standards at the same level as today. But in the last two decades, the EU's performance in this respect has not been impressive. After a long period of catch-up growth, the EU-15 labor productivity almost reached the US level in 1995. But then productivity growth in Europe started to lose speed, and the productivity level in the EU-15 has been falling relative to that in the US. One of the reasons behind this may be lower levels of ICT use in Europe. Another is a trade-off between higher employment and productivity.

We **conclude** that dislocations created in the labor market by the Digital Revolution are real and serious. We are probably still at the early stages in terms of its impact. While its benefits are tremendous, ignoring the costs is not a sensible policy. The Digital Revolution creates new sets of winners and losers in the labor market. Technological change is responsible for higher inequality, and increases risks of higher unemployment. Another problem is that some of the adjustments in the labor market occur not in a slow and gradual way, but suddenly, during recessions.

Our **main recommendation** is for policymakers to take the risk of high technological unemployment, in particular combined with job polarization and increased inequality, quite seriously. This is not just an economic problem – it might affect the whole fabric of our society. Policy measures need to be devised that prevent this scenario from happening – at least in its more extreme form – and to mitigate the most disruptive consequences. As an illustration, some of the measures to be considered might include:

- More investment in human capital and upgrading the education and training system, in particular to ensure more opportunities for and wider participation in lifelong learning;
- Combining flexibility and security in the labor market (the so-called 'flexicurity model');
- Reducing tax wedge on labor.

# 1 INTRODUCTION

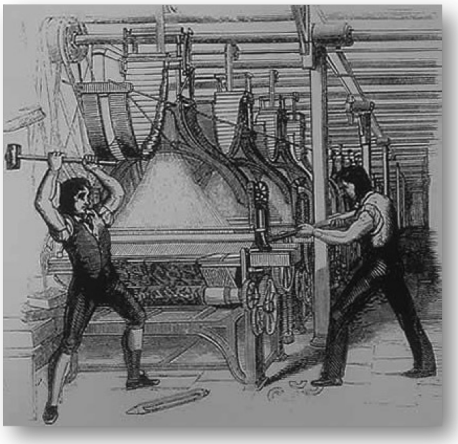
These are gloomy times for the European labor market. More than five years after the beginning of the Great Recession in the EU,[1] unemployment rates in a majority of EU-15 countries remain high and show little sign of going back to the pre-recession level. In the euro zone as a whole, unemployment reached a record-high 12.2% in September 2013. The latest OECD Employment Outlook issued in July 2013 projects that this might increase further to 12.3% in 2014. Most of the rise in the jobless population in the EU is undoubtedly caused by the recession, and an improvement in the economic conditions should reverse the trend and bring unemployment down. At the same time, there are worries that today's high unemployment is not just a cyclical phenomenon – some structural factors might also play a role. In this case, a recovery might bring a 'jobless growth', a situation that occurs when GDP increases but this growth does not create many new jobs. In other words, increases in economic output come predominantly from a higher productivity of already employed workers rather than from the expansion of the labor force. As a result, the unemployment rate could remain high for a prolonged period of time despite economic growth.

It seems that economic development in the United States over the last 3-4 years fits the description 'jobless growth' quite well. Many authors and experts think that a lackluster performance of the US labor market in the creation of new jobs[2] can be explained in part by rapid technological

1 In the EU and the euro zone, the recession started in the second quarter of 2008.

2 Although the unemployment rate in the US has gone down from just above 10% in late 2009 to approximately 7% by the end of 2013, the labor force participation ratio over the same period declined by roughly the same amount (data from the US Bureau of Labor Statistics). Therefore, most of the gains in unemployment reduction should be attributed to people dropping out of the labor force rather than to strong job creation.

changes in the economy, in particular by the wide deployment of information and communication technologies (ICT). Worries that technological progress makes many jobs redundant are not new. Technical change in the beginning of the Industrial Revolution had led to a series of protests against the introduction of new technologies. One of the best known examples involved artisanal textile workers in the late 18th and early 19th century England, who took to destroying new labor-saving machines. These machines threatened their jobs and livelihood since they could be operated by a smaller number of lower-skill and lower paid workers. The protesters were named the Luddites after Nedd Ludd who supposedly smashed two textile knitting machines in 1779.[3] Since then, the word 'Luddite' gained a broader (and derogatory) meaning to denote anyone who is opposed to technical progress. We know that, over time, the Industrial Revolution brought about large improvements in living standards and expanded employment opportunities for workers. However, its effect on those textile artisans was probably negative – at least in the short term.



VISUAL 1. BRITISH WEAVERS DESTROYING TEXTILE MACHINES IN THE EARLY 19TH CENTURY (UNKNOWN ILLUSTRATOR [C. 1840S]).
SOURCE: WIKIMEDIA, HTTP://EN.WIKIPEDIA.ORG/WIKI/FILE:FRAMEBREAKING-1812.JPG

3 Wikipedia, 'Luddite'

The impact of technological progress on unemployment has continued to regularly attract attention from observers and policymakers. Periods of increased interest seem to coincide with increases in the unemployment rate, for example, during the Great Depression in the 1930s. British economist John Maynard Keynes popularized the term 'technological unemployment' in his essay 'Economic Possibilities for our Grandchildren', in which he wrote: 'We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely technological unemployment. This means unemployment due to our discovery of means of economizing the use of labor outrunning the pace at which we can find new uses for labor. But this is only a temporary phase of maladjustment.'[4]

The last few years have seen a new surge of interest in the issue of technological unemployment. The topic suddenly moved from the sidelines of economic discussions to the mainstream debate. One recent example is a book by MIT professors Erik Brynjolfsson and Andrew McAfee, titled *Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*. In this book, they argue that rapid advances in information technology have led to slower job creation and stagnating wages in the US. Other books, such as *The Light in the Tunnel* by Martin Ford and *Average is Over* by Tyler Cowen, also warn that rapid progress in ICT leads to substantial changes on the labor market, and might cause a large increase in structural unemployment. Such prominent economists as Nobel prize winners Paul Krugman and Joseph Stiglitz have expressed similar concerns.[5]

Examples of technology replacing human workers are indeed sometimes highly visible. Automatic kiosks at airports, hotels and supermarkets are increasingly common. ATMs have replaced most bank cashiers. Telephone information lines at banks and other service providers now often employ software in the form of interactive voice response systems instead of people. Driverless cars are rapidly emerging as a new exciting technology

4 Keynes, 1930.

5 Krugman, 2013.

which might make the skills of many workers redundant in a not too distant future. Even a few years ago such skills were considered practically impossible to automate. In short, it does not require a leap of imagination to start worrying about the impact of technology on the future prospect of many types of jobs. Does this mean that we are facing a prolonged period of elevated unemployment? Is technological progress responsible for rising inequality? What kind of jobs will be replaced by computers? These questions and worries have been particularly prominent in the US, where the recovery that started back in 2009 still has not yet been able to bring employment back to its pre-recession level.

So far the situation in the EU labor market has been different in many important respects. Until the onset of the financial crisis and the Great Recession, the unemployment rate in the EU had been declining. The main problem now in Europe is a lack of growth rather than jobless growth. Many policymakers hope that the expected recovery in the EU will automatically solve most economic problems.[6] However, it is still wise to ask ourselves: could economic growth in Europe turn out to be a jobless growth with the same consequences for the labor market as seen in the US?

There is another side to this issue. Europe has been lagging behind the US in terms of ICT penetration, and this might be one of the factors explaining a slower labor productivity growth in the EU compared to the US.[7] The gap between US and EU labor productivity has only increased during the recession. However, the European demographic situation makes a faster growth of labor productivity more important than ever. Boosting labor productivity in Europe will undoubtedly require the acceleration of ICT penetration. This in turn can become one driver of jobless growth. Since the US is at the forefront of the Digital Revolution, its experience might be instructive for European countries.

The main objective of this report is to examine the impact of technological innovation on the European labor market. Most of our analysis is done from

6 The latest (late 2013) economic forecasts from such organizations as the OECD, IMF and World Bank expect that the euro area and the EU-15 will return to growth in 2014.

7 Van Ark, O'Mahony and Timmer, 2008.

a cross-country perspective. This analysis is placed within a broader context of other factors affecting the European labor market, including globalization and employment regulation.

Our focus is mainly on the EU-15 and the Dutch labor market. Labor market trends and problems in new EU members are often substantially different from those affecting the EU-15. These countries, for example, can expect a substantial period of catch-up growth to reach the labor productivity level of the EU-15. Depending on the availability of data we will sometimes refer to the euro zone market, which overlaps significantly with the EU-15[8] and should not affect broader conclusions of the study.

The report is based primarily on the review of academic sources and the analysis of statistical data. But its target audience includes policymakers at various levels, and it strives to be accessible by avoiding unnecessary formalization and academic jargon.

The next chapter describes remarkable technical progress achieved over the last 50 years in the ICT field and its main impacts on the labor market. Chapter 3 discusses the related challenges that policymakers should try to address. The last chapter suggests some policy recommendations.

8 In comparison with the EU-15, the euro zone excludes Denmark, Sweden and the UK but includes Cyprus, Estonia, Slovakia and Slovenia.

# 2 TECHNOLOGY AND ITS IMPACT ON THE LABOR MARKET

## 2.1. TECHNOLOGY

This report focuses mostly on negative impacts of technological change on the labor market. However, it is important to see the forest through the trees and keep in mind the bigger picture – the importance and benefits of technological innovations, which have been essential to our progress. This is why this chapter starts by reviewing some important facts about technological change. We also place some recent developments in the ICT field into a broader context.

Living standards in Western Europe and the US have increased tremendously over the last 100-150 years. Total economic output per capita in Western Europe grew approximately seven-fold between 1900 and 2010 despite the two world wars and many recessions that occurred in this period (see Figure 1). While economic statistics may sound dry and abstract, such an indicator as the infant mortality rate[9] can be easier to comprehend. In 1900 only one country in the world, Sweden, had an infant mortality rate below 10% while in many other Western European countries it was above 20% (e.g., Germany).[10] By 2010, this rate was below 0.5% in all Western European countries.[11] In a period of slightly more than 100 years, the chances of dying for infants have declined by at least 40 times in many European countries, hence saving millions of lives.

9 Defined as the number infants dying before reaching one year of age and expressed as per 100 live births, i.e., as a percentage.

10 Abouharb and Kimball, 2007.

11 World Development Indicators database.

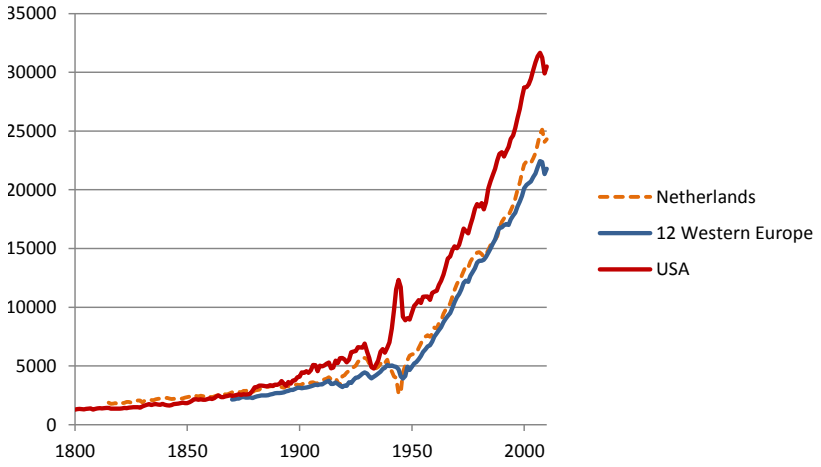



FIGURE 1. GDP PER CAPITA, IN 1990 INTERNATIONAL DOLLARS. 12 WESTERN EUROPEAN COUNTRIES INCLUDE: AUSTRIA, BELGIUM, DENMARK, FINLAND, FRANCE, GERMANY, ITALY, THE NETHERLANDS, SWEDEN, SWITZERLAND, THE UK.
SOURCE: THE MADDISON PROJECT DATABASE, HTTP://WWW.GGDC.NET/MADDISON/MADDISON-PROJECT/HOME.HTM

The most important factor driving growth in labor productivity and, as a consequence, in living standards, has been technological progress. Technological inventions have also changed how and where we live, what kind of work we do, how we spend our free time. The importance of many major inventions such as electrification, antibiotics or the internal combustion engine does not need much explanation. However, even in an industry that seems quite remote from the modern frontiers of innovation and new technologies – agriculture – technological progress and productivity growth have been nothing short of amazing. Unlike manufacturing where many products produced today did not exist 100 years ago, agricultural goods have not changed much – we still buy essentially the same bread and butter. However, the following facts illustrate a huge progress (the data here is from the US, but general trends have been similar in Western European countries).[12]

12 This data is from the United States Census Bureau, in particular, from various editions of the Statistical Abstract of the United States.

- In 1820, more than 70% of the US labor force were employed in agriculture. In 2010 this share dropped to just 1.6%.
- Total employment in US agriculture declined from around 12 million people in 1910 to 2.1 million in 2010, while output grew many-fold.
- Wheat yield per hectare increased more than 3-fold since 1930s.
- Ignoring trade, in 1820 one agricultural worker in the US supported 4.6 other people; in 1960 this ratio increased to 33 and in 2010 even more – to 140.

## DIGITAL REVOLUTION

In recent decades, technological progress has been mainly associated with ICT. The rapid penetration of digital technologies for storage, transmission and processing of information marks a momentous change. It has so profoundly transformed our lives that this transformation has been dubbed the 'Digital Revolution', the 'Third Industrial Revolution', or the onset of the 'Information Age'.

Indeed, computers and microprocessors are everywhere. Today, it is difficult to find an office worker who is not using a computer. Modern cars have more computers than space ships from two or three decades ago. Such computerized automobile systems as electronic cruise control, anti-lock braking system (ABS), collision avoidance, electronic stability control, automatic parking, entertainment and navigation systems improve safety and comfort for the driver and passengers, and are moving us closer to fully autonomous cars.

Information technology has several distinctive features that make it important. First, the speed of technical progress in information technology is unprecedented. According to Moore's law, the number of transistors on integrated circuits doubles approximately every two years.[13] A similar trend has been observed for the speed of calculations and other performance metrics in information technology. Figure 2 summarizes a systematic review of information technology performance over more than 100 years, conducted by Koh and Magee (2006). It plots, on a logarithmic scale, the evolution of the speed of calculation per unit of cost since 1890.

13 Wikipedia, 'Moore's Law.'

The leftmost dot corresponding to the year of 1891 shows the performance of manual calculation by hand. Other dots show the speed of calculations per dollar for different technologies including mechanical calculators, early vacuum tube computers, and modern integrated circuit computers. It is clear that since the invention of modern computer in the 1940s, there has been a big leap in performance, and the progress continued at roughly the same (exponential) speed after that. Koh and Magee estimate that since 1940, the speed of calculation per unit cost has increased by approximately 37% per annum (p.a.) and the speed of calculation even faster – at 42% p.a. (thus doubling every two years as Moore's law predicts). Progress in storing and transmitting information has been also very rapid but slower than processing information: authors estimate progress rates as 27% p.a. for storage and 33% p.a. for bandwidth (information transportation) in terms of performance per unit of cost.

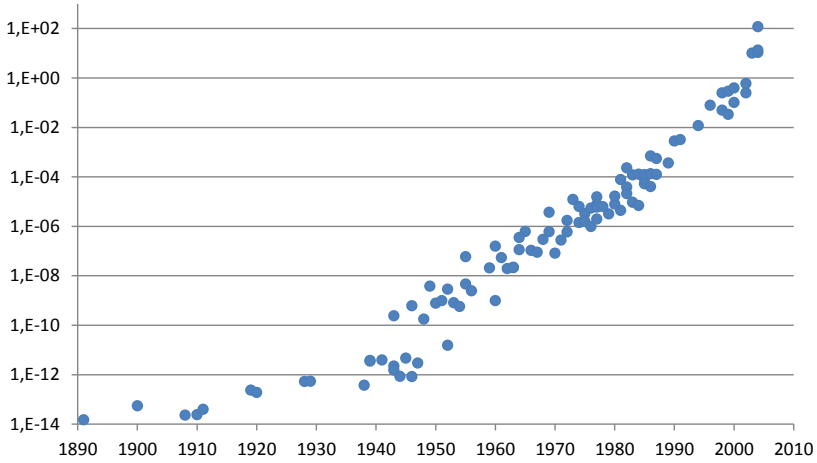



FIGURE 2. CALCULATIONS PER SECOND PER UNIT COST, MILLION INSTRUCTIONS PER SECOND (MIPS)/2004US$.
SOURCE: KOH AND MAGEE, 2006

This tremendous progress in performance coupled with rapidly falling costs has been instrumental for the very rapid penetration of information technology. Let's consider one example – smartphones. More than half of all mobile phones sold in 2013 were smartphones, and their sales were expected to reach 1 billion units worldwide in 2013.[14] Five years ago, in 2008, the global sales of smartphones amounted to only 140 million devices.[15] In addition to roughly the same computing power as the powerful desktops of 2005, today's smartphones often include a digital camera, a GPS navigation unit, a Wi-Fi receiver and, obviously, a mobile network connection.[16] Figure 3 and Figure 4 show how quickly two other information technologies – personal computers and Internet usage – have spread among the general population. The number of internet users increased from 9.2% of the total population in the US and 1.7% in the euro area in 1995 to 65% and 48% correspondingly 10 years later (in 2004). For comparison, a similar progress in the penetration of land phone lines in the euro area took approximately 40 years (it was 5% in 1960 and increased to 53% in 2000). Another point illustrated by these two charts is that the US has been ahead of Europe in adopting many digital technologies.

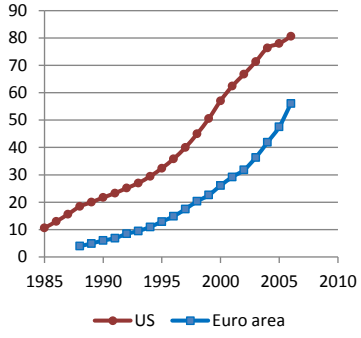



FIGURE 3. PERSONAL COMPUTERS, PER 100 PEOPLE.
SOURCE: WB WORLD DEVELOPMENT INDICATORS

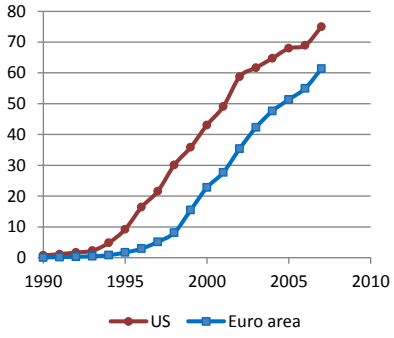



FIGURE 4. INTERNET USERS, PER 100 PEOPLE.
SOURCE: WB WORLD DEVELOPMENT INDICATORS

14 FirstPost, 2013.
15 Gartner, 2009.
16 Berman, 2013.

Information technology along with electricity can be considered as an ultimate general purpose technology or GPT. Such technologies affect an entire economy; they profoundly transform household life and business operations of firms. GPTs are pervasive and find their applications across all sectors of the economy.[17]

ICT is not the only technological field that experiences rapid progress. There have been large advances, for example, in biotechnology, which produced important applications in agriculture and medicine. Progress in biotechnology, however, has been often critically dependent on information technologies. The birth of a new scientific field – bioinformatics,[18] which develops ways to store, organize and analyze biological data, illustrates this thesis.

A recent report by McKinsey Global Institute lists several disruptive technologies that are expected to have a large impact on the economy in the near future.[19] The most important ones, in terms of their potential economic impact, are all related to ICT. They include, among others, mobile Internet, automation of knowledge work, the Internet of Things, and cloud technology. The report suggests that ICT impact on the economy and society is not slowing down, and that we should expect more disruptive changes. It estimates, for instance, that the total worldwide potential economic impact of the mobile Internet alone could reach almost 11 trillion USD p.a., which is not much less than the US GDP of roughly 16 trillion USD.

## 2.2. IMPACTS

Given rapid technological advances in ICT and its *en masse* adoption by businesses and consumers, it should not be surprising that the labor market is also experiencing momentous changes. Some of these are quite obvious – higher demand for people with IT skills, for example. However, many are not so evident, and often hotly disputed. Since we live in the midst of the Digital Revolution, it is often difficult to recognize the full scale and range of its impact. These impacts are not neatly defined, but coincide and overlap with many other changes that are taking part in social, economic or political domains.

17 Jovanovic and Rousseau, 2005.
18 Wikipedia, 'Bioinformatics.'
19 McKinsey & Company, 2013.

One area where the implementation of new digital technologies has led to substantial changes is business organization. These changes affect the nature of employer-employee relationships, business processes, compensation systems and management practices.[20] One example of such changes is the rise of telecommuting, i.e., 'a work arrangement in which employees do not commute to a central place of work.'[21] The 2013 Regus Global Economic Indicator, based on a survey of over 26,000 business managers across 90 countries, found that 48% now work remotely for at least half of their working week.[22] Another trend in business organization is toward less vertically integrated firms. This takes place on several levels. Companies outsource more and more functions such as accounting, IT infrastructure, janitorial services and other to external organizations and concentrate on those areas that they see as their core competence. The production process is also getting more dispersed with different stages taking place at different plants and often in different countries, a phenomenon described as global value chains.[23]

These developments are interesting and important, and deserve serious analysis. It is not obvious though that they warrant regulatory or policy interventions. This is why they are outside the scope of this report. We will focus only on the *negative macro impacts* of the Digital Revolution on the labor market that have society-wide consequences and should be on policymakers' agenda. Simplifying, these impacts can be summarized as *more inequality* and, potentially, *more unemployment*. There is no universal law implying the inevitability of these impacts. Country-specific labor market institutions, regulation and policies make a large difference on how technology affects the labor market outcomes. However, cross-country empirical evidence strongly suggests that recent technological changes are indeed closely associated with the trend toward higher inequality. The link between technological change and higher structural unemployment is more speculative and has not been clearly demonstrated, but such a risk does exist. The importance of these impacts for policymakers is also obvious: if left unchecked, they could put existing societal structures under severe stress and might threaten political stability in European countries.

20 Karoly and Panis, 2004.
21 Wikipedia, 'Telecommuting.'
22 Di-Ve, 2013.
23 See, for example, http://www.globalvaluechains.org/concepts.html.

For a better understanding of these impacts however, it is important to separate them into more refined categories. Based on the literature review, four such impacts were identified:

1) Growing job polarization
2) Declining share of labor income in the economy
3) Increasing skill mismatches
4) Higher structural unemployment (i.e., technological unemployment).

The first two impacts are essentially different sides of growing income inequality. The last two describe different aspects of the mismatch between supply and demand in the labor market, including its main outcome: unemployment.

It should be noted that there are substantial disagreements among economists about the role of new technologies and, more generally, of technical change in these effects. There are even doubts regarding the reality of some of the effects. For example, estimates of structural unemployment and skill mismatches are often quite uncertain, and their magnitude or even existence is questioned. In addition, the situation in the EU countries is not uniform: these impacts do not apply to all member states. Below we discuss the four impact areas one by one. We start by presenting statistical data and observations describing the phenomena. We then discuss to what extent these impacts can be explained by technological change based on the results of academic studies.

## GROWING INCOME INEQUALITY AND JOB POLARIZATION

There are many definitions of income inequality, depending on what kind of income is included and among whom.[24] There are also different measures of inequality. One of the most popular is the Gini coefficient, that ranges from 0 (when all have the same income) to 1 (when only one person receives all the income).[25] Although various definitions and metrics of

24 For example, income metrics could be wages, broader market income (including income from capital) or disposable income (which takes into account public cash transfer and taxes paid). Inequality can be defined and measured for different population subgroups (e.g., full-time workers, all workers, households, etc.). Selecting an appropriate definition should depend on the research and policy objectives.

25 OECD, 2011.

inequality might, in some cases, show different trends, by and large, income inequality has been rising in most of the OECD and EU countries for at least two decades (as shown in Figure 5). This growth has been most pronounced in the US, other Anglo-Saxon countries and some Nordic countries. Between 1985 and 2008, only two EU-15 countries – Belgium and Greece – experienced a decrease in income inequality as measured by the Gini coefficient. Academic literature provides strong evidence that technological progress has been an important contributor to this increase in inequality.[26]

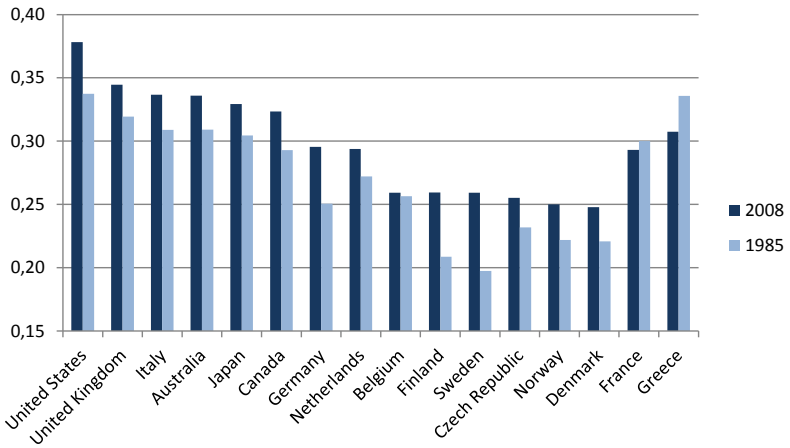



FIGURE 5. INCOME INEQUALITY IN OECD COUNTRIES (GINI COEFFICIENT OF INCOME INEQUALITY FOR DISPOSABLE INCOME).
SOURCE: OECD, 2011

One might ask: why should technological progress be related to rising inequality at all? The answer to this question comes from another well-documented trend in the last few decades: the Digital Revolution and other technological innovations have had rather positive consequences for high-skill people – their pay and employment increased much more rapidly than for other categories of workers. The idea behind this phenomenon is that technical innovations replace tasks traditionally carried out by unskilled workers, but these innovations require high-skill workers to be implemented

26 See for example, Vivarelli (2012), Van Reenen (2011), OECD (2011), Goos et al. (2010).

and used effectively. In the academic literature, this is known as the *skill-biased technological change* (SBTC) hypothesis, initially proposed by Griliches (1969). The divergent trends in the wages of the highly-skilled and low-skilled workers[27] have been one the main factor driving income inequality.

Generally speaking, technological progress is not inherently skill-biased. At least historically, it was not always so. In the early 19th century, technical innovations actually seemed to be skill-replacing: 'Products previously manufactured by skilled artisans started to be produced in factories by workers with relatively few skills, and many previously complex tasks were simplified, reducing the demand for skilled workers.'[28] The Luddite protests mentioned in the Introduction illustrate this thesis. Acemoglu (2002) argues that it was the increased supply of unskilled workers in English cities migrating from rural areas and Ireland that provided economic incentives for such innovations, and made their introduction profitable. Similarly, the rapid increase in the supply of skilled workers in the 20th century induced the development of technologies that would effectively use these skills (i.e., complement them).

A closer look at empirical data reveals a somewhat more complex picture. Figure 6 shows that the share of high-skill workers in employment increased in all EU-15 countries in recent years.[29] However, in almost all EU-15 member states, the largest declines in employment were experienced by middle-skill workers rather than by low-skill workers. The US has had the same experience. This trend is often referred to as 'job polarization'. The universality of this phenomenon across the EU-15 and more generally OECD countries is quite striking, but the SBTC hypothesis cannot directly explain it.[30] It is also silent on the underlying mechanism linking technology and higher demand for high-skill workers.

27 In other words, pay of high-skill (and high-wage) workers increased more rapidly than pay of low-skill (and low-wage) workers. This trend obviously leads to higher inequality, all other factors being equal.

28 Acemoglu, 2002.

29 The chart shows only 8 of EU-15 countries but the statement applies to the other 7 countries as well.

30 Card and DiNardo, 2002.

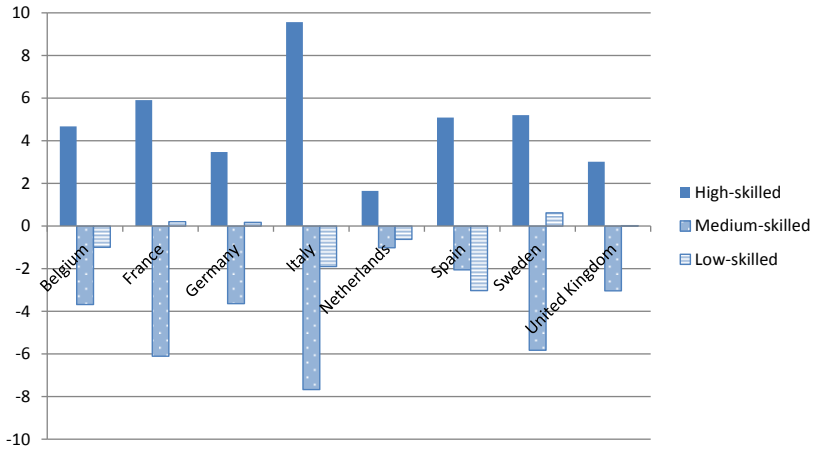



FIGURE 6. CHANGE IN SHARE OF EMPLOYMENT BETWEEN 1998 AND 2008, BY OCCUPATIONAL GROUPS DESIGNATED AS LOW-, MEDIUM- OR HIGH-SKILLED. SOURCE: OECD, 2011, TABLE B1.6

Economists tried to correct for the SBTC problems in explaining the data by looking more carefully at the tasks performed by workers, and how the tasks have changed with the introduction of computers. Autor, Levy and Murnane (2003) developed a model based on the following observations:

- ICT has been successfully replacing labor in carrying out well-defined routine tasks either manual or cognitive (which can be programmed relatively easily);

- ICT helps (or complements) workers in performing problem-solving, communication and managerial activities (non-routine tasks);

- ICT has not had much of an impact on many non-routine manual tasks, such as room cleaning and personal care.

This model, which is more a more nuanced version of SBTC, is often called the 'ALM routinization hypothesis' (based on the first letter of its authors' initials) or the *task-biased technical change* (TBTC) hypothesis. The taxonomy of tasks proposed by this hypothesis and the impact of ICT on them are summarized in Table 1. An important point in this table is that

medium-skilled workers are typically engaged in carrying out routine non-manual tasks that ICT is increasingly able to automate. As a result, the demand for such workers is declining, and they experience the largest job losses. At the same time, a significant section of low-skill workers perform non-routine manual tasks that are more difficult to automate. Their pay is also lower, which decreases economic incentives to replace such jobs with machines. Therefore, the impact of ICT on employment in this segment should be less significant.

| TASK TYPE | | TASK DESCRIPTION | EXAMPLE | EDUCATION LEVELS OR SKILLS | EFFECT OF ICT |
|---|---|---|---|---|---|
| **ROUTINE** | Manual | Repetitive, procedural | Factory/ assembly workers | Low | Direct substitution – Demand decreases |
| | Non-manual | - / - | Clerks, bookkeepers | Middle | |
| **NON-ROUTINE** | Manual | Adaptability (to the environment, people...) | Security guards, truck drivers, cleaning a hotel room | Low | Broadly neutral – Small to no demand increases |
| | Non-manual | Abstract, cognitive, analytic, mental flexibility, problem-solving | Managers, physicians, scientists, legal writing, design, advertising | High | Strongly complementary – Demand increases |

TABLE 1. TAXONOMY OF TASKS IN THE ALM HYPOTHESIS. SOURCE: AUTOR, LEVY AND MURNANE, 2003

Empirical studies have shown a strong support for the ALM hypothesis. The original article by Autor, Levy and Murnane (2003) found that changes in job task content in the US can explain about 60% of the increase in demand for university educated workers between 1970 and 1998. Goos, Manning and Salomons (2010) examined data for 16 European countries (EU-15 plus Norway), and showed that recent changes in the employment structure in continental Europe have been similar to those taking place in the US and the UK: the employment shares of high-paid professionals as well as low-paid personal services workers have increased at the expense of the

employment shares of middling manufacturing and clerical workers. They found that the ALM hypothesis was the single most important factor behind the observed changes in the structure of employment. Another paper by Michaels, Natraj and Van Reenen (2010) came to very similar conclusions. Studying industry level data for nine European countries, the US, and Japan, they showed that industries which experienced the fastest growth in ICT also experienced the strongest increase in relative demand for highly educated workers, and the fastest fall in demand for middle educated workers. The recent economic crisis seems to have reinforced and accelerated job polarization trends in Europe. A large percentage of the jobs lost were in mid-paying manufacturing and construction occupations.[31] Higher paid jobs continued to grow even during the Great Recession.

Technology is not the only driver of inequality in the Western world. The studies mentioned earlier show that although technology was the most important single factor accounting for the rise in inequality, it cannot explain all changes (total magnitude of change). Another factor that is often referred to as a driver of rising income inequality is *globalization*, in particular increasing foreign competition due to trade in goods and services. Disentangling the impacts of technology and globalization is not easy. For example, the use of offshoring has been clearly stimulated by declining communication costs and new digital technologies.

Nevertheless, studies by the IMF (2007) and the OECD (2007 and 2011) found that 'technological progress had a greater impact than globalization on inequality within countries',[32] and this seems to be a broadly shared view among economists. Still, the impact of trade is often significant. A paper by Autor, Dorn and Hanson (2013) showed that between 1990 and 2007, US local labor markets more exposed to foreign competition – in particular from China – have experienced significant employment reductions, especially in the manufacturing sector. The exposure to technological change had different impacts: the overall employment did not change much, but jobs did tend to become more polarized.

31 Eurofound, 2013.

32 IMF, 2007, Chapter 4, p. 31.

Another group of factors that contributed to rising inequality are institutional, including labor market, tax and product market liberalization policies introduced in many EU and OECD countries in recent decades. An OECD report (2011) lists the following factors as some of the drivers of wage inequality:

- Less strict employment protection legislation;
- Liberalization of product market regulation;
- Declining tax wedges (i.e., the difference between labor costs for the employers and net pay for the employee; it is the sum of income and payroll taxes expressed as a percentage of labor costs);
- Declining unemployment benefit replacement rate.

Yet this study also shows that such policies have had unambiguously positive effects on employment, in particular in Europe. This reflects an important trade-off to which we will refer back later: 'regulatory and institutional changes tend to have contrasting effects on employment and wage distribution – i.e., they tend to increase employment opportunities while, at the same time, contributing to wider wage disparities.'[33]

There is another aspect of income inequality in which technology might have also played a role. In the US and some other English-speaking countries, a substantial part of inequality growth was due to a very rapid increase in incomes at the very top of the income distribution. The income of the top 1% of income earners has grown faster than for the top 10%, and the growth has been even faster for the top 0.1% or 0.01%. The increase in income of the top 1% accounted for a substantial share of overall growth in inequality in the US. This development is difficult to explain with the economic models described earlier. There are competing explanations for the causes of this dynamic.

33 OECD, 2011, p.31.

One possible explanation is that the decline in communication and computation costs allows companies to reach more potential customers, more quickly, and more easily, in many markets. This in turn amplifies the rewards for successful entrepreneurs and superstars. As a result, we see that 'winner-takes-all' markets, in which a superior performance allows the capture of a very large share of total revenue, are becoming more and more widespread.[34]

This is only one of many other possible explanations. A recent issue (summer 2013) of the *Journal of Economic Perspectives* has been devoted to this problem. Other authors consider such factors as decreases in the top rates of personal income tax as more important in explaining this trend. European countries have not experienced such a spectacular rise in the income share of the top 1%. For example, in the two largest economies of continental Europe – France and Germany – as well as in the Netherlands, the share of the top 1% of income earners has in fact slightly declined since 1960.[35]

## DECLINE OF THE LABOR INCOME SHARE IN GDP

Another important trend that has taken place in almost all OECD countries since the 1980s is the falling share of labor income in national income (see Figure 7). The labor income includes all forms of labor compensation distributed to workers (both employees and self-employed) as wages, salaries and benefits.[36] The median labor share in OECD countries declined from 66.1% in the early 1990s to 61.7% in the late 2000s. Between 1980 and 2008 some of the largest declines in the EU-15 countries were in Austria, Ireland, France and Italy, according to OECD data.

34 Brynjolfsson and McAfee, 2012.
35 Alvaredo et al., 2013, Figures 2 and 4.
36 OECD, 2012.

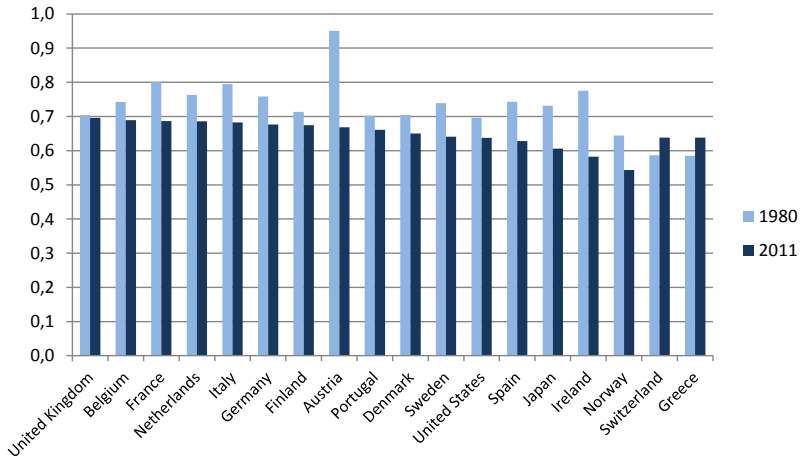



FIGURE 7. ANNUAL LABOR INCOME SHARE IN 1980 AND 2011.
SOURCE: OECD, 2012

In itself, the decline in the labor share does not mean that living standards are affected negatively – if it is accompanied by economic growth, workers can be better off. However, as discussed earlier, this has occurred in combination with growing income inequality within the labor share. Moreover, both trends seem to be closely linked – as shown in Figure 8, countries with stronger increases in income inequality have also experienced larger declines in their labor shares.

Different authors put forward various explanations for the decline in the labor share in OECD and EU countries. These explanations include such factors as:

- *Globalization,* which increases international competition through trade, offshoring and foreign direct investment,
- *Pro-competition reforms*, including the reduction of entry barriers, deregulation and particularly the privatization of state-owned companies,
- *The decline in workers' bargaining power*.

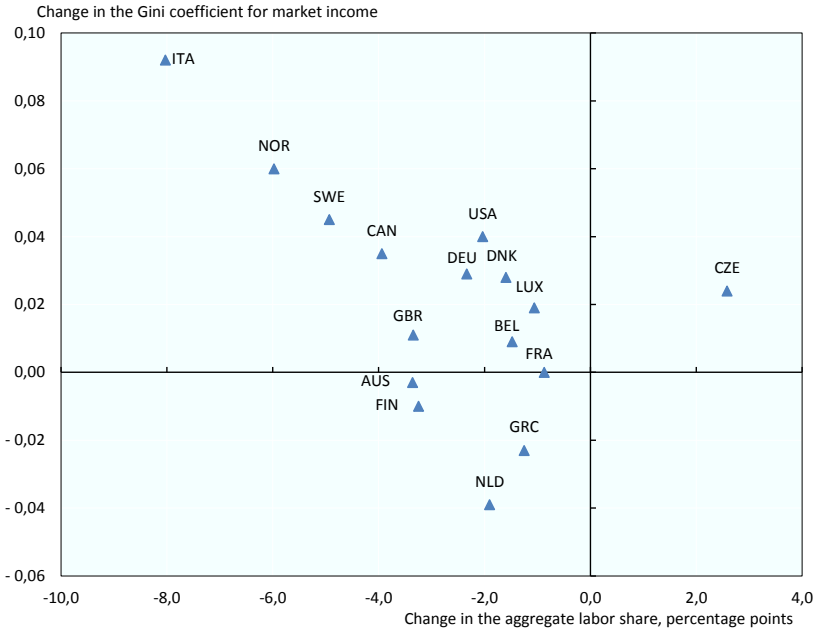



FIGURE 8. CHANGES IN THE LABOR SHARE AND IN INCOME INEQUALITY, 1990S TO MID-2000S.
SOURCE: OECD, 2012

However, recent econometric evidence suggests that technological change**,** along with capital accumulation are likely to be the main factors explaining the decline in the labor share. OECD estimated that an increase in total factor productivity (TFP), which was used as a proxy measure for technical change, by 1% would lead to a within-industry reduction in the labor share by about 0.14 percentage points. This implies that between 1990 and 2007 the increase in TFP and capital intensity, i.e., the ratio of the volume of capital services to value added, 'accounted, on average, for as much as 80% of the within-industry change of the labor share in OECD countries between 1990 and 2007.'[37]

37 OECD, 2012.

More intuitively, the wide adoption of ICTs has helped to automatize many business processes by replacing many tasks previously performed by low- and medium-skill workers. This suggests that recent technical change has increased opportunities for capital to substitute this kind of labor. In this case, growth in capital intensity and technical change should depress the labor share in the national income. At the same time, capital and high-skill labor have been strongly complementary, and the pay of workers with tertiary education has increased more rapidly than for the rest.[38] These are the same trends that have been driving increases in income inequality (as described in the previous section). Technical change associated with the Digital Revolution seems to be biased against low-skill labor.

It is difficult to say whether the negative association between technical change and the reduction in the labor share is a long-lasting one, or whether it is a temporary phenomenon. Standard economic theory posits that capital and labor complement one another in the long run and, according to Acemoglu (2002), technological change augments the output of the factor whose abundance – particularly that of high-skilled labor – is the lowest. This suggests that the substitution between capital and labor is not set to become a permanent trend. There is also a more pessimistic view that ICTs have changed the nature of technological progress, technological advances are becoming more rapid, and capital embodying ICTs is getting more capable as well as more economically attractive in replacing labor (robots do not go on strike or do not suffer from absenteeism, for instance). One indirect evidence that is often cited by the proponents of such a view is the fact that real wages in the US have been stagnating for several decades.

Another important factor affecting the labor share is *globalization* including trade and offshoring. In Europe, their impacts seem to have received more attention than the impact of technology itself. Some researchers find that the impact of various aspects of globalization is no less important in explaining the fall in the labor share than technology. Elsby, Hobijn and Đahin (2013) conclude that over the last 25 years the decline in the labor share in the US was largely driven by increased import competition.

38 OECD, 2012.

Jaumotte and Tytell (2007) estimate that the rise of intra-industry offshoring[39] negatively impacts the labor share in advanced economies. This impact remains limited, as a 1% increase in offshoring leads to approximately a 0.25 percentage point reduction in the labor share. The International Labour Office found that *financial globalization,* as measured by the sum of external assets and external liabilities divided by GDP, also has had a strong negative impact on the labor income share.[40]

According to the OECD, the *privatization* of state-owned companies since the 1990s, in particular in the telecom and network sector, has led to productivity growth, and can explain for a significant part of the labor share's decline in advanced economies. In other words, public ownership is associated with larger wage shares. The *deregulation of barriers to entry* has a much lower impact on the labor share.

The OECD also highlighted that the decline in the labor share has been facilitated by the *declining bargaining power of (particularly low-skill) workers***.** The bargaining power of workers is the ability to influence employers' decisions in matters regarding employees' interests, including labor disputes, employment conditions, but also wages. This ability depends on the capacity of inflicting costs to employers through strikes, lockouts or other collective actions, while minimizing the consequences of those actions on workers.[41] It is partly reflected in the level of 'unionization' within a country or a society. As shown in Figure 9 below, this level (or the so-called union density rate) has been falling both in the EU-15 and the US since at least the 1980s.

Several other factors have been found to have some influence on the labor income share as well.[42] They include: the degree of stringency of employment protection, the generosity of employment benefits, trade unions' power, coordination in wage bargaining processes,[43] and tax rates on capital and labor.

39 Intra-industry offshoring is the 'ratio of imported same-industry inputs to domestic output' (Source: OECD, 2012).
40 ILO, 2013.
41 Dau-Schmidt, Glenn and Ellis, 2010.
42 ILO, 2013.
43 Kim, 2011.

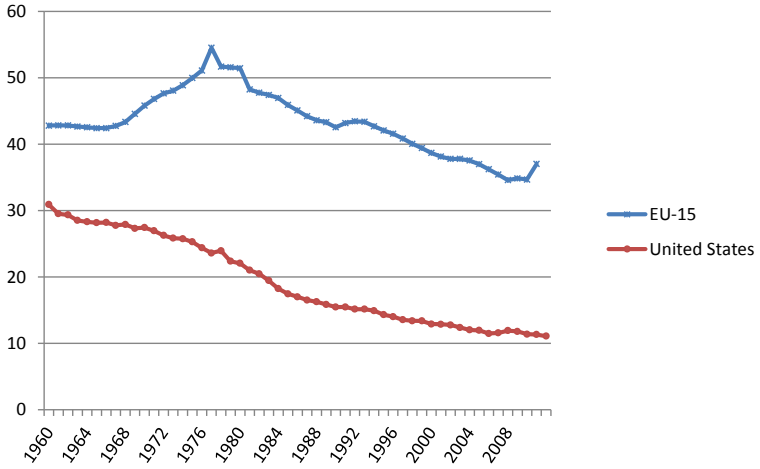



FIGURE 9. UNIONIZATION: UNION DENSITY RATES IN THE EU-15 AND THE US, BETWEEN 1961 AND 2007.
SOURCE: OECDSTAT DATABASE[44]

According to the OECD, increases in the statutory minimum wage do not have a substantial effect on the labor share in the short run but over longer periods, higher minimum wages are depressing the labor income share, and their impact is more significant than of other labor market policies such as employment protection. Firms react to higher minimum wages 'by increasing efficiency levels and productivity beyond the wage increase, leading to a decline in the labour share.'[45] This happens because higher minimum wages create incentives for firms to invest in innovations that increase capital productivity. Firms are also likely to provide more training to their workforce thereby increasing its productivity. At the same time, trained workers might find it difficult to fully reap the benefits of their increased productivity in imperfect labor markets (for instance, because training and resulting productivity gains might not be easily transferable to other firms).

44 Figures for the EU-15 correspond to the average of EU-15 countries and data until 2010. The EU-15 average only includes Greece after 1977, Portugal after 1978 and Spain after 1981. For 2009 and 2010, the average does not cover the figures from Luxembourg, as these are not available.

45 OECD, 2012, p. 145.

This discussion illustrates the fact that there is a significant overlap between the factors responsible for the rise in income inequality and the decline in the labor income share. This overlap explains a close link between the two phenomena illustrated in Figure 8. In both cases technology and globalization have been found to be the most important drivers.

## SKILL MISMATCHES

It is intuitively obvious that the rapid pace of technological progress should lead to the acceleration of skill obsolescence and, potentially, to rising skill mismatches. Technology creates demand for new and often more advanced skills, and decreases the demand for some other skills which become obsolete. If the labor force and employers do not respond to changes in demand fast enough, this should result in higher skill mismatches.

However, it is not easy to measure various types of mismatch that might occur in the labor market. First, mismatches can be analyzed at different levels – at the level of an individual or at a more aggregate level. Second, we are typically interested in *skill mismatch*, i.e., a phenomenon whereby a worker's skills are either higher or lower relative to the skills required by his/her job. But there are few databases that contain detailed information on the skills possessed by workers and skill requirements of their jobs.[46] Even when available, they tend to focus on few generic skills such as literacy and numeracy. Self-reported assessments are also uncommon and in addition might suffer from various biases. As a consequence, most of the literature has focused on *qualification mismatch*, which is a divergence between a worker's qualification level and that required by this worker's occupation. Qualification level is much easier to measure than skills. It is assumed to be a proxy for skills, but this assumption is not perfect since skills are acquired not only via formal education but also through on-the-job training or experience. Finally, even if worker's qualification level corresponds to job requirements, it tells nothing whether his or her field of study is the most appropriate for the job. This type of mismatch is called a 'horizontal mismatch'. All these issues complicate an analysis of skill mismatch and its relationship with other factors or drivers such as technological change.

46 Quintini, 2011.

There is evidence that at the aggregate macroeconomic level, skill mismatch has increased in Europe in recent years. The European Central Bank (ECB) shows that the skill mismatch index (SMI)[47] in the euro area was relatively stable before 2007 but increased significantly during the crisis. The most significant increases were in countries with the largest drop in GDP such as Spain, Ireland, Portugal. Nevertheless, mismatches increased in almost all euro zone countries. The ECB mentions that a substantial part of skill mismatches is likely to have a structural nature and might not automatically return to the pre-crisis level with the economic recovery.[48]

Job polarization, which was mentioned earlier, can be also interpreted as a skill mismatch phenomenon. At the root of the job polarization is an imbalance between the demand and supply of different skill levels. On the one hand, the growing demand for highly-educated workers faces an insufficient supply of these workers. On the other hand, the demand for many middle- and low-skill workers declines much faster that their share in the labor force. One result of these conflicting trends is a divergence in earnings between workers with different skill levels. This is shown in Figure 10 – the difference in earnings for workers with the tertiary level of education and education below upper secondary increased from 72 percentage points in 2000 to 87 in 2011. Furthermore, unemployment rates in the EU tend to be lower for workers with the tertiary education, and higher for those with lower levels of education.

Some level of skill mismatch in the economy is inevitable, since the demand for skills is constantly changing, and labor market adjustments are hindered by various imperfections including asymmetric and incomplete information, transaction costs, etc.

47 The SMI represents the difference between the demand and supply of a particular skill in a country or a region, by measuring the gap between the share of working age population by the skill level and their respective employment levels. The skill level is measured by educational attainment levels (i.e., primary, secondary and tertiary education levels for – respectively low-, middle- and high-skill workers). See European Central Bank, 2012, p. 73.

48 European Central Bank, 2012.

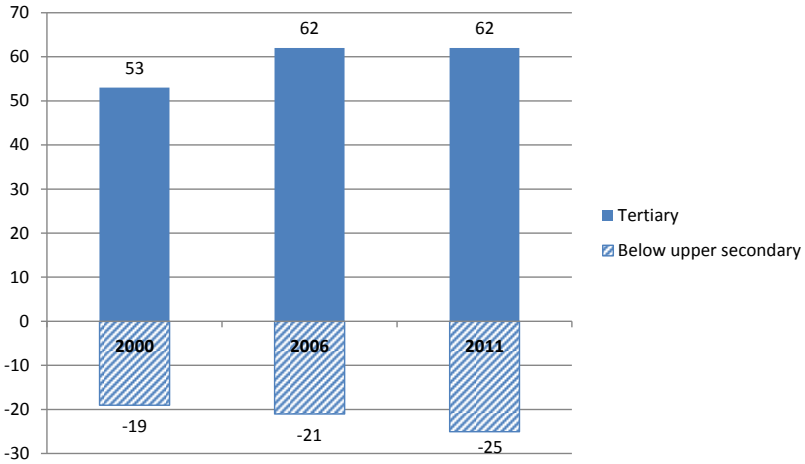



FIGURE 10. EARNINGS PREMIUMS BY EDUCATIONAL ATTAINMENT IN THE EU, %.
SOURCE: OECD, 2013A, TABLE A6.2A[49]

However, high and structural mismatches clearly should be avoided – they lead to structural unemployment, increased public expenditure on benefits, lower enterprise productivity, higher recruitment costs, absenteeism, and a decrease in job satisfaction.[50] More broadly, they weaken the social tissue of our society and represent a waste of human capital.

Another important aspect of skill mismatch is age-related differences in skill proficiency. The first Survey of Adult Skills conducted by the OECD shows that information processing skills (including literacy and numeracy) generally peak among 25-34 year-olds and then decline in older age cohorts (see Figure 11). Interestingly, in most countries, the size of the skill gap does not change much by controlling for such factors as education, gender, socio-economic background, immigration, and type of occupation.[51] A significant part of the gap is due to the process of biological aging. Technological change is likely to play a role as well since 'the gap between the old and the young is particularly marked in the domain of problem

49 Data for EU-21, i.e., EU member states which are also members of the OECD.
50 European Commission, 2012a, Chapter 6.
51 OECD, 2013c, p.107.

solving in technology-rich environments.'[52] However, more important from a policy perspective are the factors that might explain much smaller age gap in such countries as the UK and US compared to, for example, Finland and the Netherlands. This area is not well explored from an academic or policy perspective. However, changes in the quality of education received by different age groups, and the opportunities to maintain and develop various skills whether through education, training, or at work, are likely to be important.

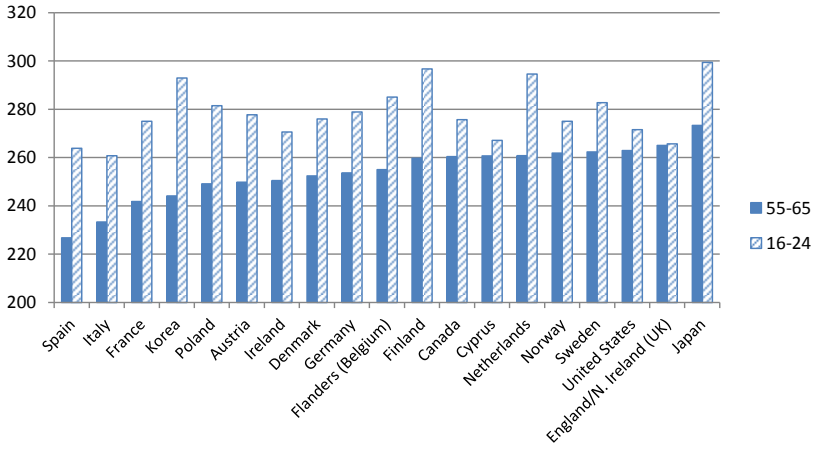



FIGURE 11. MEAN LITERACY PROFICIENCY SCORES, BY AGE GROUP.
SOURCE: OECD, 2013B, FIGURE 3.2

While the impact of the Digital Revolution on increases in skill mismatches might look obvious, academic evidence linking existing indicators of skill mismatch to technological change is not overwhelming. One reason for this might be the crudeness or subjectivity of the indicators used to measure skill mismatches. In any case, rapid technological change presents a serious problem (as well as many new opportunities) for the education and training systems. They should prepare new generations for new skills required in the labor market and even more importantly to help existing workers to continually upgrade their skills and acquire new ones.

52 OECD, 2013c, p. 105.

## STRUCTURAL UNEMPLOYMENT

One of the more controversial claims related to the impact of the Digital Revolution on the labor market is that it causes higher structural unemployment. The current economic crisis that led to much higher unemployment rates (see Figure 12) has intensified such concerns. Indeed, documented increases in skill mismatch, if caused by technological progress, would definitely indicate such a possibility.

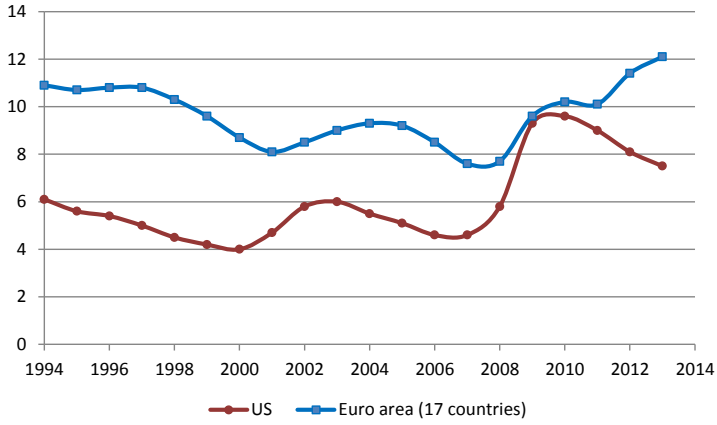



FIGURE 12. UNEMPLOYMENT RATES IN THE EURO AREA AND THE US, OECD DEFINITION. SOURCE: OECDSTAT

Technological progress allows the production of the same amount of goods with less input of labor and capital. Consequently, the direct effect of technological change is indeed 'technological unemployment'. But there are several second-order effects or compensating mechanisms that are capable of bringing full employment back. These effects stem from the fact that technological innovation increases somebody's income, and this income will flow back to the economy in one form or another. Specific forms of such effects include new investments, a decrease in prices, an increase in incomes, new products, etc.[53] The economic theory, however, does not say what is the final impact of innovation on employment is going to be – it might be positive as well as negative, depending on a variety of factors in a specific context.

53 Vivarelli, 2012.

When this issue is discussed among non-economists, it is often assumed that the total amount of output to be produced (and, correspondingly, work to be done) is fixed. This assumption leads to a logical conclusion that technological progress indeed creates more unemployment. This is called the 'lump of output' (or the 'lump of work') fallacy. However, the output does not have to be same. It might expand, or it might contract. Firms benefiting from innovation might invest more, or pay higher wages. Their shareholders could save or invest additional profit. Therefore, the impact of technological progress on unemployment is an empirical question and should be answered by analyzing statistical data.

Overall, historical data shows that there is no negative connection between productivity growth and employment growth over the medium and long term.[54] Sometimes, periods of rapid productivity growth coincide with strong job growth. In general, however, there is no significant statistical connection between these trends. Yet the proponents of the 'technological unemployment' thesis argue that 'this time is different', and that rapid technological changes increase the structural (i.e., long-term) unemployment. One of the main supporting evidence they cite is the current 'jobless recovery' in the US characterized by rapid growth in labor productivity and slow job creation.

There is some evidence that the structural rate of unemployment, or the natural rate of unemployment, has increased in the US and the EU-15 in the aftermath of the crisis, although some countries managed to avoid this.[55] However, most studies linked this increase to an increase in actual unemployment rates, which in turn are caused by a weak demand. The phenomenon through which an increase in the actual unemployment rate leads to a higher structural unemployment is called *hysteresis*. Most explanations proposed in the literature for why this can happen are related to an increase in a proportion of the long-term unemployed, which usually takes place during recessions. The long-term unemployed lose their skills, they might become discouraged in searching for a new job, and the long-term unemployment spell on their CVs sends a negative signal to potential

54 Atkinson and Miller, 2013.
55 ECB, 2012.

employers.[56] As a result, long periods of unemployment decrease their chances of reintegration in the labor market, or force the unemployed to accept jobs that provide a lower pay compared to their previous occupations. Another contributing factor might be labor legislation, which gives significant protection to those with jobs at the expense of job seekers. Technological change does not figure prominently in mainstream economic explanations for unemployment hysteresis.

However, to dismiss the 'technological unemployment' argument completely would be wrong. Some academic studies show that while technological change might eventually lead to more jobs, it often causes job losses in the short term. Papers by Basu, Fernald and Kimball (2004) and by Chen, Rezai and Semmler (2007) show a positive relationship between productivity growth and unemployment in the short term for the US economy. At the same time, they find that the relationship becomes negative over longer periods. The changing reaction of unemployment to productivity growth (which we consider as a proxy for technological change) over different time periods should be intuitively clear. The deployment of new technologies often causes some economic sectors to reduce employment, and other sectors to increase demand for workers. Matching unemployed workers with job opportunities in different sectors (and probably different geographic locations) is not easy and takes time.

Some job losses during the current recession might be also related to technological change. There is some evidence that recessions serve as a major mechanism for adjustments in the labor market. For example, Jaimovich and Siu (2012) show that 92% of the total fall in routine employment in the US between 1990 and 2011 occurred during recessions.[57] In each of the last three recessions in 1991, 2001, and 2009 employment in routine occupations plummeted and never recovered afterwards. This phenomenon might explain the jobless recoveries observed after all three recessions.

56 Ibid.

57 More precisely, within a 12-month window of recessions as dated by National Bureau of Economic Research (six months prior to the peak and six months after the trough).

In Europe, trends in employment reduction have been similar. Most job losses during the recession have been in manufacturing and other economic sectors exposed to foreign competition (they are called 'tradable' sectors). In addition, the jobs replaced by technology or relocated to lower cost locations were middle- and low-skill jobs. Job polarization trends have been reinforced by the crisis as well. The growing mismatch between jobs and workers is another indirect indicator of how technological progress renders workers' skills obsolete.

In sum, most economists posit that there has been an increase in structural unemployment, but they attribute this to the recession and overall macroeconomic weakness. The role of technological progress in this rise is very uncertain. Nevertheless, it seems that rapid advances in technology might have contributed to higher structural unemployment rates in recent years.

# 3 LABOR MARKET CHALLENGES

The previous chapter showed that the Digital Revolution brings not only huge benefits but some substantial labor market problems as well. This is not surprising. Rapid and all-encompassing technological changes always disrupt traditional ways of doing things, and require changes in policies, management practices, organizational structures, training, and other areas. These problems can be thought as inevitable disturbances associated with technical change. In this chapter, we analyze three main medium- and long-term challenges in the labor market that are related to the problems described earlier:

1) The Employment challenge – how to promote strong job growth and increase employment
2) The Inequality challenge – how to mitigate rising income inequality
3) The Productivity challenge – how to increase labor productivity growth

These challenges are not listed in any particular order, but should be tackled together as different sides of one broader challenge. They are closely interlinked and often driven by the same factors. In some cases they involve essential trade-offs: increasing labor productivity often means wider deployment of ICT, and some unfortunate effects of this might include higher inequality and, at least, temporary unemployment. Hence, addressing them is not straightforward. For one thing, slowing down the pace of technological progress is not really an option – Europe needs more of the Digital Revolution rather than less. However, the fear of job losses could plausibly lead to policies hindering industrial restructuring and diffusion of new technologies (e.g., by delaying the closure of technologically outdated plants). Another complication comes from the fact that these problems cannot be considered in isolation from other trends impacting the labor market.

## 3.1. THE EMPLOYMENT CHALLENGE

In the years preceding the financial crisis of 2008, the EU had made substantial progress in increasing employment. Many EU member states have introduced significant labor market reforms aimed at increasing flexibility and encouraging people to join employment. Statistical data demonstrates that the labor force participation ratio increased, while the unemployment rate declined until the crisis. In short, the EU had enjoyed a job rich growth (see Figure 13).

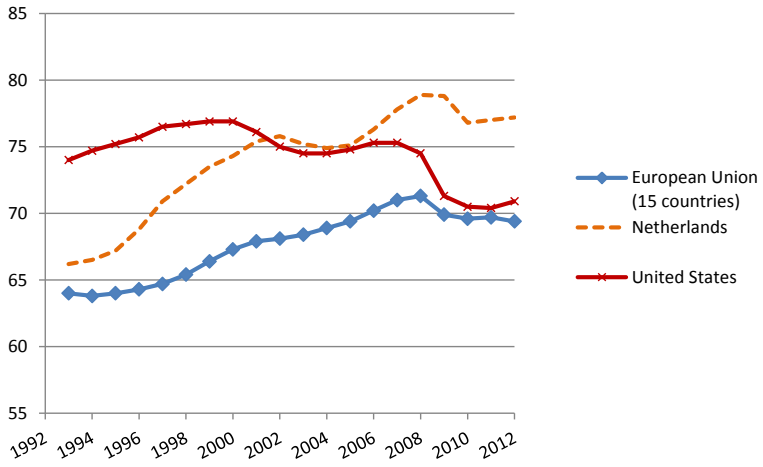



FIGURE 13. EMPLOYMENT RATIO, % (FOR 20-64 YEAR-OLDS). SOURCE: EUROSTAT, LFS

EU's flagship growth strategy, Europe 2020, has set the further target for the employment rate (for those aged 20-64) – 75% by 2020 – to be achieved by getting more people into work, especially women, the young, older and low-skill people, and legal migrants.

The economic crisis reversed many of these achievements. The unemployment rate has increased substantially. Now, the fear is that further rapid progress of ICT will lead to more and more 'creative destruction' of jobs, which will result in higher structural unemployment.

One of the main reasons for prioritizing higher employment rate as a policy goal is Europe's demographic makeup. The European population is getting

older. In the Netherlands, the median age of the population[58] increased from 28.7 years in 1960 to 41.3 years in 2012.[59] Similar increases have taken place in other European countries. This is a result of falling birth as well as death rates. On the one hand, people are living longer than before – life expectancy in the EU has increased steadily. On the other hand, the number of births per woman (the total fertility rate) in the EU-15 dropped below the replacement level (2.1) in the 1970s, and has remained substantially below this level since then.

A direct result of these trends is an increasing share of older people in total population. The old-age dependency ratio measures the number of people aged 65 and above as a share of those of working age (defined as those aged 15-65). As shown in Figure 14, this ratio has been increasing in all EU countries and is already above 30% for Germany and Italy. It is set to continue to increase, putting additional pressure on sustainability of social protection schemes in many European countries. Putting more people to work (i.e., increasing the employment ratio) will help to address such pressures to some extent.

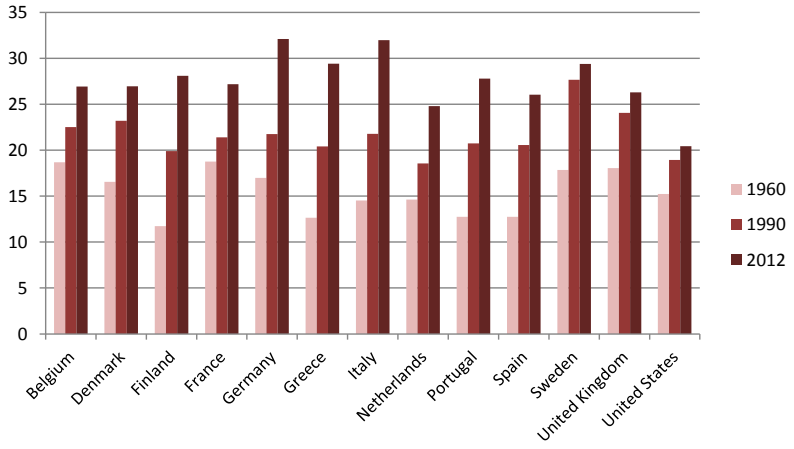



FIGURE 14. OLD AGE DEPENDENCY RATIO, %.
SOURCE: WB WORLD DEVELOPMENT INDICATORS

58 This is the age that splits the population into two equal groups, with one half of the population is younger (or of the same age) and the other half is older than this age.
59 Eurostat, 2013 (demo_pjanind).

Another aspect of European demographics is that the labor force in most EU-15 countries is expected to peak soon after 2020 and then to decline.[60] Raising the retirement age will help to soften this change, but cannot reverse the long-term trend. A declining labor force will probably shift the balance on the labor market in favor of workers, but it will also increase the need for higher productivity from the remaining workers.

Overall, the employment challenge is the most familiar to policymakers, and European countries do have a rich experience in using a multitude of policy instruments to promote job creation. Many of these instruments are broad in focus and will be appropriate irrespective of the reasons for unemployment, whether it is technological change, trade, or shifting consumer preferences. The objective remains the same – to create new and better jobs and facilitate the transition of displaced workers to new jobs, as well as the entrance to the labor markets for new candidates. Some EU-15 states including Austria, Germany, the Netherlands and Nordic countries have been quite successful in increasing employment and keeping the unemployment rate low. Other European countries could learn a lot from their experience.

## 3.2. THE INEQUALITY CHALLENGE

Rising income inequality seems to be closely linked to rapid technological change. The Digital Revolution led to job polarization, with employment growth concentrated in the high-skill segment of the labor market and job losses in middle-skill jobs. A direct outcome of such polarization is growing wage and, more generally, income inequality.

The decline of middle-skill jobs and the expansion of jobs that require more education is generally a positive trend, and should be welcomed. It is difficult to argue against the replacement of lower quality jobs with better paid and higher quality jobs. This trend leads to higher overall productivity and better living standards. Such 'job upgrading' is also necessary to ensure that Europe stays competitive in the global economy. The problem however is that matching those middle-skill workers with new jobs that require different and more advanced skills could be quite difficult. Imagine

60 Peschner and Fotakis, 2013.

a middle-aged manufacturing worker with a secondary education whose job disappeared because a new plant no longer requires so many workers. There might be still jobs available, but these are likely to require more education. Often, the only real option for such workers is to move down on the job ladder, in other words, to take a lower paid job with minimal skill requirements in the service sector. Technological progress leads to broader positive changes, but it also brings substantial pain to some affected segments of workers.

On a more macroeconomic level, job polarization is associated with higher income inequality. Societies differ in their perception and tolerance of inequality. But generally speaking, a substantial increase in inequality does not bode well for political stability. The rise of the Tea Party in the US, and such European populist parties as Freedom Party (PVV) in the Netherlands and the National Front (FN) in France, has many different reasons, but disruptions in the labor market creating disaffected population groups and higher inequality are likely to be some of them. Income inequality also impedes equality of opportunity.

One of the direct ways to address the inequality problem includes tax and benefit policies. However, redistribution strategies have their limits. They can easily have counter-productive effects, especially in terms of job creation and productivity growth. Therefore it is better to focus on creating more and better jobs.[61] This makes policy responses to the inequality challenge to some extent overlapping with those related to the employment challenge.

### 3.3. THE PRODUCTIVITY CHALLENGE

As mentioned earlier, the EU has been rather successful in increasing employment or, in other words, in generating a job-rich growth in the last two decades. This trend was in contrast with the developments in the US where the employment ratio declined compared to late 1990s even before the crisis (see Figure 13).

61 OECD, 2011.

At the same time, the opposite trends have taken place in the EU and the US with respect to labor productivity. After several decades of catch-up growth, the EU-15 labor productivity reached almost 89% of the US labor productivity level in 1995. But then productivity growth in Europe started to lose speed, and productivity level in the EU-15 has been falling behind that in the US. By 2012, labor productivity in the EU-15 declined 7 percentage points relative to the US level (see Figure 15).

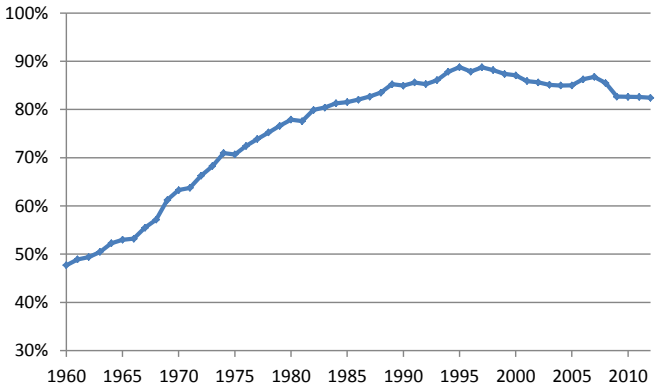



FIGURE 15. LABOR PRODUCTIVITY IN THE EU-15 AS A PERCENTAGE OF THE US LABOR PRODUCTIVITY (LABOR PRODUCTIVITY = GDP PER HOUR WORKED).
SOURCE: THE CONFERENCE BOARD

One reason for slower productivity growth in Europe *vis-à-vis* the US has been the slower adoption of new IT innovation and less investment in ICT (Figure 16). American companies seem to use IT more efficiently than European companies even when US multinationals operate in Europe. One academic study found that this is primarily due to people management practices including promotions, reward systems, hiring, and firing. These differences can account for about half of the US-EU difference in productivity growth.[62] From a sectoral perspective, Europe has had significantly lower labor productivity growth in market services. Since market service sectors accounts for a large share of total economic output, this played the key role in widening the productivity gap between two regions.

62 Bloom, Sadun and Van Reenen, 2012.

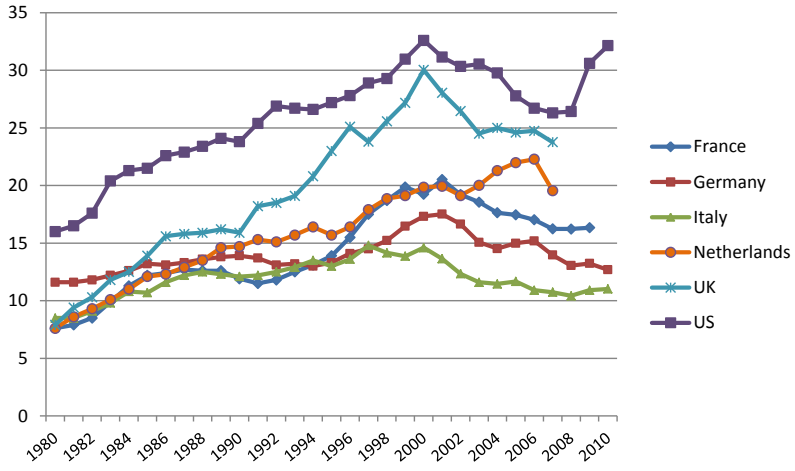



FIGURE 16. SHARES OF ICT INVESTMENT IN NON-RESIDENTIAL GROSS FIXED CAPITAL FORMATION.
SOURCE: OECD

On the macroeconomic level, job-rich growth in Europe i.e., a focus on the increasing participation ratio in the labor force by attracting population groups which are currently less well represented, including women, seems to be associated with lower labor productivity growth. It suggests that there is a trade-off between increasing employment and productivity growth. Some of the main reasons explaining this trade-off are the following:

- New workers (for example, women entering labor force for the first time, immigrants) typically have less experience, and are less-skilled than those who are already in the labor force.
- When employment increases, the amount of capital per worker declines since it takes time to increase capital. Lower capital intensity per worker should lead to lower labor productivity other things being equal.
- Another related reason is that greater labor supply is likely to result in an expansion of labor-intensive (low-productivity) activities, which will depress aggregate productivity levels.

More generally, this result is known in economics as the law of diminishing returns. This law states that in all productive processes, adding more of one factor of production, while holding all others constant, will result in lower per-unit output. Several studies demonstrated a strong negative correlation between growth in productivity and labor inputs over the medium to long term.[63] Among those listed above, the first phenomenon is likely to be the most important in its overall impact.[64]

One logical conclusion from this is that policies promoting wider employment have also contributed to lower labor productivity growth in Europe. In evaluating the impact of these policies it is important to note that we should be more concerned with GDP per capita rather GDP per worker (i.e., labor productivity). It is the level of GDP per capita that shows how large is the average slice of the economic pie in a society. GDP per capita can be decomposed into the product of labor productivity and labor utilization. Increases in labor utilization might depress labor productivity but still increase GDP per capita.

At the same time, some European countries have been quite successful in increasing both labor utilization and productivity. These include Austria, Denmark, the Netherlands and Sweden (OECD, 2007). More recently, reforms of the labor market in Germany have been also quite successful in this respect (see Box below). Even when higher labor utilization does not compensate for a decreased labor productivity, there might be strong reasons to support such policies including better social cohesion, lower welfare dependency, better integration of migrants, etc.

63 De Michelis,Estevao and Wilson, 2013; OECD, 2007, Chapter 2.

64 Dew-Becker and Gordon, 2012. Some authors suggest that it was technological change that has led to an increase in the female labor force participation rate. They call it 'female-biased technological change', in particular the spread of consumer durables and contraceptives (see Galor and Weil, 1996).

**Box. Germany's Labor Market Reforms**

The strong performance of Germany's economy and labor market in recent years has attracted a lot of attention. Despite the Great Recession, Germany managed to create millions of new jobs. Indeed, the proportion of working age population (i.e., 20-64 year-olds) that is employed reached 76.7% in 2012, an increase of 8 percentage points since 2004. At the same time, the unemployment rate plunged from 10.5% in 2004 to 5.5% in 2012,[65] while it rose in the euro area and in the EU as a whole. It can be argued that Germany now has 'the best functioning labor market among large economies in Europe and the United States.' [66]

These achievements are usually attributed to a series of labor market and social welfare reforms introduced by the government of Gerhard Schröder starting in 2003, known as the Hartz reforms.[67] The reforms modernized public employment services and social welfare centers, reduced and toughened eligibility conditions for unemployment benefits and introduced jobs with reduced social contributions.[68] The impressive job growth that followed made these reforms an example for policymakers in several European countries struggling with high unemployment.

One should be careful, however, not to overestimate the contribution of these reforms to Germany's enviable macroeconomic performance. There were other factors that played an important role, including the decentralization of the wage setting process and the decline in union coverage that led to a decrease in real wages,[69] as well as strong external demand for German manufacturing exports. Hereafter, we understand labor reforms in a broader sense as the general restructuring of the German labor market, rather than just the Hartz package.

65 Data from Eurostat Labour Force Survey (LFS) database.
66 Kirkegaard, 2014.
67 They are named after Peter Hartz who headed a reform commission at that time and was the human resource director at Volkswagen.
68 Kirkegaard, 2014.
69 Dustmann et al., 2014.

How do these reforms stand with respect to three challenges we described earlier?

*The Employment challenge.* The economic statistics cited above show that the reforms were very successful in this area.

*The Inequality challenge.* Here the results of the reforms were negative – income inequality increased substantially in recent years, making the reforms politically quite controversial in Germany itself.[70]

*The Productivity challenge.* Despite strong job creation, labor productivity in Germany continued to grow at a solid rate. This is an important illustration that the trade-off between more employment growth and lower labor productivity growth is not inevitable.

On balance, the results of the reforms should be considered positive – they managed to address two out of the three challenges. At the same time, the costs of the reforms, including higher inequality, were not insignificant either. And it is the costs of the reforms that seemed to be gaining more political importance in Germany. One such sign is the plan of a new government coalition to introduce a federal minimum wage to address some aspects of the inequality problem.[71]

70 *The Economist*, 2013.
71 Kirkegaard, 2014.

# 4 WHAT SHOULD BE DONE?

This chapter concludes the report by providing some broad policy recommendations to address the challenges described in the previous chapter. It does not aim to provide a comprehensive list of recommendations. Nor does it provide recommendations specific to any country's conditions.[72] Rather, its goal is to contribute to the discussion on the best ways to mitigate current and potential disruptions in the labor market brought by technological progress. In this respect, it suggests some policy measures that can be broadly applicable to many EU countries.

Dislocations which are being created in the labor market by the Digital Revolution are real and serious. While its benefits are tremendous, and we are probably still at its early stages in terms of impacts, ignoring its costs is not a sensible policy. The rapid deployment of digital technologies demands more workers with advanced education and skills, but also lays off many workers with lower levels of education. This creates new sets of winners and losers in the labor market. The venture capitalist Marc Andreessen nicely summarized this: 'The spread of computers and the Internet will put jobs in two categories: people who tell computers what to do, and people who are told by computers what to do.'[73] Technological change is responsible for higher inequality and increases risks of higher unemployment. Another problem is that some of the adjustments in the labor markets occur not in a slow and gradual way, but rather abruptly, during recessions.

72 There are several publications and documents that provide recommendations on reforming labor market policies. They are typically do not focus on the impact of technological change per se but most of their recommendations are still quite relevant. They include among others: Blanchard et al., 2013; European Commission, 2012b; OECD, 2006.

73 Brynjolfsson and McAfee, 2012.

These developments may put pressure on the social cohesion and social fabric of European societies. The rise of populist parties in many European countries is likely to be one indication of such pressures. Another includes isolationist and protectionist tendencies, which are clearly on the rise. In some European countries, regional separatism is becoming an important issue as well.

Hence addressing the labor market problems is not just an economic issue – it has broader social implications as well. Policies dealing with these problems should be also very broad, involving not just labor market measures but also innovation, education, social insurance, product market and other policies.

Restoring economic growth should be the first short-term priority. Most forecasts for 2014 show that the EU-15 and the euro zone should experience a recovery. This diminishes the need for the conventional boosting of aggregate demand, for which there is limited room anyway due to high levels of government debt in many European countries. However, there are substantial opportunities to promote growth and entrepreneurship through structural and microeconomic reforms. These can include, among others, such measures as lowering government barriers to new business creation, streamlining regulations that might limit business expansion, as well as promoting and supporting entrepreneurship and self-employment.

Future growth and competitiveness of the European economy can be based only on higher levels of human capital. Rapid technological change and growing competition from emerging economies imply that workforce skills should be improved at an ever faster rate. This is, as a renowned Dutch economist Jan Tinbergen put it, 'a race between education and technology.' Losing in this race will mean fewer and lower quality jobs for Europeans in the future. This is why investments in human capital are becoming more important than ever.

At the same time, the educational and training system in some European countries seems to be ill prepared to compete in this race, especially in terms of providing opportunities for lifelong learning. Higher demands for advanced skills in the workplace suggest the need to expand access to higher education, but its rising costs and government budget pressures

present a formidable obstacle for increasing university enrollment. In this case, technology might actually be an answer. In recent years, there have been many experiments in using the Internet and other digital technologies to bring education from the best universities to almost any location in the world at a fraction of cost. While distance learning has been with us for many decades, new technologies that are being implemented through, for example, massive open online courses (MOOCs), revolutionize this process and open many new opportunities.

European countries that have been successful in expanding employment and, at the same time, increasing labor productivity have all, in one way or another, adopted elements of the so-called *flexicurity model*. The main principle behind this model is the need to protect workers (and their incomes) rather than jobs. More specifically, unemployment insurance should be the main element in providing income security for workers. At the same time, employers should have enough flexibility to adjust their workforce to changing economic conditions. Employment protection helps in creating incentives for workers and firms to invest in training and other forms of human capital development, but it can be excessive.[74] This often happens at the expense of temporary workers, who get little protection and limited career prospects. Denmark's flexicurity model has received a lot of attention in recent years,[75] but some other European countries have also been quite successful in dealing with labor market challenges.

Rapid technological change accelerates the obsolescence of many workers' skills. This suggests that unemployment systems should play an important role as a source of retraining, job placement and worker mobility.[76] Yet it is important to note that active labor market policies can be expensive, and require high labor participation rates and good macroeconomic performance to be sustainable. Another requirement is the existence of a capable public service administration.[77]

74 Blanchard et al., 2013.
75 Gill and Raiser, 2012, p.318.
76 McKinsey & Company, 2012.
77 Gill and Raiser, 2012, p.337.

Reducing tax wedge on labor, i.e., the difference between take-home pay and the labor cost to an employer, improves relative costs of hiring people vs. investing in machines. In order to make such tax reductions in a budgetary neutral way, the burden of taxation can be shifted to environmental and consumption taxes as well as to taxes on capital.

Dealing with growing inequalities presents a particular challenge. For instance, the Hatz reforms in Germany, which are generally considered as very successful, were unable to stem the rise inequality (and probably even contributed to it – see the Box in the previous Chapter). The most direct and conventional way to address this problem is through redistributive tax and transfer policies. In countries where income inequality has grown particularly rapidly, a reassessment of the existing tax and social security system might be beneficial in this regard. However, in many European countries, the room for such policies seems to be rather limited. Existing income support mechanisms already appear to be fiscally unsustainable in some countries in the medium-term perspective. Such policies could also be counterproductive in terms of productivity growth.

For these reasons, the OECD suggests that expanding employment may be more important and more feasible in addressing inequality. In particular, it recommends to improve 'access to employment for under-represented groups, such as youths, older workers, women and migrants. This requires not only new jobs, but jobs that enable people to avoid and escape poverty.'[78]

Addressing labor market challenges stemming from the Digital Revolution might not be easy nor straightforward, but neither can they be put aside for the next generation. They require action now.

78 OECD, 2011.

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