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COMMISSION STAFF WORKING DOCUMENT

Employment and Social developments in Europe 2018

CHAPTER 2

A new labour market with new working conditions: future jobs, skills and earnings

1. INTRODUCTION ([1])

Recent transformations are pushing the world's economies towards rapid restructuring. Global competition increases the pressure to optimise production processes. New information and communication technologies (ICTs) are quickly developed. Organisations and markets are globally intertwined through the internet while robots, other digital technologies and artificial intelligence (AI), keep revolutionising the way products are being designed, produced and consumed. These technologies create new markets and jobs while making some traditional ones obsolete. ([2]) As a result, the structure of the EU's economy is changing rapidly.

These transformations favour services over manufacturing, as *Chart 2.1* shows. Since the turn of the century the EU's service sectors have outperformed manufacturing in terms of growth. Digitalisation supports the ICT sector, which has grown by 80%, but its impact extends far beyond it. Apart from finance, the strongest contributors to growth include professional, scientific and technical activities with their highly digitalised engineering and research branches. All these expanding branches tend to recruit skilled and well-educated workers.

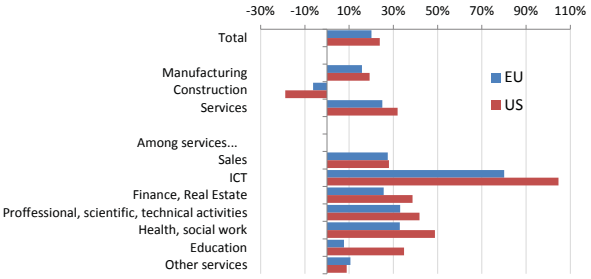
([1]) This chapter was written by Jörg Peschner, Giuseppe Piroli, Joé Rieff and Simone Rosini. Contributions by Enrique Fernández-Macías, Annarosa Pesole, Maria Cesira Urzí Brancati and Ignacio González Vázquez are gratefully acknowledged.

([2]) For a comprehensive picture of the theoretical and empirical discussion on the so-called "fourth industrial revolution", see Chapter 4 in ESDE 2016. Regarding the impact of technology on work, see also Goos et al. (2018).

Chart 2.1

More services, less manufacturing.

Real value added, percentage change between 2000 and 2015, EU-28 and US



Source: EU KLEMS database

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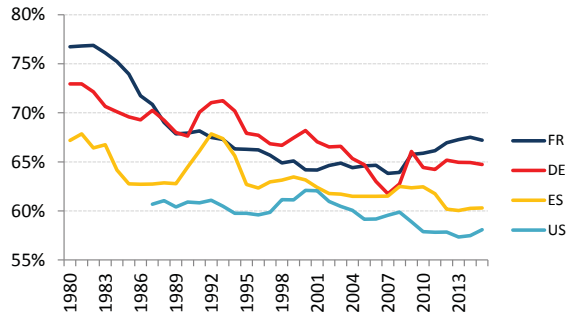
It is not only capital-intensive sectors that have grown fast. The most significant contribution to growth comes from the labour-intensive Health and Social Work sector, which has gained 1.4 pps in total added value since 2000. The sector's expansion is closely related to rising longevity and demographic ageing. As the population over 65 years old is set to increase by 50% by 2060, the Health and Social Work sector is expected to continue growing fast, ([3]) offering some reassurance to those who fear that an ever-rising number of machines will replace workers wherever technically possible.

Yet capital intensity has been rising for decades. Several indicators suggest that production in the industrialised world relies increasingly on capital. As *Chart 2.2* indicates, between 1980 and 2013 labour income fell as a proportion of total income in major EU Member States, ([4]) as in the US. A long-term trend towards higher capital intensity can be interpreted in two ways. The first interpretation is that companies are equipping their workers with more and better capital so as to increase labour productivity and hence economic growth and welfare. In this scenario, capital investment and labour complement each other, and the better skilled and qualified workers are, the stronger the complementarity. The second is that workers are losing their jobs because robots and computers can perform their tasks more efficiently. In this scenario, companies substitute capital for labour wherever technically possible. If so, social welfare may be at stake: new inequalities may arise, as more income goes to the owners of capital rather than to workers.

Chart 2.2

A decreasing share of total income is labour income

Share of labour income in total gross value added.



Source: EU KLEMS database

Click here to download chart.

Capital will destroy jobs but also bring new ones. This chapter shows that both scenarios will play a part in the future of work in the EU. Whether and to what extent they become reality will very much depend on the nature of tasks to be carried out. The relationship between capital and labour also depends on firms' and workers' potential for innovation and on the policy choices made by governments.

([3]) Related professions such as nurses have in the meantime joined the list of top skill-shortage professions, which rely heavily on an adequate supply of qualified people. See CEDEFOP at http://www.cedefop.europa.eu/en/news-and-press/news/skill-shortages-europe-which-occupations-are-demand-and-why. See also Chapter 2.

([4]) Chart 2.2 shows those Member States where sufficiently long time series are available.

The nature of work is changing. Besides its link to capital, the world of work is shaped by the way work is being organised in a more service-oriented, digitalised economy. ([5]) The impact of new forms of work, such as platform work, on non-standard work contracts is not yet clear. ([6]) However, one possibility that needs to be factored in is that permanent full-time employment may become less prominent in the future. ([7]) Organising work with fewer permanent full-time jobs may offer greater flexibility to both firms and workers. However, it would bring about new challenges. Non-standard work may lower work satisfaction and be detrimental to workers' financial stability. ([8]) Furthermore, the design of today's social security insurance is still aligned to dependent standard employment.

After looking at how the conditions of work could change as non-standard forms of work emerge, this chapter will explore in detail the capital-labour relationship in the future, engaging in model projections for a selection of countries.

2. THE CHANGING FACE OF LABOUR IN A DIGITALISED WORLD

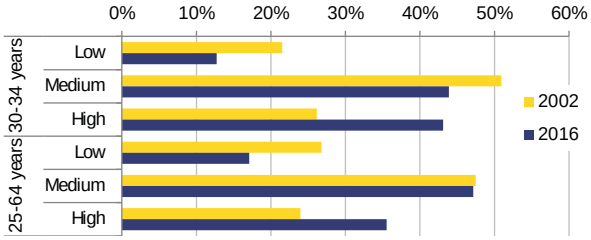
EU employment is at an all-time high. As mentioned in Chapter 1, in 2017 almost 236 million people were in employment, an increase of 19.5 million since 2002. This is mainly due to a strong increase in female employment (+15.3 million, or 15.3% between 2002 and 2017), population growth and increased employment rate of older workers. The number of employees has increased significantly (+20.2 million people in the same timespan).

In addition, workers have become better educated. For decades now the EU has seen strong educational progress. In all Member States young cohorts tend to be better educated than the generation before them. Today more than one third of the EU's employed people aged between 25 and 64 are highly educated, an increase of 12 pps since 2002. ([9]) Amongst young workers (aged 30-34) the increase is much stronger (+17 pps). At the same time, employment of low- and medium-educated people is on the decline.

Chart 2.3

Structural change towards higher education

Employment by age group and educational level in 2002 and 2016, %



Source: DG EMPL calculation based on Labour Force Survey (EU-LFS)

Click here to download chart.

However, these figures hide the structural changes in the labour market which come with digitalisation. The next section reviews how jobs have changed in an increasingly digitalised environment.

Atypical work has become more significant. Permanent full-time employment still represents by far the largest share of employment today. However, the rising incidence of non-standard forms of employment has brought with it structural changes in work patterns. *Chart 2.4* shows that permanent full-time employment as a proportion of total employment has declined by 4 pps during the last 15 years, to below

([5]) The Annex 1 presents the categorisation of new forms of employment suggested by Eurofound (2015).

([6]) Part-time work, temporary employment, and self-employment are considered non-standard work here, while standard work is defined as an open-ended full time working relation with a single employer. Defining what is 'non-standard' may become more controversial in the future. For example, Eurofound find that boundaries between dependent and self-employed work may become more blurred (Eurofound (2017:1), p. 24; Eurofound (2017:2), p. 14).

([7]) The long-term trend in the incidence of non-standard work is positive, see Eurofound (2017:2), p. 1-2.

([8]) This is a finding from Eurofound's 6th Working Conditions Survey, see Eurofound (2017:1), p 106, 107.

([9]) High education level corresponds to tertiary education (ISCED levels 5-8); medium education level to secondary and post-secondary non-tertiary education (ISCED levels 3 and 4); and low education level to no more than lower secondary education (ISCED levels 0-2).

Box 2.1: Implications of temporary contracts and self-employment

Since 2000, younger people have been leaving parental homes later (especially in Eastern and Southern Member States), and the median age of women at childbirth has been increasing, lowering fertility in the short run. In the long run, pensions may be at risk. Moreover, in the absence of a long-term commitment between firms and their workers, temporary contracts demotivate firms from investing in people which, in turn, has an adverse impact on long-term productivity growth. ([1]) At the same time, if agriculture is excluded, ([2]) strong increases in the number of employees coincided with the increasing significance of self-employment. This is primarily due to the rising proportion of solo-self-employed (those without employees).

([1]) See ESDE2017 (Chapter 3) for an extensive discussion.

([2]) The agriculture sector has, together with manufacturing, seen the most significant employment losses since the turn of the century.

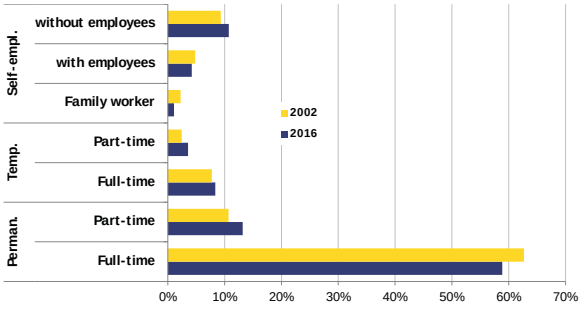
60% in 2016. Solo self-employment (without employees) has become more common, as have temporary and part-time contracts. The increase in non-standard work has disproportionately affected younger workers, many of whom would prefer not to be in that situation. ([10])

Working conditions may suffer. Technological progress and digitalisation led to new possibilities (EPSC, 2018) and labour market improvements in terms of autonomy, flexibility, and health and safety conditions. Yet, the structural changes following these trends impacted negatively on the working conditions and the quality of life of the people who were less equipped to reap the benefits of the changes. Similar results have been obtained for temporary workers, and the same may apply to many future workers who engage in new forms of work that have become more popular through digitalisation, such as platform workers (which have a high chance of being underemployed, as seen in Codagnone et al., 2016). The following section therefore gathers together what is known thus far about these new forms of work.

Chart 2.4

Permanent full time employees still is the largest part by far, but decreasing

Employment relationships - shares in 2016 and 2002



Source: DG EMPL calculation based on Labour Force Survey (EU-LFS)

Click here to download chart.

For example, the regression analysis based on Eurofound's European Working Conditions Survey (*Box 2.4* below) reveals that the statistical odds for self-employed workers of being satisfied with their working conditions overall is around half that of employees. ([11])

2.1. A new player on EU labour markets: digital labour platforms

As a concept, so-called 'platform work' does not lend itself to easy definition and categorisation. ([12]) The new collaborative economy has been described as an interaction of business models "where activities are facilitated by collaborative platforms that create an open marketplace for the temporary

([10]) For involuntary non-standard work see ESDE 2017 (Chapter 3).

([11]) The average probably hides a heterogeneous situation. There is also evidence in literature showing that self-employed are more satisfied with their work (e.g. Millan et al., 2016). This may especially be the case for voluntarily self-employed, with more chance to gain satisfaction from the higher level of autonomy and flexibility. Conversely, the most negatively affected may be those who did not choose self-employment, such as the bogus self-employed.

([12]) European Parliament (2017).

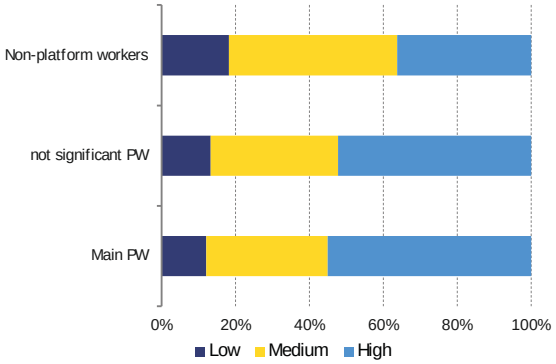
usage of goods or services" (European Commission, 2016). ([13]) Those services are usually provided online, by both professional service providers and private individuals. Prominent examples of internet-based 'platform work' or 'crowd work' include services provided from home (e.g. through Twago, Upwork or Clickworker), mobility services (e.g. through Uber), or working in somebody else's home (ListMinut, Helpling, Myhammer or Taskrabbit). These companies, born in the last decade, have seen a marked growth in recent years, and a parallel increase of the heterogeneity of the services provided (Codagnone et al., 2016; Eurofound, forthcoming).

It is known that platform workers tend to be well-educated and are often male. Recently, the European Commission's COLLEEM online survey conducted a new analysis of frequent internet users aged 16 - 74 in 14 EU countries, providing some initial tentative evidence on the situation of platform workers. ([14]) According to the results, respondents who are platform workers (particularly those for whom platform work is their main activity), are much more likely to hold a tertiary education degree than non-platform workers (*Chart 2.5*). The numbers of highly educated people among platform workers are all the more remarkable given that the tasks performed by platform workers often do not require a high level of education. This may be the outcome of selection bias: highly educated people are more likely to use ICT applications.

Chart 2.5

More than half of platform workers have tertiary education

Average educational attainment in the 14 countries considered by the COLLEEM survey, by different categories, age 25 to 74 years.



Note: 1. Non-platform workers;
2. Those for whom platform work supplies less than 50% of income;
3. Those for whom platform work is their main job, supplying 50% or more of income.

Source: European Commission´s JRC COLLEEM Survey 2017

Click here to download chart.

In addition, "access to certain global work platforms for non-native language speakers is likely to be associated with higher levels of educational attainment". ([15]) Platform workers are mostly men (*Chart 2.6*) and this gender gap widens with the relative importance of platform work to people's total income.

([13]) European Commission (2016:2), p.3.

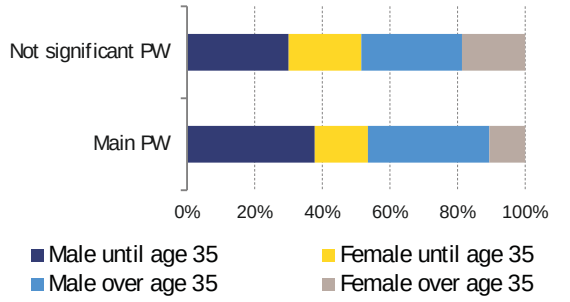
([14]) The COLLEEM survey is an online panel survey on digital platforms commissioned by DG EMPL and coordinated by the JRC. It was conducted in 14 European Member States: DE, ES, FI, FR, HR, HU, IT, LT, NL, PT, RO, SE, SK and UK. The survey was conducted in June 2017, on a sample of 32 409 people (each country contributing around 2 300 people). See Pesole et al., (2018).

([15]) European Parliament (2017), p. 31.

Chart 2.6

Platform workers tend to be male, especially if this is their main job.

Shares of respondents in the COLLEEM survey by age and gender



Note: 1. Those for whom platform work supplies less than 50% of income;
2. Those for whom platform work is their main job, supplying 50% or more of their income.

Source: European Commission's JRC COLLEEM Survey 2017

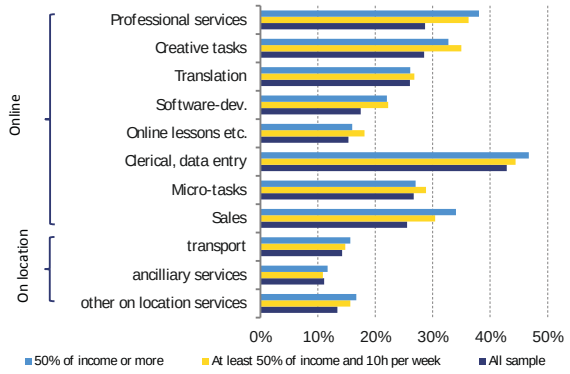
Click here to download chart.

Platform workers provide a wide range of services, typically performing a limited number of tasks. Almost 40% of them perform just one task, 20% perform two tasks and 15% three tasks. The tasks most commonly performed are clerical (including data entry, transcriptions and customer services), professional (including accounting, legal services and project management), sales and creative tasks.

Chart 2.7

Platform workers most commonly provide clerical or professional services

Types of services provided, by whether online or on location



Source: European Commission's JRC COLLEEM Survey 2017

Click here to download chart.

Chart 2.7 shows the marked heterogeneity which is a defining characteristic of platform work, and which is also reflected in the way in which services are provided. Half of platform workers provide services both online and on location; the other half split evenly between online and on location work.

One in ten adults has experience of platform work. Evidence about the platform economy (what tasks are performed on platforms, how workers are organised and protected) is extremely sparse. European Commission's COLLEEM online survey provided further evidence on the situation of platform workers. As *Table 2.1* shows, one in ten had had some experience of supplying goods or services on internet platforms. A majority of these people used platforms at least monthly or spent at least 10 hours a week on platform work. ([16]) However, other surveys focusing on individual Member States suggest that the proportion of platform workers varies considerably. The CIPS survey for the UK reports a figure of 4% (CIPD, 2017), while analysis conducted by the British Department for Business, Energy & Industrial Strategy gives a figure of 4.4% (BEIS, 2018). For Germany, recent evidence indicates a much lower figure of only around 0.5% (Maier et al., 2017), while a recent cross-national platform estimate at EU level hints

([16]) This is in line with other research on working hours of platform workers, highlighting that the majority of platform workers provide services for considerably less time than standard workers (e.g. 80% of UK platform workers working less than 16 hours per week, according to Balaram et al., 2017).

at much higher shares of platform work in seven European countries, ([17]) ranging from 9% in the Netherlands to 22% in Italy.

Only a minority of platform workers make a living from that work, and very few people draw more than half of their income from such activity. The COLLEEM survey indicates a range from 0.6% of the adult population in Finland to 4.3% in the UK, and an average of 2.3% across 14 EU countries (*Table 2.1)*. Huws et al. (2017) suggest a range from 1.6% in the Netherlands to 5.1% in Italy. Those magnitudes are in line with recent US estimates, which looked at platforms as an alternative type of employment and focused on those who mostly did platform work as a means of earning a living: those estimates indicated that in 2016, fewer than 1% of the US workforce have platform as a main source of income.

However, the overall size and number of digital labour platforms are growing. Recent estimates indicate that the monetary value of transactions within collaborative platforms grew by 56% between 2013 and 2014, and that transactions increased by 77% between 2014 and 2015. These estimates include accommodation and financial services as well as transportation, household and professional services. ([18]) The latter more labour-intensive categories make up about 28% of transactions. ([19]) Overall, there appears to be an upward trend in services demanded and provided online. This trend seems to be strongest in the US, but can also be observed in Europe (Kässi et al., 2016).

Table 2.1

One in 10 adults have experience of platform work

Adult population in 14 EU countries, by category

	Daily internet users	Has ever done platform work	Of those....		
			Monthly or more	10h per week or more	50% of income or more
UK	88%	12%	9.9%	6.7%	4.3%
ES	67%	12%	9.4%	6.6%	2.0%
DE	78%	10%	8.1%	6.6%	2.5%
NL	86%	10%	8.7%	5.4%	2.9%
PT	60%	11%	7.1%	6.0%	1.6%
IT	66%	9%	7.1%	5.4%	1.8%
LT	60%	9%	5.9%	5.6%	1.6%
RO	42%	8%	6.4%	4.5%	0.8%
FR	70%	7%	5.9%	4.2%	1.8%
HR	63%	8%	5.2%	5.2%	1.0%
SE	85%	7%	5.3%	3.5%	1.6%
HU	71%	7%	5.0%	4.1%	1.3%
SK	68%	7%	5.1%	2.7%	0.9%
FI	85%	6%	4.1%	2.9%	0.6%
Total		10%	7.7%	5.6%	2.3%

Source: DG EMPL calculations based on COLLEEM survey.

Click here to download table.

One reason is the rising demand for market coordination services. Platforms coordinate market supply and consumers' demand of specific goods and services, providing through their algorithms an immediate price for each transaction, and take a share of it as a fee for the transaction management. Platforms can therefore be defined as digital networks that coordinate transactions in an algorithmic manner (Fernández-Macías, 2018). While the coordination of goods transactions is an established reality, online platforms have recently gained a much greater market share in coordination of services. ([20]) Data available so far focus mainly on the US market, where the number of people providing services on online platforms has risen exponentially over the last 6 years. ([21])

([17]) The countries analysed were AT, DE, IT, NL, SE, UK in the EU, and Switzerland. The number of respondents ranged from 1 969 (in Austria) to 2 238 (in UK).

([18]) European Commission, (2016:3), p. 8.

([19]) For the estimates, see Vaughan et al. (2016).

([20]) Uber arrived in Europe (more precisely in Paris) in December 2011, and it was not until July 2012 that it expanded into another EU Member State, the UK.

([21]) Again for Uber, the number of active drivers-partners (defined as those providing a minimum of four rides a month) in the United States rose from less than 5 000 in July 2012 to above 150 000 in January 2016 (Hall and Krueger, 2015).

As a result, platforms may blur the classical definition of a firm. Internet platforms play an innovative role in the fabric of today's world economy. They offer an alternative form of market coordination, which deviates from the classical distinction between markets and entrepreneurial undertakings. In "The Nature of the Firm" (1937), Coase argued that firms pool capital and labour under their 'roof'' to reduce asymmetry of information and the costs of transactions. However, the logic behind establishing a firm may no longer hold today, as resources are increasingly pooled on digital platforms that may consist of an indefinite number of single, independent workers. ([22])

But platforms can prevent market failures. Digitalisation may have made Coase's asymmetry argument outdated. Low quality suppliers typically sell at lower prices than high quality suppliers. If buyers cannot distinguish between good and bad quality of products or services, those suppliers offering good quality will be discouraged from market participation, as consumers become unwilling to pay for them. Hence situations might arise where only bad quality products or services are left in the market and therefore no trade takes place (Akerlof, 1970). By increasing transparency through providing more information to buyers, platforms (as intermediaries) may help to avoid this sort of market failure (Petropolus, 2017). As a result, platforms may reduce asymmetric information between buyers and sellers and thereby reduce the risk of market failure.

Therefore, platform workers may well increase productivity. New forms of work such as collaborative work on internet platforms may still be the exception today. However, the nature of these services is their global reach and easy availability at low transaction costs. Indeed, "with peer-to-peer platforms, activities are amenable to decentralised production, unlocking previously unused or underused assets." ([23]) Accordingly, new forms of work can be expected to become more prominent in the future as they improve global resource allocation and increase productivity.

But who skims the corresponding welfare surplus? Typically self-employed, platform workers - or at least those offering standard products – may feel the pressure of global competition and may often accept low prices for their services, especially those providing offline services. The OECD concludes that "such work frequently has no social security coverage, can be terminated at will, and wages are low due to a high level of competition", so that its emergence risks a "race to the bottom in both pay and working conditions." ([24]) This means that the surplus of higher productivity would not be appropriated by those providing services on platforms but by those demanding their services, who have "access to a much larger pool of skills and experience at a fraction of the cost of hiring workers on traditional contracts." ([25])

Many platform workers are self-employed. It is difficult to classify platform workers by their employment status. The COLLEEM survey finds that half of those for whom platform work is their main activity see themselves as fully or partly self-employed (*Chart 2.8*) while 38% see themselves as employees. There is evidence that workers on online platforms, in particular, see themselves as "typically freelancers or self-employed rather than employees." ([26]) A first tentative analysis that combines COLLEEM data with longitudinal information from the Labour Force Survey shows evidence that self-employed platform work has during the last five years has increased much more than self-employment in the entire economy. Annex 2 presents the details.

([22]) See Eurofound on https://www.eurofound.europa.eu/observatories/eurwork/industrial-relations-dictionary/crowd-employment.

([23]) Bakhshi et al. (2017), p. 25.

([24]) OECD (2017), p. 14.

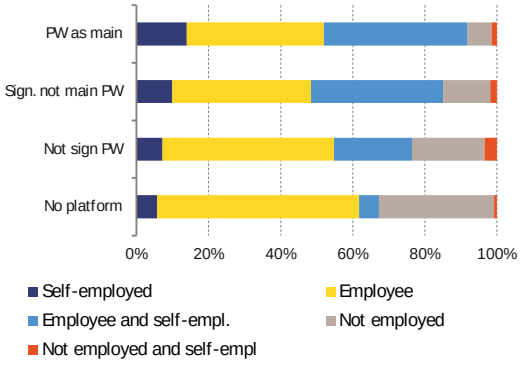
([25]) Ibidem.

([26]) European Commission (2016:3), p. 38.

Chart 2.8

Not all platform workers see themselves as self-employed

Self-defined employment status of platform workers, compared with overall population data.



Note: "Self-employed": respondents declaring themselves to be self-employed as main occupation and nothing else;
"Employee": respondents declaring themselves to be employee as main occupation and nothing else;
"Employee and self-employed" respondents seeing themselves as employees in their main activity, and self-employed in their secondary activity;
"Not employed": respondents showing the share of respondents who are unemployed, retirees, students, and homemakers
"Not employed and self-employed": respondents not participating in the labour force as main activity, but who work as self-employed as secondary activity

Source: European Commission´s JRC COLLEEM Survey 2017.

Click here to download chart.

As a result, many platform workers may not be covered by social protection systems as they are now constituted. Platform workers are often not considered as employees (European Parliament, 2015), and, also due to its heterogeneity, challenges existing regulatory frameworks (de Groen et al., 2018). Given the lack of a formal employment relationship, they are likely to be categorised as self-employed ([27]) workers for whom access to social protection is often a problem. **Chapter 5** will point out that this gap may force social security schemes to re-invent themselves, and will highlight the Commission's recent policy response on access to social protection. ([28]) Like other non-standard and self-employed workers, platform workers may not be legally entitled to be a member of a social protection scheme. Even those who are formally covered may have no effective access, either because coverage is too expensive in the absence of an employer paying a share of social contributions, or because they do not fulfil the eligibility criteria (European Commission, 2018). ([29]) For instance, a number of countries prescribe a minimum period for which an individual must have been employed before being able to claim benefits. ([30]) 54.4% of the EU's self-employed are at risk of being excluded from access to unemployment benefits. ([31])

As the collaborative economy becomes increasingly important, a larger number of people may not be covered against the risks of unemployment. This, when coupled with their low pay, may make platform workers one of the most vulnerable groups in the labour market. Their weak market power may reinforce current tendencies towards job polarisation, unless they benefit significantly from more efficient social dialogue (Chapter 6).

2.2. Accelerating job polarisation

Recent evidence suggests that the proportion of workers in mid-paid occupations is shrinking. To establish the relevance of job polarisation in European economies, the methodology suggested by Goos et al. (2014) is applied here. Using EU-LFS micro-data, occupations are grouped according to their mean

([27]) This may, however, vary from country to country: some national authorities may assess employment status on the basis of the facts, others' assessments may rely on the formal contract of the worker with the platform (European Parliament, 2015).

([28]) European Commission (2018:4).

([29]) European Commission (2018:5).

([30]) European Commission (2017): Access to social protection for people working on non-standard contracts and as self-employed in Europe. A study of national policies.

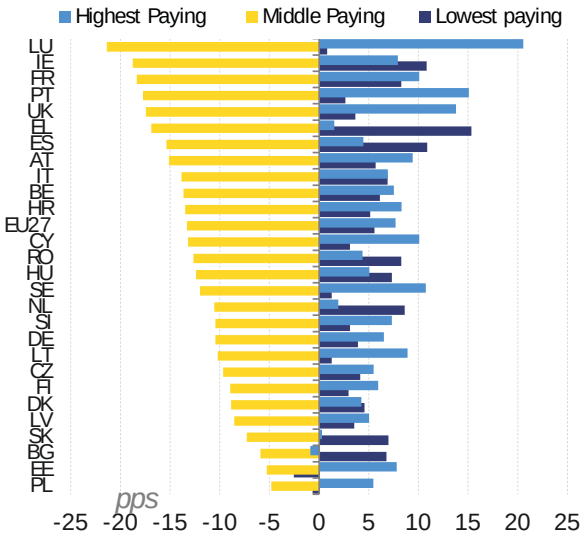
([31]) Ibidem.

wage in low, middle, and high-paying occupations. ([32]) *Chart 2.9* shows the change in the employment share of each wage group between 2002 and 2016 for EU Member States. It reveals that polarisation affected all countries, albeit to a different degree. Low-paying and high-paying jobs continue to increase, while middle-paying occupations seem to shrink fast. These findings are consistent with those by Goos et al. (2014). ([33])

Chart 2.9

The proportion of middle wage workers is shrinking everywhere.

High, middle and low-paying jobs in the EU - change from 2002 to 2016 in pps.



Source: DG EMPL calculations based on EU LFS

Click here to download chart.

Low pay does not imply low qualifications, particularly for platform workers. Each of the three pay groups (high, middle and low paid) can be found in low, medium and highly educated jobs. ([34]) *Chart 2.10*, *2.11* and *Chart 2.12* show that there is a very clear trend towards highly-educated labour in all pay groups, while workers with only low level education are getting less of the work available, not only in high-pay occupations but also in medium and (especially) low pay occupations.

([32]) The three categories are defined in the following way. **High-paying occupations**: Corporate managers; Physical, mathematical, and engineering professionals; Life science and health professionals; Other professionals; Managers of small enterprises; Physical, mathematical and engineering associate professionals; Other associate professionals, life science and health associate professionals. **Middling occupations**: Stationary plant and related, stationary plant and related operators; Metal, machinery and related trade work; Drivers and mobile plant operators; Office clerks; Precision, handicraft, craft printing and related trade workers; Extraction and building trades workers; Customer service clerks; Machine operators and assemblers; Other craft and related trade workers. **Low-paying occupations**: Labourers in mining, construction, manufacturing and transport; Personal and protective service workers; Models, sales persons and demonstrators; Sales and service elementary occupations.

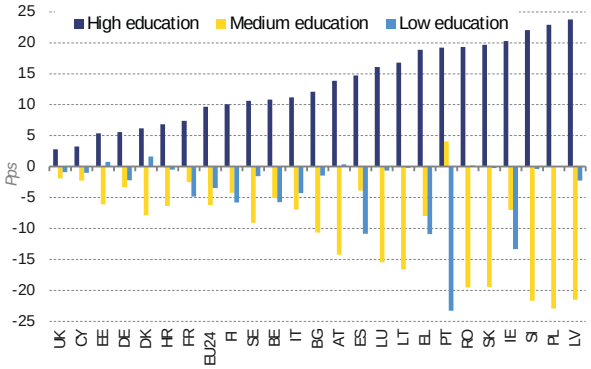
([33]) Some literature challenges this approach and its results "arguing that rather than a pervasive process of polarisation there was a plurality of patterns of structural employment change across Europe" (Fernández-Macías, 2012).

([34]) High education level corresponds to tertiary education (ISCED levels 5-8); medium education level to secondary and post-secondary non-tertiary education (ISCED levels 3 and 4); and low education level to no more than lower secondary education (ISCED levels 0-2).

Chart 2.10

Highly paid jobs: the highly educated increase their share of work in all Member States

2016-2002 change in employment shares by education level in pps – high-paying occupations



Note: Czech Republic, Malta and Hungary excluded due to missing data.

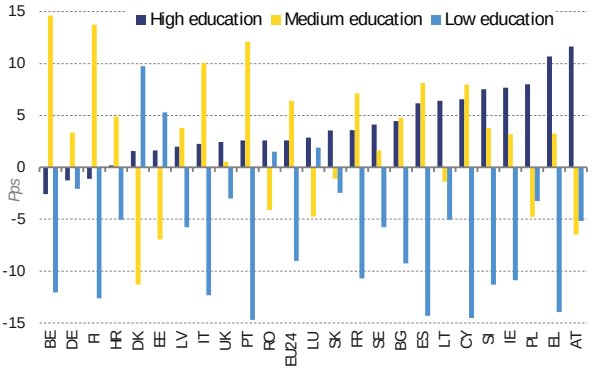
Source: DG EMPL calculation based on Labour Force Survey (EU-LFS)

Click here to download chart.

Chart 2.11

Middle-pay jobs: high and medium-educated work is increasing

2016-2002 change in employment shares by education level in pps – middle-paying occupations



Note: Czech Republic, Malta and Hungary excluded due to missing data.

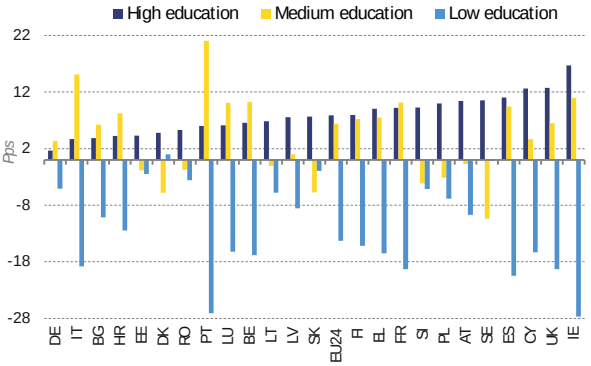
Source: DG EMPL calculation based on Labour Force Survey (EU-LFS)

Click here to download chart.

Chart 2.12

Low-pay jobs: More highly educated, less low-educated work, even in low-paid occupations

2016-2002 changes in employment share by education level in pps – low paying occupations



Note: Czech Republic, Malta and Hungary excluded due to missing data.

Source: DG EMPL calculation based on Labour Force Survey (EU-LFS)

Click here to download chart.

There is an increasing demand for highly educated workers, even in low-paying jobs (*Chart 2.12*). This means that a growing number of workers with good qualifications are working below their

Box 2.2: Job polarisation index (JPI)

JPI is composed of two terms. The first measures the growth in the share of "low-level" and "high-level" jobs (the negative of the change in the proportion of medium-level jobs). The second accounts for the imbalance, which is the greater the more the change in the proportions of low and high level jobs differ from each other:

$$JPI = \frac{1}{2} \times \left(\overline{\Delta_2} l + \overline{\Delta_2} h\right) \times (1 + |\overline{\Delta_2} l - \overline{\Delta_2} h|) \times 100,$$

where $\overline{\Delta_2} l$ and $\overline{\Delta_2} m$ are the change in the proportion of low-level and high-level jobs at year t compared with the average level of the previous two years. Hence, the value of the index is zero if the proportion of "medium-level" jobs has not deviated from its reference value.

JPI distinguishes two situations. Both have in common that the share of "medium-level" jobs declines.

1. **True polarisation: the proportion of both "low-level" and "high-level" jobs increases (first bracket).**
2. **Skill or wage upgrading: only the proportion of "high-level" jobs grows (second bracket).**

qualification level (ILO, 2014), which is very likely to be the case for (typically well-educated) platform workers. Workers tend to be concentrated at the extremes of the wage distribution. And within each pay segment, there is a general demand for higher qualifications. ([35])

Job polarisation has been occurring for some time. Recent economic literature ([36]) favours using a single index - the Job Polarisation Index (JPI), see *Box 2.2* - to measure polarisation over time, for either skill level or pay level.

The JPI traces what happens to "medium-level" jobs. The index points to higher polarisation at a point in time if the proportion of "medium-level" jobs, relative to its average in previous years, has fallen (and vice versa). ([37]) The index also registers changes in the proportion of medium-level jobs that come about in a very imbalanced manner, e.g. if there is a strong change to *either* low *or* high-level jobs. Such an 'imbalance effect' would inflate the JPI. Using the three pay segments in *Chart 2.9*, it is possible to calculate the JPI since 2002.

The trend towards job polarisation peaked in 2011, as *Chart 2.13* **shows.** The index shows positive values at the aggregate (EU-26) level for all years, but with a spike in 2011. The 2011 spike could be observed in all Member States. ([38])

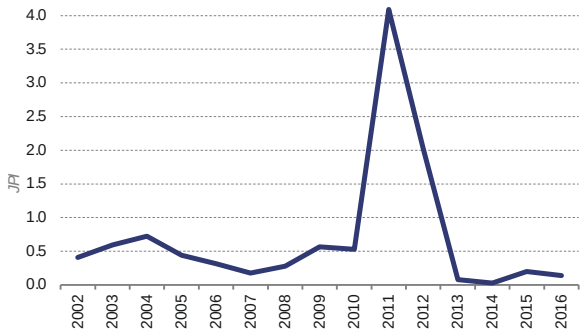
([35]) Increased upward skill pressure is a finding that also holds if one ranks employees (instead of occupations) according to their wages.

([36]) Sparreboom and Tarvid (2016) developed the polarization index using three groups of occupations categorised by skill level; we apply the index to occupational groups classified by pay level.

([37]) Sparreboom and Tarvid (2016) use the average of the five previous years to avoid cycle effects. In our application only the previous two years have been used due to the short time series available.

([38]) Except Malta and Croatia, excluded due to missing data.

Chart 2.13
Job polarisation peaked in 2011
Job polarisation index (JPI) from 2002 to 2016



Note: Malta and Croatia are excluded due to missing data.
Source: DG EMPL calculation based on Labour Force Survey (EU-LFS), following Sparreboom and Tarvid (2016)
Click here to download chart.

While signals of job polarisation were present before the "Great Recession", such phenomenon strongly accelerated during 2011 and 2012. According the literature on the topic, globalization, technological change and routinization are considered the main drivers (Goos et al., 2014; Autor et al., 2003). Since the onset of recovery in 2013, job polarisation has fallen close to zero, indicating that the tendency for different occupational groups to drift apart has stopped (at least for now).

A declining group of workers with "middle level pay" means that pay levels are becoming polarised, rather than generally upgraded. Wage polarisation is happening in a relatively balanced way: both low-paid and highly paid jobs are tending to increase, so that it is possible to speak of "true polarisation" of pay levels (see *Box 2.2*).

The declining share of work going to workers with middle levels of education is thought to signify that education is being upgraded, rather than polarised. Calculation of the index by reference to level of education (rather than pay) produces very different results. The last 15 years have seen a general upward trend in educational attainment. As result, the polarisation index shows lower magnitudes (even negative change) despite a much more significant imbalance effect. This is because positive changes in the proportion of highly-educated workers tend to be larger than the negative changes in the proportion of workers with only low level education.

The increasing use of labour platforms could, in future, lead to greater polarisation of wages. Workers on collaborative platforms tend to receive low pay. If the future brings more of these platforms, this may therefore mean that 'true' wage polarisation will become a bigger problem. At the same time, workers on collaborative platforms are relatively well educated, leading to an overall upgrading of workers' education and, in combination with low pay, potentially aggravating skill mismatches (through over-qualification).

3. LESS LABOUR, MORE CAPITAL? EXISTING EVIDENCE

Historically, processes of technological change fuelled growth and improved workers' skills. The first and second industrial revolutions were pivotal moments in modern economic history. Sparked by major technological achievements (e.g. steam engines, telegraph, electrification, vulcanisation of rubber), large companies replaced small artisanal workshops. At the same time, tasks within these larger companies were simplified, and workers became more specialised so as to increase productivity. ([39]) Demand for workers increased, attracting rural populations to the cities. Later, full exploitation of increasingly complex new technologies required more and more new qualifications. As a result, the increasing demand for qualified workers drove the expansion of the education system; and many workers had the chance of upgrading their skills. This process has been called "Skills-Biased Technological

([39]) Frey and Osborne (2017), p. 254-280.

Change" or SBTC (Katz and Murphy, 1992). Based on individual data, Biagi et al. (2018) find fresh evidence that the odds of being automatized is decreases quickly as people attain higher formal qualifications. ([40])

Today, technological change seems to be steered not only by qualifications but also by routines. Another theoretical strand known as "Routine-Biased Technological Change (RBTC)" ([41]) looks at tasks and the degree to which they can be automated (and separated) from other tasks. Tasks which allow for automation are more likely to be allocated to "machines" than workers, where "machines" refer to hardware, software and combinations of the two (such as robots).

This implies that skilled workers are not safe from being displaced. Over the last three decades, capital has increasingly taken over routine tasks – not only from low-qualified workers but also notably from medium-qualified workers (e.g. numbers of plant and machine operators and assemblers declined by 13 pps between 2008 and 2016). The same phenomenon was seen in the service sector (e.g. numbers of clerical support workers fell by 10 pps in the same period). ([42]) Automation and digitalisation enabled these tasks to be performed more efficiently, while the price difference between labour and capital continued to increase. ([43]) The result was more substitution of capital for labour. Economists refer to this development as "Routine-Replacing Technological Change" or RRTC (Acemoglu and Autor, 2011).

There are growing concerns about future technologies facilitating substitution of routine jobs as well as of some currently non-routine tasks. The combination of digital sensors and algorithmic control of machines is expected to expand further the range of tasks machines can perform. As a result, the effect on employment in the future may be different from what has been experienced so far. Today's routine tasks, characterised by repetition and standardisation, may gradually disappear as machines are introduced to do them. ([44]) A similar fate may befall tasks which, though not routine by today's standards, may become so in the near future as technology makes them routine. ([45])

Evidence about the extent to which people could be replaced by machines is controversial. A high level of uncertainty accompanies different authors' estimates, as they are highly sensitive to the choice of data sources and the methods used to categorise tasks. ([46]) Arntz, Gregory and Zierahn (2016), using PIAAC data from 2012, estimated the automatibility of jobs for 21 OECD countries based on a task-based approach. This approach breaks down jobs into different kinds of tasks, categorising them into: routine versus non-routine tasks; manual versus abstract/cognitive contents; and more versus less interactive. Routine manual tasks involve repetitive and physical labour that could easily be replicated by automation, as could cognitive tasks requiring the collection and processing of information. Taking the heterogeneity of workers' tasks within occupations into account, they found that relatively few jobs are automatable, ranging from 6% in Estonia to 12% in Germany and Austria. However Lordan (2018) ([47]), using Autor and Dorn (2013) definitions of a 'routine task intensity' for each occupation (see *Box 2.3*), estimated that - with today's technological frontier – the jobs that could be automated range from 37% of current employment in Norway to 69% in the Czech Republic.

Moreover, robots are becoming ever more intelligent. The potential for outsourcing tasks from people to machines depends mainly on the importance of human interactions in performing the tasks. Algorithms built into robots are increasingly performing like the perceptual parts of the brain, resulting in robots making large strides in their non-cognitive abilities, such as human interaction and perception. ([48])

([40]) Controlling for other relevant variables such as the type of contract or migrant status, the odds for secondary (tertiary)-educated workers is 62% (95%) lower than the odds for the primary educated. Biagi et al. (2018), Table 3.

([41]) Autor, Levy, and Murnane (2003); Acemoglu and Autor (2011).

([42]) Moreover, it has to be noted that even a constant number of workers in an occupational group translates into a relative decrease, due to the overall increase in the sheer number of workers in Europe in the last decade.

([43]) Low-skilled workers suffered less from this process in more developed countries, given that technological change had already cut large numbers of them.

([44]) Fernández-Macías, 2018.

([45]) Eurofound, 2016.

([46]) Biagi and Lago, 2018.

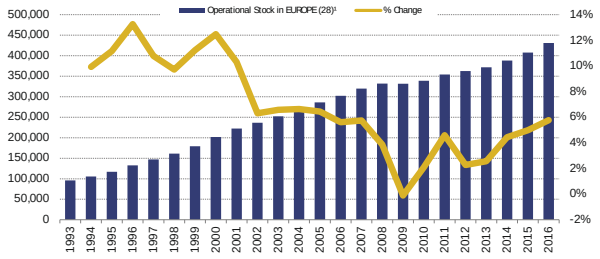
([47]) This study has been carried out for the European Commission in the context of the Social Situation Monitor. See http://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=8104&furtherPubs=yes

([48]) Pratt (2015).

This suggests that, in the long run, the potential for automation is higher than current estimates suggest. ([49])

The number of robots keeps growing. The stock of industrial robots in the EU has increased impressively in the last 25 years. According to data from the International Federation of Robotics (IFR), ([50]) it has more than quadrupled, even though its growth slowed after the onset of the crisis (see *Chart 2.14*). The EU country with by far the most robots is Germany, with its highly automated automotive sector.

Chart 2.14
Robotisation is increasing
Level and growth of the operational stock of robots in the EU28

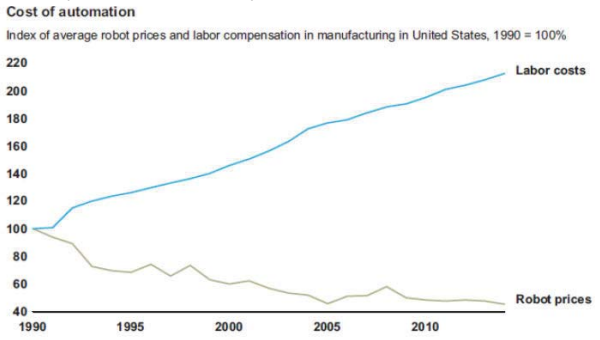


Source: DG JRC calculations based on data from International Federation of Robotics
Click here to download chart.

The markets for robotic technologies and Artificial Intelligence (AI) are growing fast. According to recent forecasts, ([51]) global spending on robots will be USD188 billion in 2020, whereas in 2016 it was less than half that. By 2025 the worldwide AI market is expected to be worth around USD59 billion, which is a significant increase on the USD1.8 billion spent in 2016. ([52]) The extensive use of AI and robots is one of the megatrends most likely to generate the higher productivity growth which is so urgently needed in ageing societies, ([53]) but it will also put many of today's jobs at risk while creating others.

Robots are becoming ever cheaper, compared with human labour. The cost of labour and the cost of capital seem to be diverging strongly. In the US the real price of robots has halved since 1990, while that of labour has nearly doubled (see *Chart 2.15*).

Chart 2.15
Labour costs are increasing while robots become ever cheaper.
Robot prices and labour compensation index in the US, 1990=100



Source: McKinsey&Company, 2017
Click here to download chart.

Job losses due to robots have mainly occurred in manufacturing, where, according to available data, 85% of the operational stock of industrial robots is used. *Chart 2.16* shows, for a selected number of

([49]) Brynjolfsson and McAfee (2017) recently revived the debate on the possibility of modern robots and artificial intelligence automating non-routine labour tasks.

([50]) The IFR defines an industrial robot as "an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications."

([51]) IDC, January 2017.

([52]) Tractica, Artificial Intelligence Market Forecasts, September 2017.

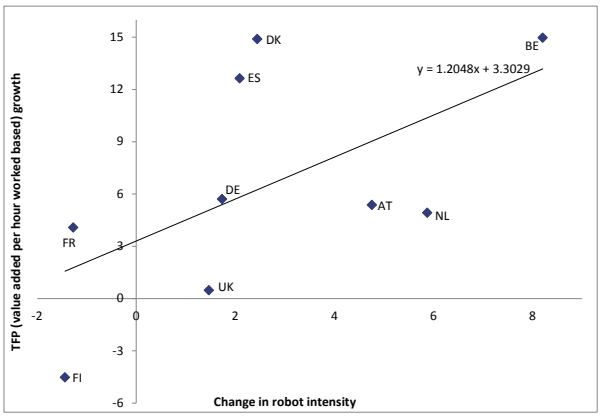
([53]) European Commission (2018:2).

countries, a positive correlation (+0.58) in manufacturing between the robot intensity (number of robots/number of workers) and total factor productivity (value added per hour worked).

Chart 2.16

There is a positive correlation between the use of robots and productivity

Robot intensity and total factor productivity in Manufacturing between 2015 and 2010



Note: Limited selection of countries due to missing data.

Source: DG EMPL calculation based on data from IFR and EU KLEMS

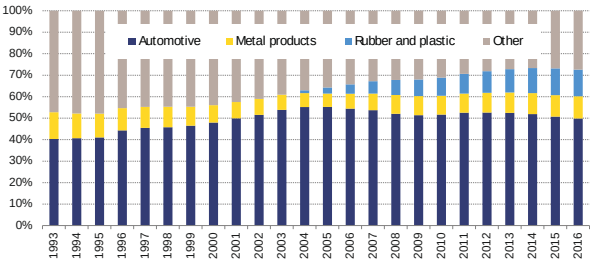
Click here to download chart.

Within manufacturing, the automotive industry employs most robots (see *Chart 2.17),* finding them particularly useful because much of that industry's work involves carrying out specific repetitive actions with little variation, but to a high degree of precision and accuracy.

Chart 2.17

The automotive sector is the main user of robots within manufacturing.

Main sectors using industrial robots - Operational Stock (% of total manufacturing), EU



Source: DG JRC calculations based on data from International Federation of Robotics

Click here to download chart.

There are also concerns about the quality of work in the age of digitalisation. The digitalisation of processes and the changes brought by the 'Internet of things' (with sensors all along the production process, from inputs to outputs) make processing, storage and communication of information easier and faster. Several available forecasts point to the positive effects of digitalisation: estimates for Germany suggest EUR 30 billion per year, or 1% of GDP (Gerbert et al., 2015), while the potential for revenue growth would be close to 3% a year in cases of high digitalisation (Schrauf and Berttram, 2015). However, workers may lose autonomy. Entire production strands may disappear, while activities may be outsourced and subcontracted. Workers may then be pushed into self-employment with little social protection. In addition, the blurring of boundaries set by European labour law raises concerns about the representativeness and effectiveness of collective agreements (Fernández-Macías, 2018).

Consequently, working conditions may be affected by digitalisation. Indeed, the regression analysis presented in *Box 2.4* on the basis of Eurofound's 6th European Working Conditions Survey (2015) finds that prominent concomitants of digitalisation, such as dependence on machines and permanent exposure

to electronic tools, clearly reduce overall job satisfaction. "New technology standardises the work to a degree and constrains the autonomy of high-skill professionals." ([54])

([54]) Kornelakis and Petrakaki (2017).

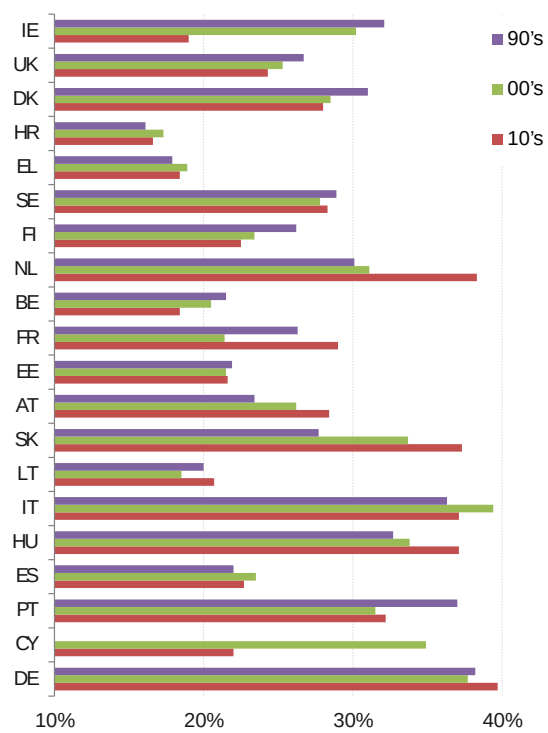
Box 2.3: Job displacement through machines could be significant – two concepts

Autor and Dorn (2013) define 'routine task intensity' (RTI) for occupations. Three types of tasks are distinguished: **Routine tasks** involve a predictable sequence of actions which are easily codifiable. Replacement of people by machines is relatively easy in this case. Conversely, **manual tasks** require actions that are not generally predictable, so substitution with technology has so far been limited. **Abstract tasks** require high-level thinking that is complementary with technology. Therefore, many routine tasks, but few manual and few abstract tasks involve low RTI. An occupation is defined as automatable if its RTI is in the top 30% of all occupations. Based on the Autor-Dorn definition, Lordan (2018) calculates the share of automatable jobs for the decades starting in 1990, 2000 and 2010.

Chart 1

Based on Autor and Dorn (2013), almost 40 % of jobs in Germany and Italy could already have been automatable in the past.

Share of automatable employment in selected countries following Autor and Dorn (2013)



Source: Lordan (2018), based on Autor and Dorn (2013)

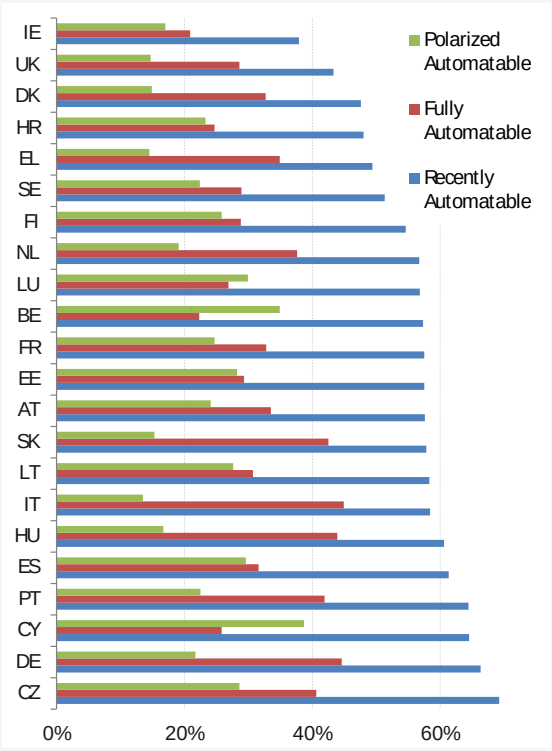
Lordan (2018) re-calculates the proportions of automatable employment using the definition put forward by Lordan and Josten (2017) who considered jobs that are currently automatable, given the technologies that are now available. Those jobs are labelled **recently automatable**. The share of automatable jobs ranges from 37 % (Ireland) to 69 % (Czech Republic).

1. Jobs that require interpersonal skills are unlikely to be automated (**non-automatable jobs**). Examples include aerospace engineers, mathematicians, nurses, teachers, economists, psychologists and hairdressers.
2. Jobs requiring some interpersonal interaction but which are also characterised by a more predictable sequence of events. In this category of **polarised automatable jobs**, although the technology is available, it will be able to take on some tasks but not others. Human employees will be retained in establishments where personal interaction still holds some value and robots will be utilised where it does not. An example here is waiting staff where machines are unlikely to displace waiters offering a fine dining experience. Another is lawyers, where machines can substitute for synthesising large volumes of text from law books but cannot substitute for the abstract thinking evidenced by top barristers during serious trials.
3. **Fully automatable jobs** are usually those where previously high R&D investment (patents being an indicator) has resulted in machines being able easily to replace people and where personal interaction does not play an important role. In such jobs, customers may be unconcerned whether the job is done by a robot or a human being. Here, there have been significant developments to the extent that Lordan and Josten (2017) predict a cull of jobs in the next decade. Vehicle drivers, packers, power plant operators and mail carriers belong to this category.

Chart 2

With today's technologies the proportion of automatable jobs could reach 70 % in some countries.

Share of automatable employment in selected countries following Lordan and Josten (2017)



Source: Source Lordan (2018), based on Jordan and Josten (2017)

(Continued on the next page)

Box (continued)

These projections range at the upper margin of estimates on potential future job losses due to automatisation. However, other authors confirm that losses could be significant.

Nedelkoska and Quintini (2018) find that 46% of jobs in 32 OECD countries have a probability of being automated of 50% or more ([1])

([1]) Nedelkoska and Quintini (2018), p. 47.

Box 2.4: Working conditions and digitalisation: Evidence from Eurofound's 6th European Working Conditions Survey

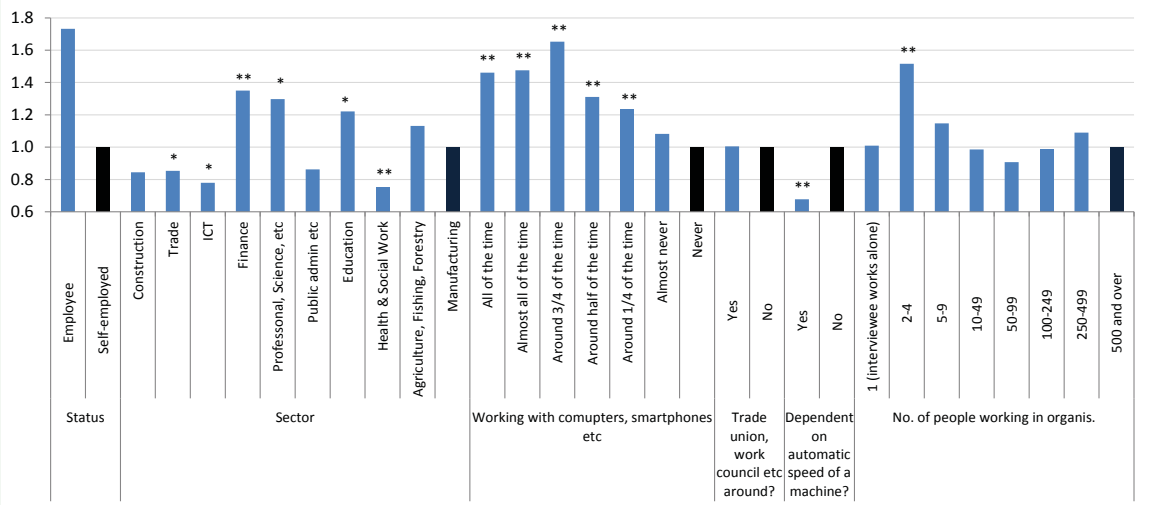
A logistic regression analyses the determinants of workers' job satisfaction, using micro data from the European Working Conditions Survey conducted in 2015 in 35 European countries. Taking into account a series of relevant control variables (see note below the chart), the chart shows the following facts:

- **Dependence on machines**: Exposure to machines while being dependent on their speed reduces workers' statistical odds of being overall more satisfied by one third.
- **Working with digital tools**: exposure to computers, smartphones etc. tends to increase job satisfaction somewhat. However, after a certain degree of exposure it starts to decline again.
- **Employment status:** The job satisfaction of the self-employed is below that of employees. ([1])
- **Relatively low satisfaction in ICT:** Job satisfaction in the ICT sector is more than 20% lower than in manufacturing.

Chart 1

Job satisfaction strongly reduced by dependence on machines and much lower for the self-employed

Logistic regression, showing the odds of experiencing higher job satisfaction, relative to the reference group (=1 in dark bars)



Note: Controlled for age, sex, education, private/public sector, family context, migration background of parents, own migration background, country of observation
** , * : significant at below 1%, 5%, resp.

Source: DG EMPL calculations based on Eurofound's 6th European Working Conditions Survey form 2015.

([1]) The coefficient is not statistically significant due to the low number of self-employed in the sample.

Nonetheless, digitalisation may also create new jobs. Arntz et al. (2016) find that job destruction has so far been limited, as robots replace tasks rather than workers. They conclude that the human presence could never be replaced completely. The case of Germany supports this finding. Germany has the highest share of robots in the EU (almost 3 times the EU average), giving it a high potential to automate routine tasks. Yet there is little evidence of robots having a negative effect on jobs. Indeed, employment contractions in some sectors (especially manufacturing) have so far been compensated for by positive spill-overs into service sectors (Dauth et al., 2017).

Displacement of workers by machines is only the first-round effect on the labour market. Digitalisation affects the economy, not only through its potential to automate routines, but also because it can yield significant cost savings and induce demand-side economies of scale through network

effects. ([55]) The cost savings and network effects give customers better value from digital products as the number of customers increases, ([56]) potentially creating additional jobs. New technologies, even when displacing workers in the first instance, can create jobs in the medium term by expanding demand for new machines and related services. They can improve labour allocation and increase productivity, as workers who are displaced (as their tasks are taken over by machines) are re-allocated to new tasks. ([57]) Much will depend on whether or not education and training systems are agile enough to respond appropriately to fast-changing technological opportunities. ([58]) The following country-specific model-based case studies demonstrate these points.

4. JOB DESTRUCTION AND JOB CREATION: A MODEL-BASED PERSPECTIVE

4.1. Italy: capital deepening continues, substitution mainly occurs in manufacturing.

In a world where neither the emergence of new technologies nor exogenous shocks can be accurately predicted, it is increasingly complex to foresee the nature of future structural change and its implications for employment. This section attempts to look ahead to the year 2030. It uses the EU KLEMS growth and productivity accounts ([59]) and adapts their projection methodology so as to make it simpler and more accessible. Given that EU economies differ greatly in terms of their sectoral composition, model simulations have been carried out for individual Member States, not for the EU-28 in aggregate. In this sub-section, the case of Italy is used as a proxy, based on the assumption that future structural changes are of vital importance to a country where "long-standing structural weaknesses contribute to high levels of poverty and income inequality." ([60]) The approach is validated by simulations for other EU Member States, which are largely in line with the results obtained in this section.

A baseline scenario until 2030

Since the year 2000, Italy has seen stagnating real GDP and low productivity growth. The building blocks of economic growth are capital, labour and total factor productivity (TFP) - a measure of how efficiently capital and labour are used in the production process. Efficiency gains may come from product innovations, technological progress or organisational improvements. ([61]) Over the last 15 years, capital, labour and TFP have not expanded Italy's production: average annual economic growth has been nearly zero since the year 2000, dragged down by steep declines in two sectors that between them provide more than 20% of Italy's total production: manufacturing (-0.7% per annum) and transport/logistics (-0.4% per annum). The financial crisis has pushed the country into a double-dip recession so severe that today's production (real added value) is still considerably below the 2008 level. The same is true for overall employment, where manufacturing saw the strongest absolute decline following the crisis, although employment gains were realised in labour-intensive service sectors. Those include professional, scientific and technical activities, but also accommodation and health/social work.

Capital intensity is increasing. As is the case in many other EU countries, one decisive feature of Italy's long-term growth trend is an almost continuous deepening into capital. On average, workers are being endowed with more and more capital in the production process. Capital deepening had two faces though. Before the crisis, investment was in line with the euro area's average so that the capital stock grew faster than employment. During the crisis, capital intensity increased despite declining investment, as a result of layoffs. ([62]) As capital intensity increased in most sectors, an extrapolation of this trend based on a log-linear regression seems an appropriate assumption for a base scenario which rests on continuously

([55]) "Size begets size: The more sellers [online platforms] can attract, the more buyers will stop there, which attracts more sellers, and so on." (The Economist, Jan 20, 2018, p. 11)

([56]) Fernández-Macías (2018).

([57]) Acemoglu and Restrepo (2017).

([58]) Bakhshi et al. (2017), p. 89.

([59]) Available online at http://www.euklems.net/project_site.html. For an overview see Timmer et al. (2007).

([60]) European Commission (2018:3), p. 1.

([61]) See http://www.businessdictionary.com/definition/total-factor-productivity-FTP.html. Unlike EU KLEMS the simplified growth account does not explicitly consider intermediate input as a third production factor. Hence the concept of TFP (as the residual contributor to growth) used here is different from the original KLEMS database.

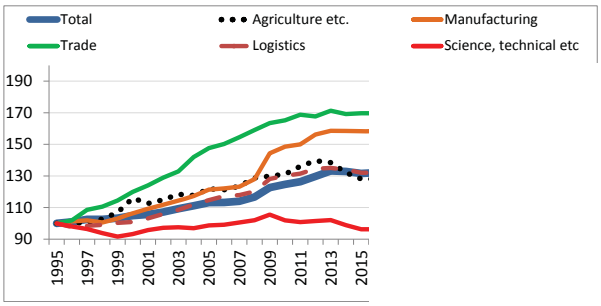
([62]) European Commission (2018:3), p.11.

increasing capital intensity, but at a declining pace of 0.7% every year on average between 2015 and 2030, down from 1.7% during the period between 2000 to 2015 (*Chart 2.18*).

Chart 2.18

Rising capital intensity in most sectors

Capital per worker ratio, 1995 = 100, Italy (selected sectors)



Note: Projection: Log-linear trend regression.

Source: DG EMPL calculations based on EU KLEMS database

Click here to download chart.

Capital deepening can replace workers – and create jobs. The extent to which countries rely on capital in their production process strongly determines their long-term growth path and labour market conditions. However, looking to the future there are major uncertainties because important assumptions have to be made about the nature of physical investment. It can be hypothesised that, in an attempt to improve profitability, firms may deepen capital in order to replace workers wherever strong automation potential induces them to do so. On the other hand, physical and human capital may be complementary where physical investment leads to innovation ([63]), thereby lifting productivity and generating new jobs in newly developed markets.

Capital intensity and productivity are linked. A regression analysis (Annex 3) confirms that faster capital deepening tends to increase Total Factor Productivity (TFP). Endowing more workers with capital would improve resource allocation and thus be conductive to higher efficiency (TFP). On these projections, Italy's sluggish overall efficiency gains could continue until 2030 (+0.2% per year, see *Chart 2.19*).

Future employment growth depends on economic growth and on the technology applied in production. To answer the question of how the labour market (employment) will develop until 2030 in a base scenario, the following assumptions have to be made in addition to the assumption about the degree to which the economy will continue capital deepening (the Annex 3 presents the details):

– An assumption about future economic growth per sector, where the base scenario has been aligned to the overall (total-economy) growth rate as projected in the 2018 Ageing Report. ([64]) This assumes the economy will, on average, grow by 0.6% per year between now and 2030 (as opposed to the 0% growth which typified the last 15 years).

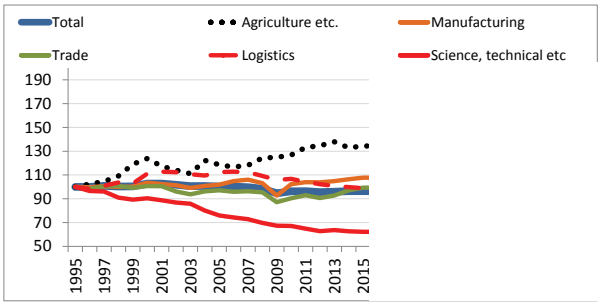
([63]) Especially ICT investment is found to correlate positively to innovation. See Hall et al. (2010).

([64]) European Commission (2017:2), European Commission (2018:1).

Chart 2.19

TFP is stagnant overall

Total Factor Productivity, 1995 = 100, Italy (projection based on a regression)



Note: Projection: A simple regression model with log (Capital Intensity) as independent variable. Controlled for sectoral specificities (sector dummy) and the year.

Source: DG EMPL calculation based on EU KLEMS data

Click here to download chart.

– An assumption about what production technology will look like: in particular, it is important to make assumptions about how the input of capital and labour and the degree of efficiency in production (TFP) will drive economic growth in each of the sectors. The technical link between output and those three contributors to growth is calculated with the help of one production function for each of the 16 sectors included in the analysis. This information is important as it defines the degree to which capital can be substituted for labour without causing any loss in output.

Based on the assumptions about growth performance and capital intensity, it is possible to use the production function to work out the labour volume used in production from the level of production. The labour volume is the product of the number of workers (employment) and the number of hours worked per worker, the latter being influenced by the prevalence of part-time work.

The base scenario shown in *Chart 2.20* comes close to representing accurately Italy's growth and labour market performance before the onset of the crisis. Raising growth from stagnation levels ([65]) to 0.6% every year would require Italy's capital endowment per worker to continue increasing (by 0.7% per year) while total labour input to production (the number of hours worked in total) could grow by 0.1% every year on average – close to the 2018 Ageing Report's projected level of growth. The increase in the number of workers in employment would then be a bit higher: by 0.2% per year (+0.75 million in total until 2030). This is because the model predicts the trend towards reducing average working hours to continue. The two sectors gaining most employed workers are ICT and health/social work (more than 0.2 million each), while industry would lose half a million people in employment (more than 0.2 million each in manufacturing and construction).

Capital deepening is most prevalent in manufacturing.

A high share of automatable tasks can be found in Italy. Italy being one of the most automatable economies (*Box 2.5* below), numerous authors find evidence for a very significant risk that more tasks will be automated, particularly those requiring low and medium skills. On the basis of the PIAAC survey of 2012, ([66]) the OECD reckons that the likelihood of future automation for the job of today's average worker in Italy could be around 50%. Lordan (2018) confirms that a job's potential for automation depends on the skill level it requires. In the case of Italy, she finds that around 70% of low-skilled and some 60% of medium-skilled jobs are automatable. Likewise, Nedelkoska and Quintini (2018) look at 32 OECD countries and see the risk of automation decrease as people attain higher education and better skills. ([67]) As impressive as these figures may seem, they represent *gross* job losses and do not imply a particular trend or scenario for the creation of new (especially high-qualification) jobs.

([65]) Average growth rate between 2000 and 2015.

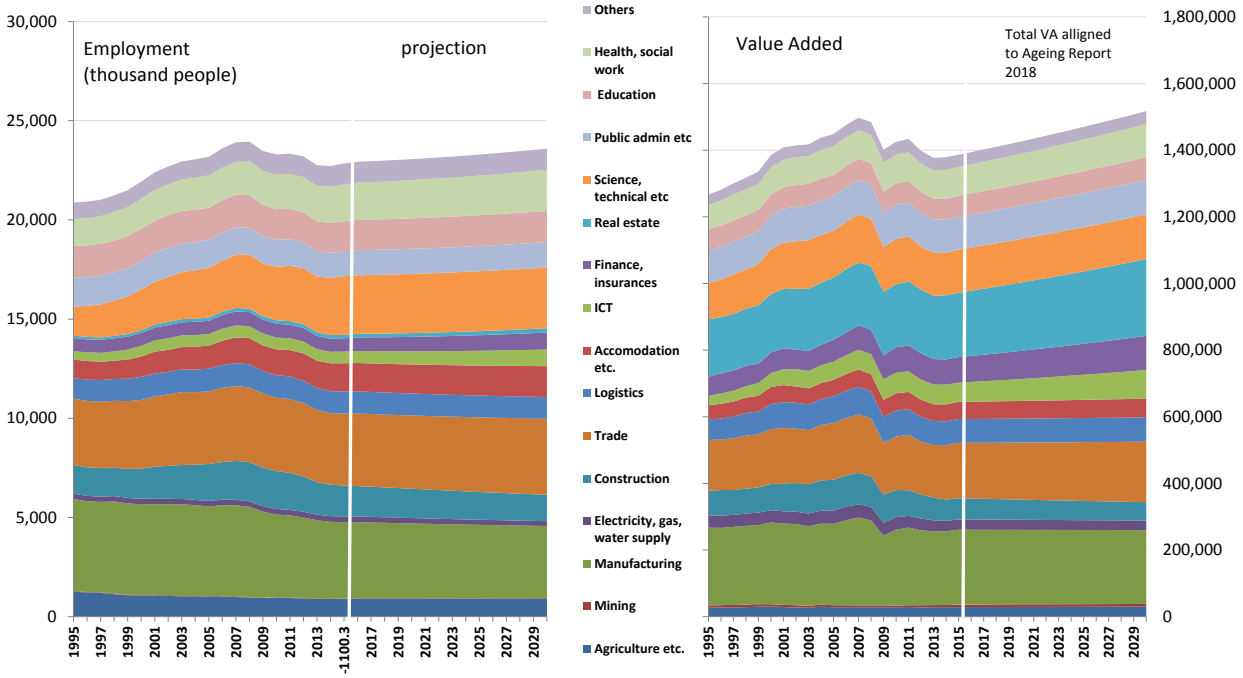
([66]) PIAAC is the OECD's Survey of Adult Skills. See http://www.oecd.org/skills/piaac/

([67]) Nedelkoska and Quintini (2018), p. 50.

Chart 2.20

Services gain weight: a base scenario for Italy

Number of employed workers and value added in the base scenario



Source: DG EMPL calculatoins based on EU KLEMS

Click here to download chart.

Based on Eurostat's 2016 Labour Force Survey, *Table 2.2* gives a distribution of employment per main sector in terms of the main occupations. Following the International Labour Office's International Standard Classification of Occupations (ISCO), ([68]) the table assigns each occupation to a skill level and finds that the proportion of workers in jobs that require skill level 1 or 2 (the lowest two out of four ISCO-levels) varies greatly across sectors. ([69])

The risk of automatisation is not *only* a question of low skills. *Table 2.2* seems to confirm the OECD's and other sources' main finding that the risk of job automation would affect industrial sectors and agriculture in the first instance because their share of lower-skill jobs (at ISCED levels 1 and 2) is much higher than in services. However, other factors also influence job substitution. For example, agriculture has already seen large reductions in the number of workers over the last decades. Capital intensity in agriculture is currently among the highest across all sectors. The evolution of employment in agriculture suggests that the greater the reduction that has already occurred in a sector, the narrower the margin for further reductions. In addition, many of the remaining agricultural workers are rural families: the scope for incentivising them to substitute capital for labour is very limited.

Higher capital intensity has different implications in different sectors. The production function applied to each sector in the simple employment projection of *Chart 2.20* takes into account that substitution is more difficult in some sectors than in others. In the following projection, with given sectoral growth prospects, it is assumed that capital intensity shifts by another 30% between 2015 and by 2030, or 1.7% every year ([70]) as opposed to 0.7% in the base scenario. ([71]) This assumption implies an annual increase in capital intensity equal to the average shift seen since 2008; over this period capital deepening has accelerated while total employment has declined by almost 5%, i.e. by more than 1 million workers.

([68]) ISCO-08, see http://www.ilo.org/public/english/bureau/stat/isco/isco08/index.htm

([69]) For the assignment of skill-levels to the respective occupations, see Annex 1 of Chapter 3 in this review.

([70]) The real estate sector is excluded from the assumption. It would not make sense here as capital intensity in the real estate sector is already a large multiple of the average across sectors as the sector combines more than half of the overall capital stock - with mainly buildings, for which the notion of human capital substitution seems irrelevant.

([71]) This increase is achieved by multiplying, for every sector, the projected (smooth) increase of capital intensity in the base scenario by a factor 3.4.

Table 2.2

Automatable jobs unevenly distributed across sectors

Employment 2016 in Italy, by sector and occupation

	Occupation	Managers	Professionals	Technicians and associate professionals	Clerical support workers	Service and sales workers	Agricult., forestry, craft, trade, machine workers	Elementary occupations		
	Skill level	Skill-level 4 (highest)	Skill-level 4 (highest)	Skill-level 3	Skill-level 2	Skill-level 2	Skill-level 2	Skill-level 1 (lowest)	Sum	Share Skill level 1 and 2
Sector	Agriculture etc.	4	4	16	15	7	522	317	885	**97%**
	Mining	2	5	5	3	0	15	3	33	**64%**
	Manufacturing	142	214	855	419	48	2218	253	4149	**71%**
	Electricity, gas, water supply	10	18	95	64	2	75	96	360	**66%**
	Construction	67	23	102	66	1	1070	76	1405	**86%**
	Trade	160	108	445	303	1561	392	274	3243	**78%**
	Logistics	27	24	114	285	31	449	155	1085	**85%**
	Accomodation etc.	227	5	29	73	894	38	131	1397	**81%**
	ICT	21	204	230	82	7	14	4	562	**19%**
	Finance, insurances	21	80	363	182	1	0	2	649	**29%**
	Real estate	7	3	80	30	1	1	19	141	**36%**
	Science, technicians, professionals etc	43	781	512	425	136	119	437	2453	**46%**
	Public admin etc	33	150	222	353	214	26	31	1029	**61%**
	Education	16	1142	70	122	31	5	157	1543	**20%**
	Health, social work	36	429	698	179	381	32	76	1831	**36%**
	Others	43	132	146	119	364	105	81	990	**68%**

Note: For the assignation of occupations to skill-levels see Annex 1 of Chapter 3 in this review.

Source: Eurostat EU LFS

Click here to download table.

With capital intensity increasing fast, traditional sectors, manufacturing in particular, are expected to see most job displacements. According to *Chart 2.21*, while in the base scenario employment between 2015 and 2030 would increase by 3%, in this 'increased capital deepening' scenario it would decline by 8%. More than 40% of the predicted loss would be due to job losses in Italy's important manufacturing sector, where technical conditions for straight substitution of workers by capital (captured in the estimated production function) seem most valid. In this extreme scenario, by 2030 manufacturing alone would lose 20% of its 2015 employment (some 0.8 million workers), 15 pps more than in the base scenario. The three traditional sectors manufacturing, construction, and trade combine more than three quarters of the job losses in the increased capital intensity scenario while services such as ICT, science/technicians, and finance would still gain employment ([72]).

Simulations for other EU countries confirm these findings, as do other sources. ([73]) By 2030 the dimension of potential job losses due to capital deepening found by the sources mentioned earlier may be reached in the manufacturing sector, where the proportion of people working in 'lower medium' and low skilled occupations (the lowest two out of four ISCO skill-levels) is above 70% and technical conditions allow for easier substitution of capital for workers.

However, as the following sections will demonstrate, job destruction in manufacturing may be only part of a bigger picture in which new technologies and digitalisation become net job creators. Indeed, the OECD points out that "the automation of agriculture in the 1960s gave way to manufacturing and the automation of manufacturing gave way to services." Displacement of workers in manufacturing may thus reflect the re-allocation of productive resources towards higher productivity activities. ([74])

([72]) The three sectors mentioned would gain some 0.2 million jobs altogether in the increased capital deepening scenario.

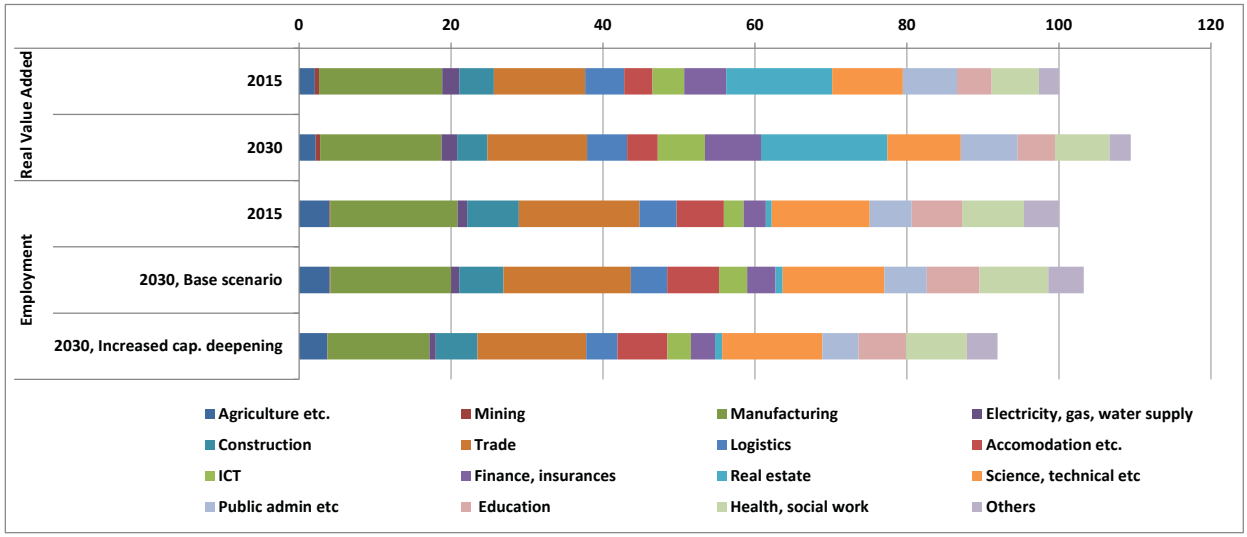
([73]) Most recently, Nedelkoska and Quintini (2018).

([74]) Bessen (2015).

Chart 2.21

Substitution costs jobs mainly in manufacturing

Real value added and employment by sector in the Accelerated Capital Deepening scenario, Italy



Note: Index with total employment in 2015 normalised to value 100. Capital intensity of the whole economy in the base scenario increases by +0.7% per year, in the Accelerated Capital Intensity scenario by +1.7% per year.

Source: DG EMPL calculations based on EU KLEMS database

Click here to download chart.

Box 2.5: The Italian economy

That manufacturing sector still contributes one third of the country's non-financial business economy's value added, and provides 17% of its employment (currently almost 4 million people). ([1]) However, compared with the Italian economy as a whole the sector has been underperforming, with growth stagnating, and a loss of 16% of its employment over the last 15 years. Sources indicate that Italy's manufacturing sector may have suffered from a relatively strong specialisation on low-skilled labour intensive sectors for which the potential of automatisation is high. ([2]) The low 'sophistication level of its specialisation pattern' ([3]) may thus induce firms to substitute jobs for capital when their overall productivity declines. In addition, strict employment protection legislation (firing and hiring rules) may dissuade employers from investing in human capital but instead induce them to invest in physical capital. ([4])

([1]) Eurostat (2008).
([2]) See, for example, Di Maio (2013).
([3]) Ibidem, p. 14.
([4]) Cingano et al. (2014).

4.2. Germany: low-qualified workers are at risk of being substituted but not only by capital

The sectoral model has its limits. In the previous section a sectoral growth accounting framework was used to explore the sectoral dimension of capital deepening. The analysis showed that capital deepening occurs not only for reasons of substitution; qualifications also play an important role in explaining the degree of substitution between capital and labour. To explore in greater depth the role that the nature of skills and education plays in investment, GDP and the labour market, it is necessary to turn to a different analytical framework. This should allow for the interplay between capital accumulation and workers' qualifications, and for endogenous growth that may raise (or depress) employment, as second-round effects following faster accumulation of capital. What will be the relationship between capital and labour in future labour markets?

Labour productivity (skills, education) will impact on how capital relates to labour. The Commission's Labour Market Model (LMM) is a general equilibrium model with a particular focus on the institutional framework and popular policy tools for the labour market. ([75]) It does not distinguish economic activities (sectors), but differentiates between age groups and, most importantly, between three different levels of workers' education: high (tertiary education), medium and low (up to lower secondary

([75]) Berger et al. (2009), see the model description in Part II.

education). ([76]) In addition, the model takes into account that an individual worker's productivity at each level of education depends on their level of skills, which, in turn, may be formed through training.

Apart from capital replacing labour, labour also substitutes for labour. Unlike the simple sectoral model applied above, LMM incorporates a 'nested production function' ([77]) which is very important when it comes to exploring how labour reacts to capital accumulation. This has two implications. First, it means that capital can substitute to a different degree for each one of the three types of labour. The higher a worker's qualification, the lower is their probability of being replaced by capital. Moreover, according to specialised literature, ([78]) qualified labour and capital complement each other in production. Secondly, the three qualification groups are imperfect substitutes for each other. For instance, in order to get a foothold in the labour market, highly educated workers may compete for jobs that only require lower qualifications, crowding lower-qualified people out of the market. An increasing proportion of tertiary-educated workers (some 23% of those in the EU today) works outside the three highest-qualified occupations, ([79]) probably competing with lower-educated workers for lower-skilled jobs. ([80])

Technically, these circumstances are taken into account by the model through the so-called 'elasticity of substitution' between the four factor inputs in production, i.e. the three types of labour and capital. The easier it is to substitute those inputs for each other, the more elastic is production. Under these conditions, if low-qualified workers become relatively more expensive firms will be more inclined to replace them by higher qualified workers or by capital.

The impact of accelerated structural change in Germany is skill-biased. Given its highly industrialised economic infrastructure, numerous authors consider Germany to be among those countries with the highest potential for automation, now as in the past. Germany has lost half a million jobs in manufacturing since 1995, while at the same time services have gained more than 7 million new jobs. Furthermore, the transformation was accompanied by a changing mix of the qualifications needed in production. While Germany is in its 12th year of labour market recovery, with overall employment at all-time high levels, low-qualified employment is still well below the pre-crisis level, and has been static at around 5 million workers since 2011. ([81]) Similarly, more complex occupations requiring higher skills have gained much more employment than activities with lower skill requirements. ([82])

([76]) See Eurostat's description of the International Standard Classification of Education (ISCED) on 'Statistics Explained'.

([77]) The 'nest' referred to is the total input of productive factors in production: labour input at three different education levels and capital. See Berger et al. (2009), Part II, p. 45.

([78]) For example, Krussel et al. (1997).

([79]) See the first 3 columns in Table 2.2 for Italy.

([80]) Eurostat EU LFS data (2016).

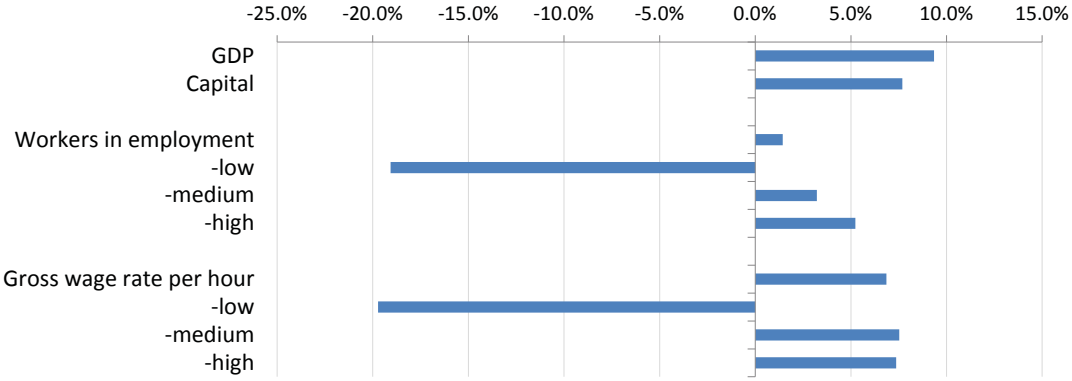
([81]) At the same time the number of low-qualified people in Germany has strongly declined during the crisis so that their employment *rate* went up.

([82]) Occupations in the upper two skill level categories (see Table 2.2) have won 5 million workers while other occupations have increased by only 1 million since 1995 (army jobs excluded). Source: Eurostat EU LFS.

Chart 2.22

Employers switch to employing better qualified people and to higher capital investment, low-qualified workers lose out

Structural change away from low-educated labour towards higher education and capital, Germany



Note: Elasticity of substitution of low-educated workers increases from 1.3 to 1.6; Chart shows the change relative to no-change scenario.

Source: DG EMPL calculations based on LMM

Click here to download chart.

Box 2.6: Input factors in the model

For low-qualified workers the model assumes an elasticity of substitution equal to 1.3 in its initial situation. That is, as the average price of the other three input factors (called 'the nest') increases by 1%, the factor input of low-qualified workers, relative to the input of the nest, increases by 1.3%. Thus, it is assumed that firms react more sensitively to factor price/wage changes of the nest: the elasticity of substitution increases by around 25% - from 1.3 to slightly over 1.6.

Germany's impressive labour-market recovery was therefore skill-biased. It is expected that digitalisation will reinforce the trend towards more complex activities, while others remain at risk of being automated. ([83]) While the evidence on how this will impact on Germany's large and heterogeneous supply of medium-educated workers is mixed, the changes are likely to bring declining demand for (and supply of) low-qualified workers. ([84])

Low-qualified labour is assumed to be substituted more easily. To model the economic impact of such trends, it is assumed below that future structural change towards innovative products, increasingly efficient production processes and better-qualified workers will increase the elasticity of substitution away from low-qualified workers. In other words, it is assumed that firms' demand for low-qualified workers will be more sensitive to changes in the relative costs of capital and labour. How would an increase in the elasticity of substitution by 30% ([85]) shape the qualification mix of the country's workers in the long run, and how would that impact on Germany's wage profile and the economy's growth prospects?

The mix of workers' qualifications changes in favour of higher end skills, triggering investment. *Chart 2.22* shows that the demand shift towards higher qualifications would cause a decline of low-qualified employment by almost 20% in the long run. It would drag down their wages, causing supply of low-qualified workers to also decline. However, the impact on the labour market does not end there. Faster substitution of workers with only low-level education triggers demand for higher qualifications (reflected in the respective wage levels). The capital stock increases for two reasons: first, due to the direct substitution of higher-educated for low-educated workers; secondly, due to the better overall education mix of workers (inducing firms to deepen their capital, since higher qualification of workers is complementary to capital)**.** A better-qualified workforce enables firms to be more innovative, hence more competitive. Both higher investment and the better qualification mix of workers push up average labour

([83]) Wolter et al. (2016), p. 10, reckon that in a fully digitalised working environment an estimated 1.5 million jobs will disappear by 2025, compared with a situation in which technical progress is based on past trends (baseline). However, there will be 1.5 million new jobs that would not exist in the baseline scenario.

([84]) The group of medium-educated workers in Germany is very heterogeneous. For example, graduates from vocational schools (ISCED 4a), a particularity in Germany's education system, are counted as medium educated while German statistics include them as highly educated. Between 2018 and 2030, Cedefop (2018) projects the labour force to decline by only 2.4% for medium educated people, while for low-educated it falls by more than 14%.

([85]) See Box 2.7.

productivity. As a result, total employment increases despite the direct substitution of the low-qualified. GDP is pulled up by higher employment and the increased capital stock.

Employment of low-qualified workers will decline, as will their wages. There may be a social cost, in the form of massive job losses for low-qualified workers and downward pressure on their wages. In addition, as the capital-labour ratio in production increases strongly, so does capital income, relative to wages. Indeed, income from wages is projected to increase more slowly (by 9%) than capital income (by 10%). In most other EU countries the difference would be higher because they have a higher proportion of workers with low-level education.

In other words, despite the overall wage increase, in relative terms income will shift away from labour towards capital owners. This finding confirms Autor and Salomons who find for 18 OECD countries that since 1970, automation has reduced the labour share in value added. ([86])

4.3. Czech Republic: developing human capital protects workers from direct substitution

Skilled human resources are in short supply. While noting that "skilled human resources are crucial to developing a well-functioning research and innovation ecosystem", the European Commission's 2018 Country Report on the Czech Republic concludes that skilled human resources "are in short supply." The proportion of tertiary-educated people aged 30-34 in the Czech Republic has increased strongly over the last ten years, surpassing the 32% national target for 2020. However, at 33% it is still one of the lowest in the EU. Moreover, the Country Report finds structural problems: relatively few people graduate in science and engineering, potentially leading to new shortages in these core disciplines. ([87])

Simulated policy: investment in the education system. Future structural change will inevitably be accompanied by higher demand for well-educated people. Given the relatively low current proportion of highly educated employment in the Czech Republic, Cedefop projections see a need for highly educated employment to increase by 46%, double the EU average, between 2015 and 2025. ([88])

The higher education reforms of 2016 aimed to promote greater social diversity and increase attainment rates further. This will involve amending the system for funding scholarships for tertiary education students. Currently, only 1% of students receive a scholarship, based not on merit alone but on social grounds. ([89])

The additional supply of high-educated people would put downward pressure on the growth of their wages. One possible scenario is that the Czech government increases the current general government budget for tertiary education by 50%, investing another 0.4% of GDP ([90]) in scholarships in order to motivate more young people to engage in tertiary education. The long-term results of that policy initiative are modelled in *Chart 2.23*. The workforce composition will be shifted towards the high-education end. The additional supply of highly-educated people will cause their wages to decline. The decline shown in *Chart 2.23* appears massive, but it has to be remembered that at present in the Czech Republic only 24% of the working age population aged 20-64 are tertiary-educated, far below the EU average of 35%. Therefore, additional resources invested in this relatively small group can be expected to have a relatively strong impact on the group's opportunities and productivity potential.

Capital and qualified labour are complementary: higher physical investment follows. Moreover, as the workforce will be better educated on average, firms will change their investment plans, investing more in endowing their better-educated workers with more capital. In this case, capital deepening takes place not to substitute for labour, but to provide better-educated workers with the innovative technologies they need to reap the fruits of higher productivity. Capital accumulation (investment) will accelerate, pushing

([86]) Autor and Salomons (2018).

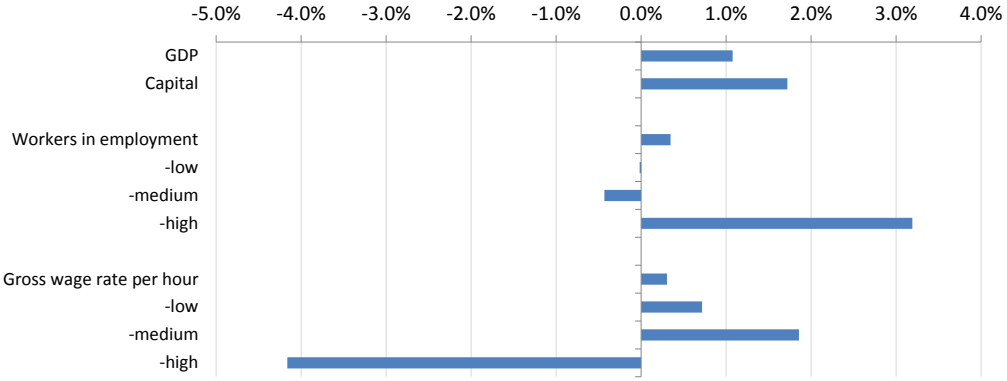
([87]) Country Report on the Czech Republic, p. 36.

([88]) See the European Centre for the Development of Vocational Training (Cedefop), Skills forecast, available at http://www.cedefop.europa.eu/en/events-and-projects/projects/forecasting-skill-demand-and-supply/data-visualisations

([89]) European Commission, Education and Training Monitor for the Czech Republic (2017), p. 10.

([90]) Currently (2016) the general government spends 0.7% of GDP for tertiary education (EU average). See Eurostat table gov_10a_exp.

Chart 2.23
The benefits of supporting tertiary education: more investment, higher GDP
Long-term impact of a scholarship for taking up higher education (+0.35% of GDP), Czech Republic



Note: % change compared to the no-policy scenario.
Source: DG EMPL calculations with LMM
Click here to download chart.

up GDP and demand (and wages) for low and medium-educated workers. However, the supply of low and medium-educated workers will decline, pulling down employment in those two groups despite higher demand. This is because the education subsidy will induce more young people to invest in higher education, abandoning initial plans to stay in the lower- level education groups. Finally, despite average wages increasing, the wage component within total income will decline slightly, pulled down by strongly increasing capital income which is being fuelled by the growth in investment.

Incentives will lead to a better education mix. What occurs in this scenario may be interpreted as substitution of low- and medium-educated workers by highly educated workers, rather than by capital. People are not being pushed out of the labour market by better-educated workers. Instead, they decide for themselves to invest in higher education, supported by new incentives. Rather than waiting for structural change to allow capital to operate as a mere substitute for people, governments can decide to be proactive and invest in human capital, so as to equip people with the qualifications which are increasingly needed in the changing world of work. Nevertheless, the phenomenon of over-qualification and over-skilling may demand more attention and monitoring, so to avoid ineffective investment in human capital and the lower productivity associated with skills mismatch. ([91])

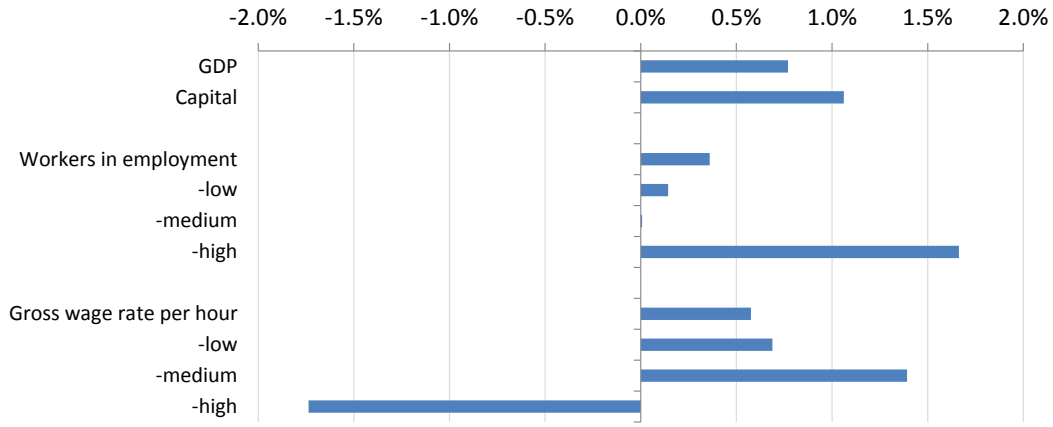
What if the Czech government decides also to invest in job-related training for low and medium-educated workers? While the level of education is important, so is the level of people's job-related skills, beyond the education level one may have attained formally. The simulation above channels all additional resources into tertiary-level education. However, governments may decide to diversify, also stepping up investment in training for job skills. In Italy, for example, training intensity is very low, especially amongst low-educated workers who would be in need of such training in the first place. ([92]) In order to improve the latter's labour market prospects, that country's government may want to support firms in sponsoring the training of workers with low and medium levels of education.

Investment in training for job skills will mean less substitution of low and medium educated workers as they become more productive. *Chart 2.24* shows an alternative scenario for the Czech Republic. Instead of investing 0.4% of GDP solely in increasing the take-up of tertiary studies, the government is assumed to decide to spend half this budget on supporting firm-sponsored training for the two lower-educated groups. The effect on overall employment is nearly the same as above. But the positive impact on investment and GDP is smaller than in the tertiary-education-only case, because the change in workforce composition towards better-educated workers is less strong than in the previous scenario. The impact on the employment situation of low and medium-educated workers is therefore more neutral. Some will still invest in higher education. Others will stay in the low and medium-educated section of the labour force as training improves their productivity, and consequently their wages. In this

([91]) European Commission (2017:3), p. 10.

([92]) While this is particularly true for Italy, Chapter 3 (section 3) finds that EU-wide take-up of lifelong learning measures is generally low amongst low-qualified workers, those in small firms, and those who work in jobs requiring low skills..

Chart 2.24
The benefits of supporting both education and training: more neutral for low and medium-educated workers
Long-term impact of a tertiary education scholarship, plus a training subsidy for low and medium educated workers (0.18% of GDP each), Czech Republic



Note: % change compared to the no-policy scenario..
Source: DG EMPL calculations with LMM
Click here to download chart.

scenario, involving lower additional investment in formal education alone, overall wages increase but labour income as a percentage of total income improves only slightly (by +0.1 pp).

4.4. Investing in education and skills favours net job creation

Demand for well-educated workers should continue to increase. The demand for well-educated workers with particular skills is expected to pick up within the next 10 years. It is impossible, even in the medium term, to forecast in which direction product and factor markets will move. Nonetheless, the model simulations presented in this section on the basis of simple scenarios provide some insight into how labour could relate to capital in the future world of work.

Job substitution in manufacturing is set to continue. Workers who lack the necessary skills and qualifications will be competing with capital on unfavourable terms. Firms will feel more pressure to deepen their capital, replacing labour whenever they can expect a return for this. A simple sectoral growth-accounting has shown a moderate growth scenario for Italy until 2030 where capital intensity would continue increasing. Total employment would increase as well. However, jobs displacements are likely to continue in the industrial sector. Assuming faster increasing capital intensity (at given economic growth), the pressure on jobs will be strongest in the manufacturing sector where the conditions for substituting capital for labour are best fulfilled (i.e. where substitution can take place at low cost).

Substitution will occur within groups of workers as well as between labour and capital. A model simulation shown for Germany assumes that some new technology will make substituting low-qualified workers easier. In the long run this would lead not only to more capital investment to replace those workers but also to higher employment of medium and highly qualified workers. As a result, the qualification mix of workers changes to the higher end. Thus, the structural change would speed up firms' preferences for better-qualified people while accelerating capital investment and overall productivity. Production will consequently become more efficient and GDP will increase. However, low-qualified individuals could suffer great losses. Their employment and their wages would decline. In addition, the scenario implies that more better-qualified workers would compete with those holding low qualifications for low-profile jobs. Indeed, over-qualification in the EU is already a widespread phenomenon. ([93])

Job substitution is not the only motivation for capital investment. To avoid the social cost imposed on low-qualified workers, governments may proactively invest in training and better education in order to facilitate economic transition towards innovative technologies. In a corresponding scenario shown for the Czech Republic such investment will increase productivity of workers and stimulate both labour demand and capital investment. Capital deepening in this scenario occurs not to replace labour but to enable

([93]) For example: ESDE 2015, Chapter III.1, see European Commission (2016:1).

better-qualified workers to get full value from more efficient, innovative technologies. In fact, a better-qualified labour force is complementary to capital, and an increase in physical capital can be stimulated by an upgrade of human capital.

Investment in education and training (skills formation) will help turn structural change into growth. Therefore, governments may decide to invest in people's education and their skills in order to prepare them for the future world of work. Rather than accepting that growth will only benefit some while others become victims of structural change, government spending on education and skills should improve productivity and support wage growth, producing increases in GDP per capita (greater welfare) and better employment prospects. In this scenario, the nature of capital deepening is radically different from the pure substitution scenario. More and better-qualified workers will require more capital investment so as to improve firms' competitiveness and increase society's welfare. While this is the macro-economic role of investment in skills and education, Chapter 3 will look at their role from the individual's perspective.

5. CONCLUSION: STRUCTURAL CHANGE CALLS FOR INVESTMENT

Ever fiercer competition in global product and factor markets is expected to increase the pressure on firms to launch innovative products in new markets. Thus globalisation brings new technologies, with new opportunities for firms, workers and consumers. However, many workers fear losing out as a result of technological change which may take their jobs.

Work organisation is changing. While collaborative platforms have been growing fast, they do not yet constitute a significant share of the EU's workforce. However, these non-standard forms of work are expected to grow faster. Major social challenges may emerge in the future. Firstly, non-standard workers stand significantly higher risk of working on a job with high automation potential. ([94]) Secondly, as many platform workers are not covered by social insurance and their earnings tend to be low. Evidence suggests that many workers, including well-qualified ones, have been pushed into the low-pay segment of the labour market over the last 15 years. Platform workers stand a great risk of joining them - adding to on-going job polarisation, which is already reducing the middle-paid segment of workers. All workers are feeling stronger pressure to upskill.

Current high employment levels may suggest that there is little need for concern about the displacement of workers, but the future may be rather different. EU employment is indeed at all-time high levels, but there is a growing risk that in years to come, human labour could be replaced by machines on a massive scale. European labour markets are not yet signalling any such major change. However new types of business, such as collaborative internet platforms, have yet to show their full potential. The net employment effect of structural change remains uncertain.

Digitalisation and capital deepening, in combination with the process of globalisation, have brought about the disappearance of many traditional jobs in Europe. Workers performing routine tasks, mainly in the manufacturing sector, continue to be displaced by capital, while services have been expanding for decades. Capital intensity per worker has increased and is expected to increase further, a situation carrying the risk of further job displacements, especially in manufacturing, where the technical conditions for increased substitution of workers by self-learning and ever more intelligent machines seem to be optimal. Tasks requiring human interaction and creativity tend to run a much smaller risk of being assigned to machines.

At the same time, digitalisation and capital deepening are creating new jobs. There has been direct job creation in robotics industries, and the loss of 'old' jobs is often accompanied by the creation of new employment opportunities. Capital deepening entails opportunities for job creation in innovative industries and services where workers are complementary to physical capital. Model simulations confirm that (1) workers are being replaced not only by capital, but also by other workers with a different profile of qualifications; and (2) qualifications are key to making labour more complementary to physical capital, thus increasing productivity and accelerating the demand for well-qualified workers.

([94]) Biagi et al. (2018), esp. Table 3.

Investment in education helps Member States develop their human capital so as to complement new technologies and improved processes. As well as investing appropriately in physical and human capital, Member States also need to ensure that the benefits from new technologies and new ways of working are fairly shared between their citizens. The following chapters will analyse the consequences of this transformation and the related political challenges.

While better education remains a priority, matching labour demand is necessary to avoid over-qualification. As many earlier analyses have shown, ([95]) resources could be better used and lead to higher growth if the EU managed to reduce the number of people who are working below the level of their formal qualifications. The impact of a better-educated labour force on long-term growth will depend on how efficiently the new supply of better-educated workers matches labour demand. Preventing early school leaving, facilitating upskilling, promoting skill-intensive industries and reducing barriers to firm entry, exit and growth are found tools to address over-qualification. ([96])

([95]) The Commission has devoted much research recently to qualification mismatches. See European Commission (2014), p. 124-126 and esp. ESDE 2015. See European Commission (2016:1), p. 236-250.

([96]) Vandeplas and Thum-Thysen (forthcoming).

Box 2.7: The effect of technological progress on EU and national policies

The chapter analyses the effects of technological development on the tasks required in the labour market. The consequence is a change in the skillset required by European workers. First, this Box aims to identify the main policy areas which are relevant to tackling some of these challenges, in particular education and training policies, labour market policies and income redistribution policies. Secondly, it describes recent policy initiatives adopted at both European and national level to tackle the challenges identified in the fields of education, labour market and social protection policies. The focus here is on policies that directly stem from the substitutability between new technologies and differently-skilled workers and its equilibrium effects through consequent changes in labour supply and product markets. The most important policy challenge is to European education and training policies. A majority of highly skilled workers receives substantially higher wages, suggesting that these workers are in short supply (Autor, 2014). Investing more and more efficiently in education will address this issue by increasing the supply of high-skilled workers and dampening the rise in the skill premium, which is itself a major component of overall rises in wage inequality (Autor, 2014).

More STEM graduates and more digital skills are needed. The EU and its Member States seek to encourage young people to choose scientific, technical, technological and mathematical (STEM) university majors and professions and to improve their digital skills. ([1]) STEM graduates on average earn more than other graduates (Daymont and Andrisani, 1984; James et al., 1989; Grogger and Eide, 1995; Arcidiacono, 2004) and are less likely to be overqualified for the work they do (Dolton and Vignoles, 2000; Frenette, 2004; McGuinness, 2006). There is also evidence that the social returns to STEM graduates exceed their private returns through human capital externalities (Winters 2013). This suggests that the policy focus should remain on raising the proportion of graduates in STEM fields and on improving the matching of skills between curricula and business practice. Furthermore, there is a need to strengthen digital skills horizontally across all skills levels (a recently published communication by the European Commission on the Digital Education Action Plan reports that 90% of jobs require some level of digital skills). ([2])

Non-cognitive skills are becoming ever more crucial. There is an increasing demand for workers with creative and social intelligence, such as entrepreneurship, leadership or interaction skills. The latter are "engineering bottlenecks", i.e. difficult to codify in computer language and embed in digital applications. ([3]) Demand for these non-cognitive skills exists across many different occupations and sectors, including many low-paid service jobs. A first policy implication is therefore to measure more effectively which non-cognitive skills are key to being successful in the labour market. ([4]) If the speed of technological change accelerates further, then workers will be forced to adjust their skills to meet changing requirements more frequently. Research concerning the development of non-cognitive skills is less abundant in comparison with their cognitive skills counterpart, but there is evidence that early interventions (Heckman, 2008), lower dimension of classes (Dee and West, 2008), positive attitude from the teachers (Behncke, 2009), particular institutional design in the education system (Woessmann et al., 2009), and work based learning (Green et al., 2001) seem to have positive effects on the development of non-cognitive skills (Brunello and Schlotter, 2011).

Training and education systems must adapt to meet changing needs and improve job matching. This requires education and training systems to adapt their curricula to changing skill requirements. Moreover, workers require not only educational and training opportunities but potentially also the financial support and incentives to participate in such opportunities (Arntz et al., 2016). Policy measures can train workers preventively i.e. to equip them for changing skill requirements before they become unemployed. This is particularly important for low-skilled workers and older workers who – despite typically being those who are most exposed to automation – are on average the least likely to undertake training (Albert et al., 2010; Bassanini and Ok, 2004). Studies show that training raises the employability of these workers (Sanders and de Grip, 2004). As regards labour market policies, Autor (2009) shows how labour market intermediation can help to provide job seekers with information about relevant vacancies (and vice versa) to make the matching process more efficient. It is important therefore that PES and other market institutions collaborate to facilitate job matching and reduce adjustment costs for both workers and firms.

The European Pillar of Social Rights addresses these problems. The following paragraphs aim to illustrate the policy instruments to tackle these policy challenges, following the 20 principles listed in the European Pillar of Social Rights, especially those in chapter 1 (equal opportunities and access to the labour market) and chapter 3 (Social Protection and inclusion). ([5]) Mirroring the order of the section above, the starting point is education and training policies, the importance of which have been confirmed at EU level through the New Skills Agenda and the European Education Area (especially in the first package of measures, addressing key competences for lifelong learning and

([1]) For example: https://rio.jrc.ec.europa.eu/en/library/stem-action-plan.

([2]) See http://europa.eu/rapid/press-release_IP-18-102_en.htm

([3]) Creative and social intelligence and interaction skills are the automation bottlenecks identified by computer scientists in the study by Frey and Osborne (2017).

([4]) The PISA and PIAAC surveys are good examples containing non-standard skill measures, but fall short of adequately capturing the non-cognitive skills that matter in labour markets.

([5]) The initiative, launched in November 2017, was jointly proclaimed by the European Commission, and the European Council. Further information is available at https://ec.europa.eu/commission/priorities/deeper-and-fairer-economic-and-monetary-union/european-pillar-social-rights_en

(Continued on the next page)

Box (continued)

digital skills). This foresees specific action to strengthen the presence of digital skills (action 3), and the Blueprint for Sectoral Cooperation on Skills ([6]) (action 4) to address sector skills mismatches and improve digital skills, given their relevance in an evolving world of work. ([7]) These changes require first of all policies to improve the quality and labour-market relevance of education systems at all levels. This has also been discussed at EU level through the 2018 Council Recommendation on Key Competences for Lifelong Learning, focused on improving the development of key competences (for all people) and changing labour markets (for the Member States).

Member States are adapting their education and training systems. Several Member States have worked to modernise their education systems in recent years, ([8]) as well as to meet the high-skilled labour shortage through changes in their higher education systems and by achieving the target set by the Education and training in Europe 2020 strategic framework. ([9]) Similar actions have been undertaken to improve the attractiveness of STEM, ([10]) to reduce skills mismatch between education and businesses, ([11]) and (in a smaller number of Member States) to develop VET systems. ([12]) More broadly, responsive and well connected means of assessing and preparing for future skill needs and skills governance systems have to be developed in all Member States, so they can react promptly to labour market changes. Finally, ten Member States ([13]) have legislated to strengthen lifelong learning and take into account the new skills needs created by the digital revolution, also thanks to the recommendations on key competences for lifelong learning proposed within the European Semester. ([14])

Further EU initiatives for redistributive policies: as regards labour market policies and redistribution policies, the flagship EU initiative in the field is the European Pillar of Social Rights. Its 20 principles reaffirm rights already present in the Union acquis and add new ones to address the challenges arising from social, technological and economic developments, including the digital revolution. Moreover, the European Network of Public Employment Services ([15]) should facilitate the comparison of public employment services' performance across Member States and facilitate and support the transition between jobs and strengthen occupational mobility. Several countries at national level have undertaken reforms to improve the effectiveness of their public employment services. ([16]) More specifically, EU and national initiatives for redistribution policies will be analysed in the "Access and sustainability of social protection in the age of new forms of work" chapter.

([6]) See http://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=7969

([7]) See http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0381.

([8]) Latvia through a change in its teacher remuneration model, the raising of teaching salaries in Lithuania, professional development programmes in Italy and Denmark, education policy measures in Luxembourg, and incorporating transferable skills in Croatia.

([9]) Estonia revised their tertiary education funding system model, the foreseen launch of the Teaching Excellence Framework in UK to align funding and teaching quality, and an independent national accreditation agency in Lithuania.

([10]) The Netherlands plans to tackle the issue through their National Technology Pact 2020, Latvia introduced diagnostic tests in these fields, and in the UK new funding to reduce the STEM skills shortages were proposed in the Industrial Strategy green paper.

([11]) Poland and Estonia have introduced public systems for monitoring and forecasting labour market needs and skills, in Ireland an expert group has an advisory role with the government on future skills needs, while Lithuania adopted actions in the higher education and research system to achieve better results in skills matching.

([12]) Bulgaria promoted dual training, Czech Republic involved employers in designing curricula, new types of apprenticeships closer to labour market needs were introduced in Ireland and Cyprus, and Spain took steps to improve cooperation between universities and business.

([13]) Austria, Belgium, Bulgaria, Croatia, Cyprus, France, Ireland, Malta, Portugal and Sweden.

([14]) https://ec.europa.eu/education/sites/education/files/swd-recommendation-key-competences-lifelong-learning.pdf

([15]) http://ec.europa.eu/social/main.jsp?catId=1100&langId=en

([16]) Greece and Hungary have introduced new profiling systems to allow a better targeting of active labour market policies. Cyprus increased the number of counsellors, and many countries have launched activation programmes targeted on young people (Cyprus, Bulgaria, Latvia, Estonia and the Netherlands), or the long-term unemployed (Denmark, Spain, Portugal).