Brunello, Giorgio; Wruuck, Patricia

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Skill Shortages and Skill Mismatch in Europe: A Review of the Literature

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Giorgio Brunello
University of Padua, IZA, CESifo and ROA

Patricia Wruuck
European Investment Bank

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Skill Shortages and Skill Mismatch in Europe: A Review of the Literature*

Labour markets are currently in a phase of cyclical recovery and undergoing structural transformation due to globalisation, demographic trends, advancing digital technologies and automation and changes in labour market institutions. Against this background, businesses increasingly report that the limited availability of skills poses an impediment to corporate investment. Genuine skill constraints can negatively affect labour productivity and hamper the ability to innovate and adopt technological developments. For individual Europeans, not having "the right skills" limits employability prospects and access to quality jobs. For Europe at large, persistent skill gaps and mismatches come at economic and social costs. This paper reviews the recent economic literature on skill mismatch and skill shortages with a focus on Europe a focus on Europe.

JEL Classification: J24

Keywords: skill, shortages, mismatch, Europe

Corresponding author:
Giorgio Brunello
Department of Economics and Management "M. Fanno"
University of Padova
via del Santo 33
35123 Padova
Italy

E-mail: giorgio.brunello@unipd.it

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Skill shortages and skill mismatch in Europe: A review of the literature

Giorgio Brunello (University of Padua, IZA, CESifo and ROA)

Patricia Wruuck (European Investment Bank)

Introduction

Labour markets are currently in a phase of cyclical recovery and undergoing structural transformation due to globalisation, demographic trends, advancing digital technologies and automation and changes in labour market institutions. Against this background, businesses increasingly report that the limited availability of skills poses an impediment to corporate investment. Genuine skill constraints can negatively affect labour productivity and hamper the ability to innovate and adopt technological developments. For individual Europeans, not having "the right skills" limits employability prospects and access to quality jobs. For Europe at large, persistent skill gaps and mismatches come at economic and social costs.

This paper reviews the recent economic literature on skill mismatch and skill shortages with a focus on Europe. The review starts with a conceptual overview of skill mismatch and skill shortages and how to measure them. An issue discussed in the first section is the measurement of job requirements, i.e. a demand side variable, that some authors compute using surveys of individuals, which typically collect information on the supply side (educational attainment, foundation skills). Individuals, however, do not often have a reliable view of job requirements, and may actually have an incentive to inflate them. Another issue is whether skill shortages stated by employers reflect the lack of suitable candidates among job seekers or are due instead to the wage and working conditions being offered.

The second section looks at how skill shortages and mismatch are affected by cyclical and structural factors. Whether mismatch is pro or counter-cyclical depends on the relative strength of cleansing effects (poor matches are destroyed in a recession) and sullying effects (in a recession skilled workers are willing to accept unskilled jobs as jobs are scarce). Structural factors contributing to skill mismatch and shortages in Europe include 'megatrends', notably globalisation, digitalisation and ageing. In addition, institutional factors shaping labour markets, skill utilization and formation at national and European level can work to reinforce or mitigate skill shortages and mismatches and are an important factor mediating the impact of structural trends.

The third section discusses the economic costs of skill mismatch and shortages. Mismatch not only affects individuals but can also reduce average productivity by leading to an inefficient allocation of resources across firms. The final section considers policy implications, including how responsibilities for skill development can best be shared and what role EU policies can play to better address skill shortages and mismatches.

1. Measuring skill mismatch and shortages

Skill is a complex concept and challenging to measure.[1] According to a definition provided by the OECD, 2017, *skills* refer to both cognitive and non-cognitive abilities and to abilities that are specific to a particular job, occupation or sector (technical skills). Cognitive skills consist in the ability to understand complex ideas, adapt effectively to the environment, learn from experience, engage in various forms of reasoning, overcome obstacles by taking thought. They include literacy, numeracy and the ability to solve abstract problems. Non-cognitive skills are characteristics across multiple domains (social, emotional, behavioural) not included under cognitive skills, such as work habits, behavioural traits, physical characteristics. Finally, technical skills are combinations of cognitive and non - cognitive skills used to accomplish specific tasks (Margolis, 2014). These combinations could also include manual skills. While skills are multi-dimensional, their measurement often focuses on selected dimensions, mainly due to data limitations.

Skill mismatch at the macro level refers to the gap between the (aggregate) supply and demand for skills, typically with reference to a specific geographical unit (region, country or country group), and to the fact that observed matches between available workers and available jobs offered by firms in terms of skills and/or qualifications are sub-optimal. Skill mismatch at the micro level occurs when workers have a level of skills that is different from what is required for their job.[2]

Skill shortages arise when employers are unable to recruit staff with the required skills in the accessible labour market and at the ongoing rate of pay (Quintini, 2011) and *skill surpluses* occur when the supply of certain skills is higher than demand. Skill shortages do not imply skill mismatch if vacant jobs remain unfilled, but can create skill mismatch if employers unable to find the skills they need end up recruiting workers who are under-skilled for a specific job (Desjardins and Rubenson, 2011). Finally, the term *skill gaps* is often used when the skill levels

[1] Despite the key role skills play in the labour market and economies, there is little agreement in the literature as to what "skills" are and how they should be defined. See for instance Clarke and Winch, 2006.

[2] Eurostat, 2016, further classifies "micro" skills mismatch into: a) vertical mismatch, i.e. the mismatch between formal education and job requirements measured against a benchmark; b) horizontal mismatch, for example mismatches between the worker's field of education and job requirements. Mismatches have also been analysed in terms of over-skilling and under-skilling of workers.

of the existing workforce are insufficient to meet the requirements of firms (McGuiness et al. 2017).

Skill mismatch at the macro level can be assessed by comparing the composition of vacancies by qualification or education with that of the working age population (as a proxy of labour supply). Instead of vacancies, one can compare the composition of employment as a proxy of labour demand with that of the population at working age, or the composition of unemployment with that of the labour force. These are used to compute relative or absolute dispersion measures.[3] Macroeconomic measures of skill mismatch focus on whether or not individuals with a certain type of qualification or skill are (un)employed but do not assess whether – if they are employed – their job is in line with qualifications (see McGuiness et. al 2017 for discussion).

Skill mismatch (micro) is typically measured by comparing the skills or qualifications of an employed worker with the skills or qualifications required by her or his job. If the worker has skills compatible with what the job requires, the pair is a good match. A worker can also be classified as over (under) skilled with reference to a specific position.

Different methods are used to identify skill requirements and the quality of matches. Some authors use information from surveys asking employees whether they have the skills required to do a more demanding job that their current one or whether training is needed to carry out the job in a satisfactory way (Allen and van der Velden, 2001; Green and McIntosh, 2007). Affirmative answers to either question are used to define over-skilled and under-skilled individuals, matched individuals being the residual. This approach, however, suffers from measurement error, for instance due to individual overconfidence. Respondents have a tendency to overstate the requirements of their jobs and to upgrade the status of their position (Hartog, 2000).

The realized matches approach (see Quintini, 2011) relies instead on the individual measurement of cognitive skills (literacy, numeracy and problem solving) and the comparison of attained values with average or median values in the occupation, which are used as proxies of job requirements. Workers whose measured skills are significantly below or above the centrality measure are classified as under or over-skilled. Again, the well matched are obtained as residual. This approach implicitly assumes that the technical and non-cognitive skills required to be a plumber are entirely captured by measured cognitive skills. Its implementation also requires information on detailed occupational classifications.[4]

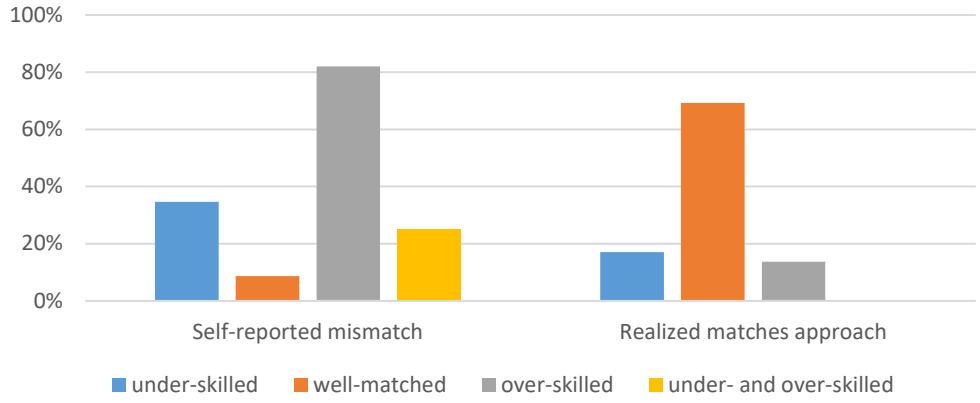
[3] For example, Kiss and Vandenplas, 2015, compute an indicator of macroeconomic skill mismatch using the relative dispersion of employment rates across three main skill groups. In their computation, the deviations of group-specific employment rates from the national employment rate are weighted by the population shares of skill groups. See European Commission, 2017, and Kiss and Vandenplas, 2015, for further discussion of issues concerning the measurement of macroeconomic skill mismatch.

[4] The Survey on Adult Skills (PIAAC) collects information on 4 digits ISCO 2008 occupations.

When information on both skill proficiency and skill use is available, an alternative approach is to classify workers in four groups: the low skilled with low to medium – low engagement (low skill match); the medium to high skilled with medium high to high engagement (high skill match); the low skilled with medium – high to high engagement (deficit mismatch) and the medium to high skilled with low to medium engagement (surplus mismatch) (Desjardins and Rubenson, 2011). This approach assumes that self - reported skill use is an adequate measure of job requirement.

The importance of how job requirements are defined for measured skill mismatch is shown by Pellizzari and Fichen, 2017, who use the data from the Survey of Adult Skills (PIAAC) to compare the approach based on self-reported mismatch and the realised matches approach. They find that the large majority of workers are considered to be over-skilled with the former method, but well matched with the latter method (Figure 1).

Figure 1. Comparing self-reported and realized-matches mismatch



Source: Pellizzari and Fichen, 2017.

Recently, these authors have also developed a measure of skill mismatch, which combines both methods and consists of two steps. First, the proficiency scores of workers who report to be well matched to their job are used to create a quantitative scale of the skills required to perform the job for each (ISCO 1-digit) occupation. Second, minimum and maximum threshold values in this scale are identified, and workers with scores above the maximum or below the minimum are classified as over and under - skilled. This approach identifies the level of skills in an occupation with the literacy test score attained by each adult worker. This seems restrictive but perhaps unavoidable given the data at hand. A potential problem is that ISCO 1-digit occupations are too broad and can span a range of tasks, which may require different skills (see McGowan and Andrews, 2015a).

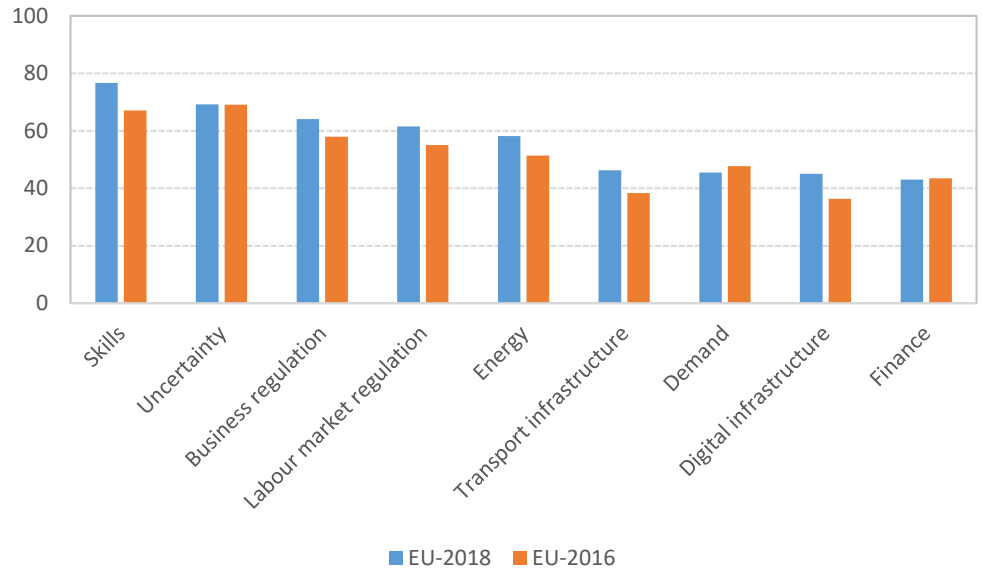
Since employers and managers are likely to have more accurate information than employees about skill requirements, employer surveys can provide valuable information on skill mismatches and skill shortages from a demand side perspective.[5] Examples of employer

[5] McGuiness and Ortiz, 2014, compare the skill gaps as perceived by managers and employees located in the same firm. Their evidence suggests that employee perceptions may be prone to higher level of subjective bias.

surveys include the UK Employer Skills Survey, the European Skills and Jobs Survey, the EU Business and Consumer Surveys, the Manpower Talent Shortage Survey and the Continuing Vocational Training Survey, which focuses however on training issues. Since surveys in the area cover different aspects, it may be difficult to compare results because of differences in samples, frequencies and questions asked. Broadly, employer surveys provide subjective assessments of skill mismatch and shortages, how they affect firms, and what firms do, for instance in the area of talent management and training, to address skills-related problems.

The EIB Investment Survey (EIBIS) provides information on skills and investment-related aspects, by regularly assessing corporate investment for training and whether the availability of staff with the right skills poses an impediment to investment for firms in the EU.[6] Data from the first three EIBIS waves show that, since 2016, the limited availability of skills has increasingly become a concern for firms and is the most frequently named impediment to investment in a list of nine obstacles to investment (Figure 2). On average, 77% of firms report the limited availability of skills as an impediment to investment.

Figure 2: Share of firms reporting different obstacles to investment, in % (2016-2018)



Notes: The question asked in the questionnaire is: thinking about your investment activities in your country, to what extent is each of the following an obstacle? The graph adds the share of firms naming the impediment as a major or minor obstacle. Sample: all firms. Source: EIBIS 2016 - 2018.

When interpreting the results of employer surveys, it is important to connect the responses of firms to company characteristics and complement these responses with an understanding of the operating environment, i.e. including the cyclical position as well as labour market characteristics that affect firms' difficulties to hire (see Savšek 2018). At the firm level,

Barron et al, 1997, examine to what extent employer and employee responses to training questions are consistent and find that establishments report 25% more hours of training than workers do.

[6] For further description of the EIBIS, the methodology and the questionnaire see also http://www.eib.org/en/about/economic-research/surveys-data/about-eibis.htm

reported shortages and problems to fill vacancies could be due to the wage and working conditions being offered, workforce characteristics, or the effectiveness of the recruitment process, rather than to the lack of suitable candidates among job seekers. Establishments offering a higher average wage relative to the average wage for the same occupational group in a given area have been found to report fewer shortages (Haskel and Martin, 2001; Directorate General for Internal Policies, European Parliament, 2015). In addition, Monti and Pellizzari, 2016, have shown that the occupations where hiring was declared to be the most difficult in Italy in 2012 were not the ones where wages increased the most during the period 2012-15.

In a series of studies, CEDEFOP, 2015, 2018, has attempted to separate "genuine" shortages, defined as recruitment bottlenecks that occur when firms offer competitive starting salaries to potential recruits, from reported shortages that originate from wage offers below competitive levels. Drawing on the Eurobarometer Flash Survey 304, these studies show that while 47 percent of interviewed firms report difficulties in recruiting graduates with suitable skills, the total proportion of employers facing genuine shortages is much lower at 34 percent (see McGuiness et al, 2017).

To disentangle genuine from other shortages, results from employer surveys should be complemented with indirect measures that signal shortages in specific occupations, including price measures (wage growth), volume measures (employment growth, vacancy rates) and work intensity measures (incidence of overtime). The rationale is that occupations with genuine shortages should be characterised by faster wage growth, or by higher overtime, than occupations without genuine shortages.

These indirect measures have been recently used by the OECD to compute an index of skill shortages in two steps: first, an occupational indicator is constructed by combining information on hourly wage growth, employment growth, and growth in hours worked by occupation. The relevant data are drawn from large comparable international surveys, including the European Labour Force Survey and the European SILC Survey. Second, this indicator is translated into a skill index using the O*Net database, which maps occupations into bundles of tasks and skills.

Based on this methodology, recent skill shortages are concentrated among content skills (e.g. reading comprehension, writing, speaking and active listening), process skills (e.g. critical thinking and active learning), complex problem solving skills and social skills (e.g. instructing, social perceptiveness) (Appendix Figure A1). By country, these shortages are biggest in Finland, Luxembourg, the Netherlands, Spain and Germany and smallest in Switzerland and Hungary. Surpluses are more common for some technical skills, including maintenance and repairing (OECD, 2017).

This overview of measurement approaches points out that sizing the magnitude of skill mismatch and shortages is not a trivial matter. There are different types of mismatches and

ways to measure them using information on the fit between skills and jobs, as well as sources to proxy them (e.g. through qualification, information based on skill proficiency assessment and occupational qualifications). While the former are perception-based, information obtained from the latter is often not granular enough and it can be challenging, for instance, to infer actual job content and tasks from broad job classifications.

2. Cyclical and structural factors affect skill shortages and skill mismatch

In the medium to long run, the demand for skills is driven by technological and organisational innovations, demographic changes and changes in the patterns of consumption.[7] New sectors and jobs continuously emerge while others shrink.[8] Even within existing occupations, the tasks performed by workers and the skills needed to carry them out are subject to important changes. In the short to medium run, skill demand varies with business cycle conditions.

The supply of skills also changes, due for instance to the expansion of higher education, increased female labour force participation, changes in retirement patterns and migration flows.[9] To some extent, labour mobility is a short to medium term supply response to demand fluctuations (see Boswell, Stiller and Straubhaar 2004 and Danish National Bank 2019). Most changes on the supply side, however, happen slowly and skill imbalances might occur as a consequence. While short periods of shortages and mismatch are to be expected in any dynamic economy, persistently high skill mismatch or shortages are symptoms of structural problems that can have adverse economic consequences for individuals, firms and the aggregate economy.

2.1 Cyclical Factors

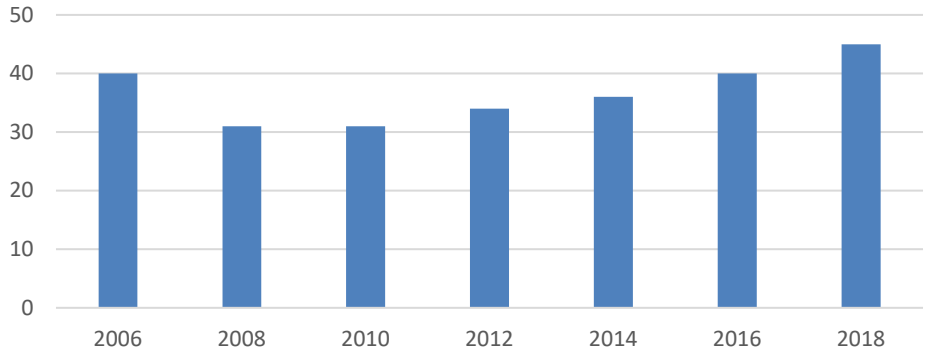
Skill and labour shortages typically increase during economic expansions, when many firms rely on the outside labour market to recruit the skills required to fill new positions. Whether and how labour supply respond to rapid increases of demand depends on the distribution of existing skills, the extent of geographical mobility and the signals provided by wage adjustments.

Globally, the Manpower Talent Shortage Survey indicates that skill shortages have increased since 2009 (Manpower 2018, see Figure 3). For Europe, the European Business Survey similarly indicates an increase in reported average labour shortages as the economy recovers from the 2008 financial crisis followed by the sovereign debt crisis (see Figure 4). This trend,

[7] At the same time, the demand side determinants can be affected by skills supply, e.g. through production and adoption of innovation or differences in consumption patterns.
[8] A distinctive trait of developed economies is the decline in manufacturing jobs. See IMF, 2018.
[9] See IMF, 2018, for a discussion of recent trends in labour force participation by gender and age, and Batsaikhan, Darvas and Raposo, 2018, on migration flows into the European Union.

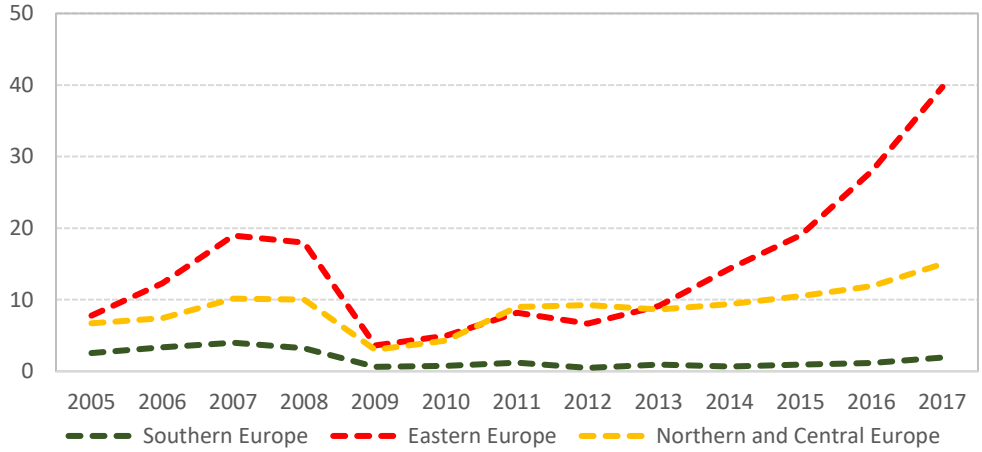
however, is considerably less pronounced in Southern Europe, where recovery has been slower than in the rest of the Continent.

Figure 3. Recent trend in global talent shortages



Source: Manpower Talent Shortage Survey, 2018. The survey does not cover Russia, Africa (with exception of South Africa), the Middle East, Indonesia and the Philippines.

Figure 4. Incidence of companies indicating that labour shortages are a factor currently limiting their production (%), by macro area



Source: Eurostat Business Surveys, several years. Southern Europe: Italy, Spain and Portugal; Eastern Europe: Czech Republic, Hungary, Latvia, Lithuania, Poland, Slovenia and Slovakia; Northern and Central Europe: Austria, Belgium, Denmark, France, Germany, Luxembourg, Netherlands, Finland, Sweden and UK.

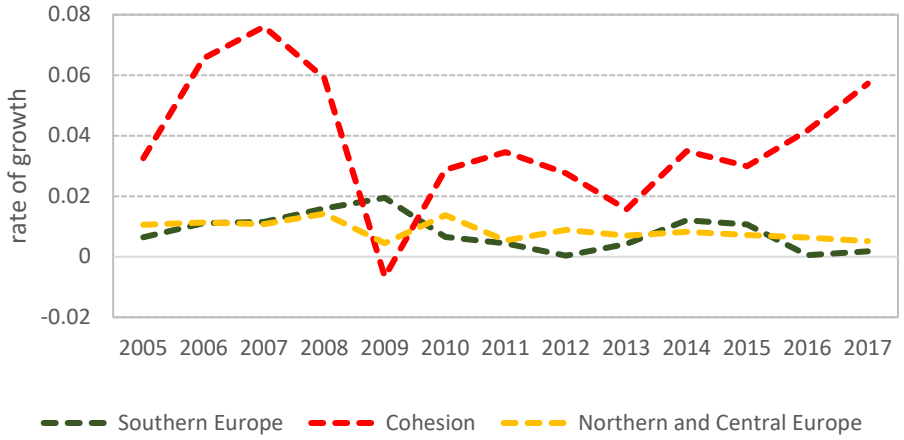
Increasing shortages in Eastern Europe have been accompanied by sustained real earnings growth, in contrast with developments in the "core" countries of Northern and Central Europe, where shortages have also increased but real earnings growth has so far remained subdued, indicating persistent labour market slack (see ECB 2017, EIB 2018a).[10]

The relationship between skill mismatch and the business cycle is driven by several factors. In downturns, there are two factors at play: on the one hand, mismatch declines because low quality jobs are destroyed but high quality matches between firms and employees survive

[10] However, with labour market slack continuing to diminish, wage dynamics might accelerate (also see European Commission 2018 for further discussion).

(*cleansing*). On the other hand, mismatch increases because firms post fewer vacancies and job seekers are willing to accept less desirable jobs because of the higher competition they face (*sullying*). When demand is buoyant and the labour market is tight, employers may be forced to adjust their hiring standards downward to cope with difficulties in recruiting skilled labour, which increases the incidence of *under-skilling* (Healy, Mavromaras and Sloane, 2015 and Livanos and Nunez, 2017).

Figure 5. Real hourly earnings growth in manufacturing, by macro area



Whether cleansing or sullying effects prevail during an economic downturn is unclear and may depend on labour market institutions and the approach of firms to talent management. On the one hand, empirical evidence based on US data suggests that the cleansing effect dominates in recessions (Baley, Figueredo and Ulbright, 2018) and that skill mismatch is pro-cyclical. On the other hand, stricter employment protection - which reduces involuntary separations in a downturn (Belot, 2007) - suggests that cleansing may be less important in Europe than in the US.[11] Consistent with this conjecture, Liu, Salvanes and Sorensen, 2012, find that in Norway skill mismatch among college graduates is strongly counter-cyclical and driven both by over-skilling and downgrading in the average quality of job matches.[12]

The impact of the business cycle on skill mismatch can be studied using the Beveridge curve, that describes the negative relationship between aggregate unemployment and vacancy rates.[13] Economic contractions can produce movements along the curve, as vacancy rates decrease and unemployment rises, but can also shift the curve (an increase in unemployment

[11] The relative importance of sullying versus cleansing effects can also vary within Europe due to labour market differences.

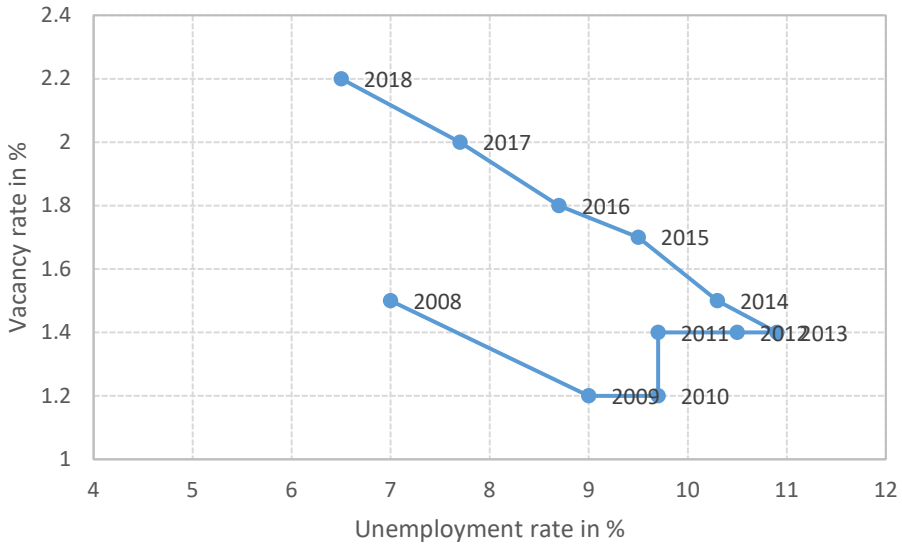
[12] In a similar fashion, Summerfield, 2015, shows that jobs formed in a recessions have relatively more manual tasks, increasing the probability that workers are overqualified. Counter-cyclical mismatch and pro-cyclical productivity suggest that the former should negatively correlate with the latter. Conditional on business cycle effects, however, the residual correlation could take either sign, as shown by European Commission, 2017.

[13] The theoretical search and matching literature discussing how unemployment, job vacancies, and employment are determined as equilibrium phenomena is reviewed by Yashiv, 2007. See also Pissarides, 2000.

given vacancies) because of induced changes in search intensity and sectoral and skill mismatch.

In the EU, the Beveridge curve has shifted outwards during the 2008-2018 period (see Figure 6). The shift occurred between 2010 and 2013. After that, movements along the curve prevailed as the European economy recovered. Job vacancy rates increased and unemployment rates declined. By the end of 2018, the former were higher than in 2008, and the latter were slightly lower.

Figure 6. The EU beveridge curve



Source: Eurostat. For EU 27, excluding Croatia due to missing data. Values for 2018 refer to Q3.

The observed outward shift, however, was mostly driven by the countries of Southern Europe, where unemployment increased markedly with little changes in vacancy rates.[14] Disaggregate analysis by area shows no clear evidence of an outward shift from 2008 to 2017 in the countries of Northern, Central and Eastern Europe for which comparative data are available. Both country groups show instead higher vacancy rates and lower levels of unemployment at present compared to 2008 and 2009, consistent with increases in labour shortages and movements along the curve.

These facts are broadly consistent with the evidence presented by Bonthuis et al, 2016, who estimate Beveridge curves for the four largest euro countries over the period 1990Q1-2015Q4 and assess whether these curves have shifted after the 2008 recession. For Germany, they find evidence for an inward shift, reflecting – they argue – both the effects of the earlier Hartz reforms as well as the widespread reliance on short-term working schemes. For France and Spain, their evidence point to a strong and significant outward shift, and for Italy to no

[14] In these countries, a large initial outward shift of the Beveridge curve was followed by a partial return toward the origin as labour markets started to recover from the 2008 recession. In 2018, vacancy rates were higher than in 2008 in some countries (Portugal, Spain), but remained lower in others (Greece), while unemployment was still higher.

statistically significant effect, which they attribute to the fact that their empirical model does not perform well for this country. They also point out that the outward shifts in France and Spain are partly driven by sectoral declines in the construction sector.

One reason why economic downturns affect mismatch is that matching efficiency, defined as the quality of the matching process involving unemployed workers and unfilled vacancies, declines. A recent analysis (European Commission 2018) examining determinants of matching efficiency in EU labour markets suggests that sectoral mismatches, measured by unemployment dispersion across sectors, have a bigger impact on aggregate matching efficiency during recoveries, whereas skill mismatches matter more during normal periods. Matching efficiency can be improved by active labour market policies (ALMP), including re- and up-skilling measures improving the matching prospects of the long term unemployed. These policies may become increasingly relevant as recent research suggests that: a) job polarization, skill mismatches and the business cycle are linked in the sense that the structural trend towards job polarization can be aggravated by the business cycle (Zago 2017); b) longer unemployment spells together with changing skill requirements due to technological change worsen reemployment prospects.

Business cycle effects on matching efficiency are mediated by the strategies and management practices of firms, which can fill new vacancies either by hiring or by developing the required skills in-house, using training and upgrading.[15] In the US, for example, the observed decline of promotion-from-within systems in medium and large firms is bound to increase hiring challenges substantially, by expanding the range of jobs through which hiring takes place: from "entry-level" jobs filled by inexperienced school leavers to virtually every position in the organisation (Cappelli, 2014).[16] This shift in human resources management policies can accentuate skill shortages during expansions. It is not clear whether this applies to Europe as well. One indicator that this may not be the case is that average job tenure has been declining in the US (see Farber 2010) – in line with the reduced importance of promotion-from-within systems – but has remained more or less constant in Europe (see Cazes and Tonin, 2010, Rhein, 2010).

2.2 Structural Factors

Demographic trends are one factor that can add to skill shortages through its impact on size, age and composition of the labour force. Demographic change also impacts on the demand for goods and services, and hence on the demand for the skills necessary to provide them, medical services and personal care being one example. The combination of shifts in the demand for labour towards more skilled jobs and of population ageing – a long-term feature

[15] See Brunello, Garibaldi and Wasmer, 2007.

[16] "…Hiring may well be more difficult now simply because employers have to do much more hiring these days because of widespread and substantial declines in employee tenure …, which translates into more frequent vacancies and more hiring to fill them. The decline of life-time employment practices and the associated rise of lateral hiring have been underway for some time especially in larger organizations…" (Cappelli 2014).

of European economies – can produce skill shortages and mismatch as older workers are endowed with partially outdated education and skills that do not match closely with those required by the process of digitalisation of modern economies (European Parliament, 2015).

Europe at large has a comparative advantage in goods and services that use (high)-skilled labour intensively and globalisation tends to reinforce this.[17] Globalisation – as a standalone factor and in combination with technological change - has been associated with increasing polarisation of the occupational structure and a decline in middle-skilled jobs, and can produce skill shortages if labour reallocates slowly from declining to growing sectors where different skillsets may be needed. To what extent this materialises, depends on the intensity of the adjustment shock, on the pool of skills in the workforce, and on the possibilities to (re)deploy these skills.

Some European economies have been able to offset the employment losses from import competing sectors with job creation in exporting sectors, for instance by penetrating new markets (see Donoso et al 2014, Dauth 2014). While the spread of global value chains has been accompanied by offshoring of intermediate inputs and back-office services, mainly affecting middle skilled workers, a lot of offshoring activity has taken place as nearshoring from Western to Eastern Europe, shifting skill demand in both locations but allowing firms to become more productive.

Technological change is a factor inducing sectoral dynamics[18] – with some sectors gaining employment and some other sectors shrinking – and changing the demand for skills within occupations and firms. Technological change can produce skill shortages by creating the need for new skills that are not immediately available in the labour market, until the broad education system (including employer training) is able to meet the new skill requirements. Also, firms operating in rapidly changing markets may wish to hire workers with higher qualifications to ease labour adaptation in the future (Desjardins and Rubenson, 2011).

Technological progress in the past few decades has been characterised by the spread of information and communication technologies (ICT), which have resulted in: (1) an acceleration in the demand for skilled workers that outweighs the available supply (*skill biased technical change*; see Katz and Autor, 1999; Acemoglu and Autor, 2011);[19] (2) the combined reduction in the demand for routine cognitive and manual tasks and increased reliance of production on no-routine tasks that cannot be easily automated, which has led to the polarisation (*hollowing out*) of employment – the contemporaneous increase in the share

[17] It is reasonable to assume that countries with higher GDP per capita tend to be better endowed with skilled labour in global comparison and that they specialize in production of goods for which they have a comparative advantage.

[18] Sectoral dynamics may refer to shifts across sectors as well as the emergence of new products.

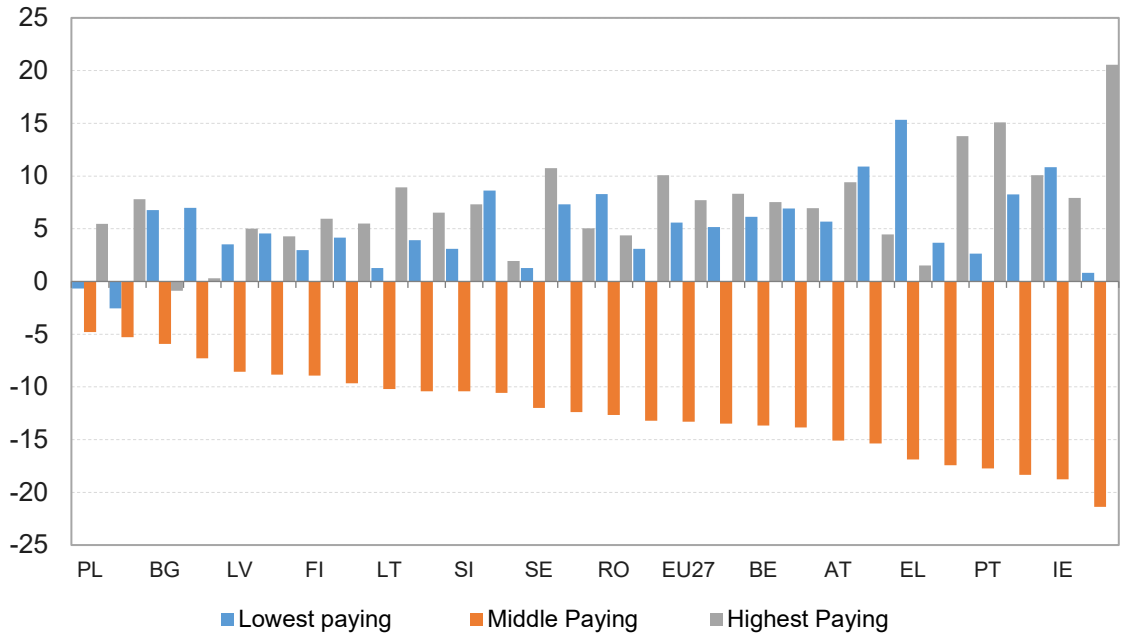
[19] During the previous decade, about a million jobs were created in Europe in occupations tightly knit to ICT services, such as ICT professionals, technicians and associate professionals. According to CEDEFOP skill forecasts, a further half a million more jobs are anticipated to be created in the next decade in Europe (CEDEFOP, 2018).

of low-skilled and high skilled occupations and decline in the share of medium-skilled jobs (see Autor et al, 2003; Goos et al, 2009; Das and Hilgenstock, 2018).[20]

For Europe, projections based on the Skills and Job forecast by CEDEFOP indicate that employment shares are rising and expected to increase further for professionals, managers and technicians on the one hand and for elementary occupations on the other hand, and to decline for clerks, craft workers and plant and machine operators, suggesting (further) polarisation.[21]

There is evidence that the employment share of middle paying jobs has decreased between 2002 and 2016, a trend also associated with technological change (European Commission 2018a) (Figure 7). These effects, however, vary across Europe. While polarisation has affected all countries, its intensity has been higher than average in France, the UK, Ireland and Portugal – among others – and lower in Germany, Poland and Denmark (see also Goos, Manning and Solomons, 2009).

Figure 7. Changes in employment shares by wage group, 2002-26 (in percentage points, EU member states)



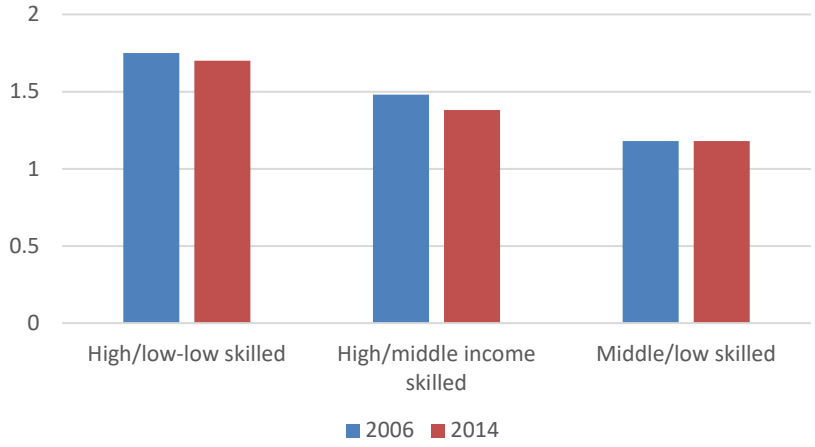
Source: DG EMPL calculations based on Labour Force Survey; European Commission, 2018.

[20] A consequence of widespread digitalization is the rising incidence of new online forms of platform employment or crowd work in the so-called gig economy. According to McKinsey, 2015, such platforms could add more than 370 billion to the EU economy and bring more than 5.2 million workers into employment. See CEDEFOP, 2018.

[21] In a similar fashion, the top growth occupations identified by CEDEFOP, 2016b, and the European Vacancy and Recruitment report (European Commission, 2014) are in health, ICT, engineering, teaching, administration and sales (see also Directorate General for Internal Policies, European Parliament, 2015).

In spite of the fact that recent technological progress has increased the relative demand for skills and non-routine tasks. Technological developments are not necessarily an incessant force creating demand for higher skills. First, the college wage premium, after increasing in several countries during the 1980s and the 1990s, has remained relatively stable in the 2000s, at least in the US, in spite of a slowdown in the increase in the number of college graduates, and consistent with a slowdown in the demand for college skills (Cappelli, 2014).[22] The maturation of information technology slowing the demand for higher skills, a levelling off of complementarities between highly educated labour and new technologies and stronger competition between education groups for increasingly scarce well-paid jobs have been suggested as factors explaining the flattening skill premium in the US. In Europe, there is some indication (see Figure 8) that the skill premium, i.e. the ratio of the skilled to unskilled wages, has remained stable or mildly declined in recent years (IMF, 2018), possibly reflecting increased competition for jobs as the economy emerged from the 2008 recession.

Figure 8. Skills premiums in European economies



Source: IMF, 2018.

Second, the recent advances in digital technology suggest that digital innovation and machine learning may be able to substitute not only routine tasks but also some non-routine tasks that are typically performed by skilled workers (Brynjolfsson and McAfee, 2014, and Frey and Osborne, 2017). Estimates of the impact of automation on jobs are subject to some uncertainty. Compared to Frye and Osborne, 2017, who find that 47% of the jobs in the US are at high risk of being automated, a recent OECD study (Nedelkoska and Quintini, 2018) estimates that about 14% of jobs in OECD countries participating to the Survey on Adult Skills (PIAAC) are highly automatable, i.e., have a probability of automation of over 70%.[23] This is equivalent to over 66 million workers in the 32 countries covered by the study. In addition, another 32% of jobs have a risk of between 50 and 70% of being automated. Richer countries

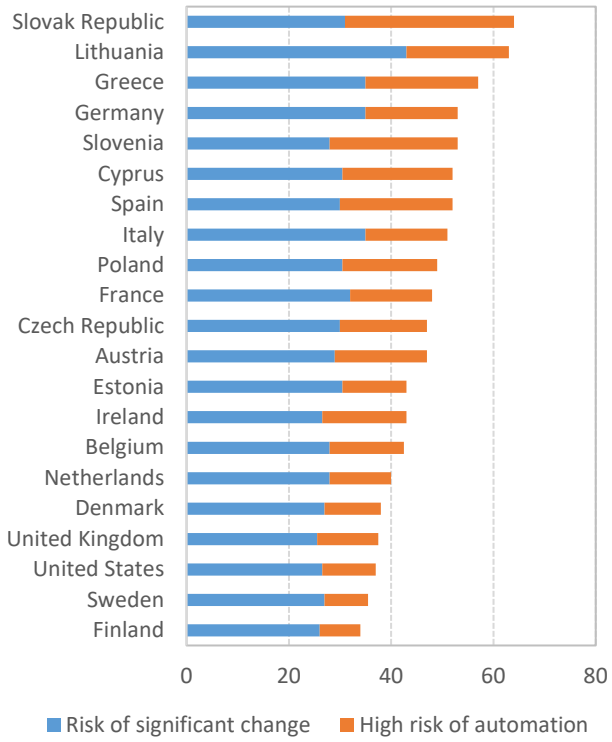
[22] The observed slowdown in the supply of college graduates may have been even higher if one considers the possibility that the average quality of graduates has declined because of increased access.

[23] Quintini and Nedelkoska build on the methodology developed by Fry and Osborne to estimate automation risk but go beyond occupation levels in their analysis, using PIAAC data to assess the relationship between job tasks and the risk of automation.

appear to be less at risk than middle income ones but wide gaps exist between countries of similar wealth, reflecting differences in specialization, job content and in institutional and organisational structures.

In terms of the types of jobs at risks of automation, typically jobs requiring professional training or tertiary occupation are considered less automatable (Figure 9). Unfortunately, workers in these jobs who are most exposed to the risk of automation are also less likely to invest in training (see Nedelkoska and Quintini, 2018) and often have limited access to it. One of the questions this prompts is what strategies should be used to encourage training participation and what type of training can effectively work to allow people to upgrade skills and move to jobs that are less automatable (see for instance Goerlitz and Tamm, 2017, Tamm 2018, Schmidpeter and Winter-Ebmer 2018).

Figure 9. Automation risk, selected countries, % of jobs at risk by degree of risk



Source: Nedelkoska and Quintini, 2018.

Skill requirements will continue to change rapidly with international competition and technological change. Skills that are complementary to technology and facilitate adaptation to changing job requirements, i.e. a good mix of solid literacy, numeracy, ICT and problem-solving but also autonomy, coordination and collaborative skills, carry additional value for employees.[24] At the same time, employees' skills are also becoming increasingly important for the ability of firms to adopt new technologies and practices (European Economic and Social Committee 2018, EIB 2018a).

[24] See Deming, 2017, on the growing importance of soft skills.

3. The costs of skill mismatch and shortages

The economic costs of skill mismatch and skill shortages affect individuals, firms and the overall economy. Individual costs include lower wages and poorer skill development, and can partly turn from temporary to permanent. The costs faced by firms comprise lower productivity and the hiring and training costs associated to increasing job turnover. Aggregate costs include the efficiency losses – in terms of lower average productivity and higher unemployment - associated with the sub-optimal allocation of resources.

3.1 Effects on individuals

Mismatch can negatively impact on earnings if individuals accept a less desirable job because of the higher competition they face (the sullying effect), and can turn at least in part from temporary to permanent if it produces a scarring effect, for instance because of human capital depreciation.

Oreopoulos, van Watcher and Heisz, 2012 investigate the long term effects on earnings of graduating from college during a recession, when the quality of labour market matches is typically lower than average (see also Altonji, Kahn and Speer, 2016). Using a large longitudinal university-employer-employee dataset from Canada, they find that the cost of recessions for new graduates is substantial and unequal. Unlucky graduates suffer persistent earnings declines lasting ten years. They start to work for lower paying employers, and only partly recover through a gradual process of mobility toward better firms. Oreopoulos et al also document that graduates of better quality suffer less that the rest from completing their studies during recessions because they manage to switch earlier to better firms.

The wage costs endured by graduates graduating in a recession may spill-over to the unskilled because the search strategies of the former during recessions, which include accepting lower pay jobs, crowd out the job opportunities of the latter, with consequences for their current and future earnings. This crowding out effect could also delay the recovery of the labour market, particularly for low skilled individuals (Arsenau and Epstein, 2014).

Assessing the direct effects of mismatch on individual productivity is difficult because of measurement problems. The existing empirical evidence relies on two approaches, one exploiting the idea that in a competitive equilibrium wages always equal marginal productivity, and the other focusing on the impact of mismatch on individual job satisfaction. Quintini, 2011, uses data from the European Community Household Panel – a European wide household survey that preceded the SILC - to study the effects of qualification mismatch on earnings. Adopting an empirical approach that controls for individual unobserved heterogeneity, she finds that over-qualified individuals earn about three percent less than individuals who have the same qualification but are well matched, and that under-qualified workers earn about two to three percent more than workers with similar qualifications who are well matched. Under the assumption that productivity is always equal to wages, this can

be interpreted as evidence that over and under-qualification are associated to a productivity loss and gain, respectively.

An alternative view, that does not subscribe to the assumption that wages are continuously equal to productivity, is that the over and under-qualified are as productive as the well matched but their earnings reflect either excess supply (over-education) or excess demand (under-education) for the job.

Studies exploring the impact of mismatch on job satisfaction have argued that, by reducing satisfaction, mismatch can increase absenteeism and/or reduce productivity. Mismatched workers are more likely not only to be absent from work more often, but also to change jobs more frequently and invest less in training, with potentially negative consequences on productivity. The existing evidence indicates that over-qualified workers are less likely to participate in training than well-matched workers with the same qualifications (Verhaest and Omey, 2006), and that over-skilling has a negative effect on job satisfaction (Allen and van der Velden, 2001).

3.2 Effects on firms

Several studies (see for instance Allen and van der Velden 2001) have found that over-qualified workers are more mobile than well-matched workers with the same qualifications. By increasing job turnover, mismatch is costly to firms, that have to incur additional hiring and training costs.

The argument behind skill shortages having a negative impact on firms focuses on production losses due to unfilled positions or on the recruitment of workers with lower skills than the job would require (Bennett and McGuinness 2009). It has also been argued that skill shortages limit investment and the adoption of new technologies, with negative impact on productivity (e.g. Foley et al, 1993). Haskel and Martin, 1993, find that the increase in the shortage of skilled labour in the United Kingdom over the mid-80s reduced productivity growth by around 0.7% per year. Similarly, Bennet and McGuinness, 2009, after controlling for selection effects as it is often more productive firms that are more likely to experience skill shortages, find a negative effect of hard-to-fill and unfilled vacancies on the output per worker of high-tech firms in Northern Ireland. Tang and Wang (2005) also find a negative impact of skill shortages on labour productivity of small and medium-sized companies.

In addition, Foley et al., 1993, suggest that the shortages of craft workers in the United Kingdom have acted as a barrier to the use of new technologies and have led to lower productivity. An indirect effect of skill shortages on productivity via difficulties in technology adoption is also found by Forth and Mason, 2006, in their study on ICT skill shortages in the

United Kingdom. Similarly, Nickell and Nicolitsas, 2000, find that skill shortages reduce firms' investment in R&D, although the effect is found to be only temporary.[25]

The costs of shortages to firms also depend on their duration. Bellman and Hubler, 2014, for instance, find that skill shortages in German firms are normally short-term phenomena. Healy et al., 2015, investigate the strategies used by firms to respond to skill shortages using the Australian Business Longitudinal Database and find that most firms respond to skill shortages by improved utilization of their core workforce through longer hours and better pay, while some firms use peripheral strategies such as temporary employment and outsourcing (see McGuiness et al, 2017).

3.3 Aggregate effects

By distorting the optimal allocation of resources, skill shortages and mismatch are expected to reduce average productivity. Mavromaras et al., 2007, attempt to quantify the costs of skill mismatch in terms of GDP. They proxy the individual productivity loss with the estimated wage penalty associated with over-skilling, and multiply this penalty by the number of over-skilled workers by educational attainment level, concluding that the costs of over-skilling in Australia amount to about 2.6% of GDP in 2005.

Although several researchers have argued that they also cause higher (structural) unemployment and unemployment persistence, the empirical evidence reported by Quintini, 2011, is mixed. Skill mismatch can also affect wage inequality. Skott and Auerbach, 2003, propose a theoretical model where a negative skill neutral shock causes high-skilled workers to accept low-skilled positions and low-skilled workers to lose their job. They show that wage inequality both between and within skill groups and unemployment particularly among low-skilled individuals increase. Using data for the US, Slonimczyk, 2009, reports that a substantial part of the observed increase in wage dispersion (11% for men and 32% for women during 1973-2002) can be attributed to increases in over-qualification rates and premia.[26]

The negative relationship between skill mismatch and average productivity operates mainly via two channels: lower *within-firm* productivity and a less efficient allocation of labour resources across firms. McGowan and Andrews, 2015a, estimate the association between skill mismatch – measured using data from the OECD Survey of Adult Skills (PIAAC) – and labour productivity – measured using industry data for 19 OECD countries - and report that higher skill mismatch is associated with lower labour productivity because of a less efficient allocation of resources across firms. Because of mismatch, more productive firms find it difficult to attract skilled labour and gain market shares at the expense of less productive firms. Using these results, they simulate for the countries in their sample the counterfactual productivity gains from reducing skill mismatch to the level associated to best practice. These

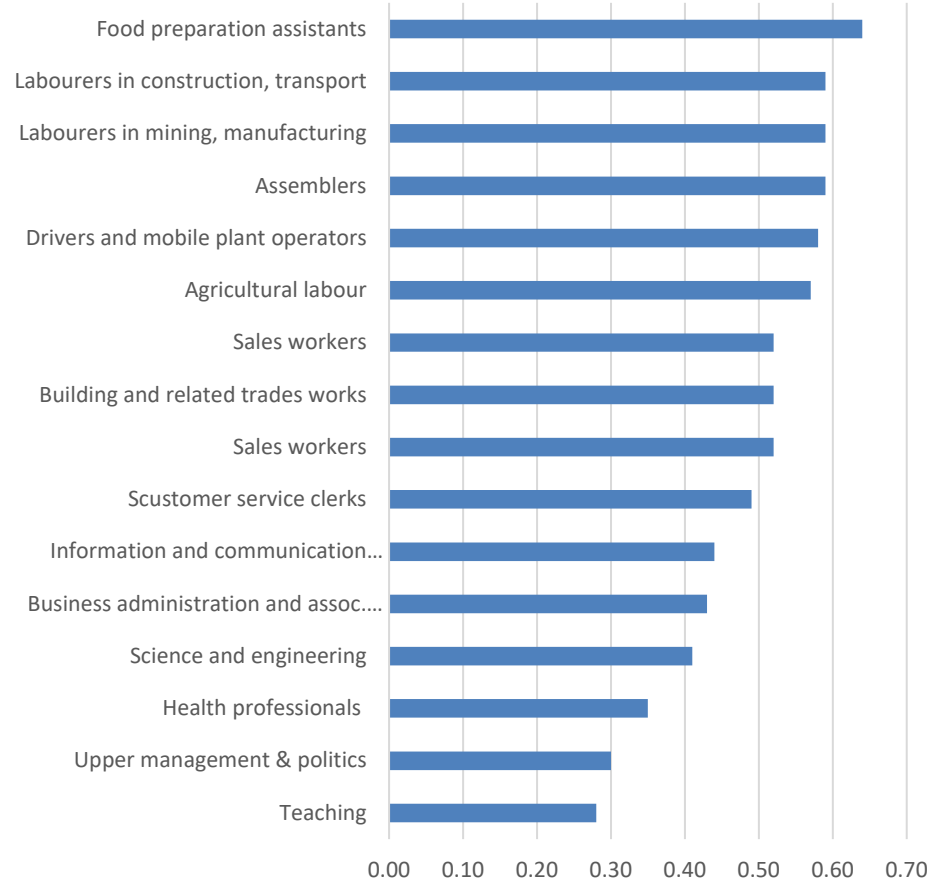
[25] See Quintini, 2011.

[26] Budria and Egido, 2008, also find that mismatch contributes to higher wage differences within education groups.

gains turn out to be sizeable in a number of countries (above 9% in Italy, Spain and the Czech Republic; between 5 and 9% in Germany, Norway, Great Britain and Austria).

The observed differences in skill mismatch across countries are associated with differences in the institutional and policy environment. According to a recent OECD study, skill mismatch turns out to be lower in countries with economic institutions that promote the efficient reallocation of resources – including less cumbersome product and labour market regulations and a bankruptcy legislation that does not excessively punish business failure - and where housing policies do not impede residential mobility. Lower mismatch is also associated with greater flexibility in wage negotiations and higher participation in lifelong learning as well as with higher managerial quality (see McGowan and Andrews, 2015b). Given that it relies on data from a cross section, however, this study cannot separate the effects on mismatch of variables characterising the environment from unobserved country effects. Results should therefore be considered as suggestive, requiring further examination. The theoretical framework connecting structural conditions that foster skill development and efficient allocation with innovation and hence aggregate productivity increases is illustrated in Figure 10.

Figure 10. Probability of automation by job type (selected occupations, mean probability of automation)



Source: Nedelkoska and Quintini, 2018.

4. Policies to address skill shortages and mismatch in the EU

Skill development starts from school and continues over the life cycle as individuals and firms invest in training and on-the-job learning. Under-investment in education can occur if individuals do not have the resources to finance their desired education, or if they fail to properly account for the social benefits and costs of education. Under-investment in training can also occur for several reasons, including that: (i) the private and social returns to training do not coincide, and workers or employers only consider private returns in their rational decisions. Examples of social returns are the spill-overs of training on the productivity of other workers and the effects of training on innovation activities (see Brunello, Garibaldi and Wasmer, 2008); (ii) employers who invest in the training of employees are often forced to share the returns to their investment either with the employees themselves by paying higher wages (the hold - up problem) of with other employers, who can hire the trained workers (the poaching problem).

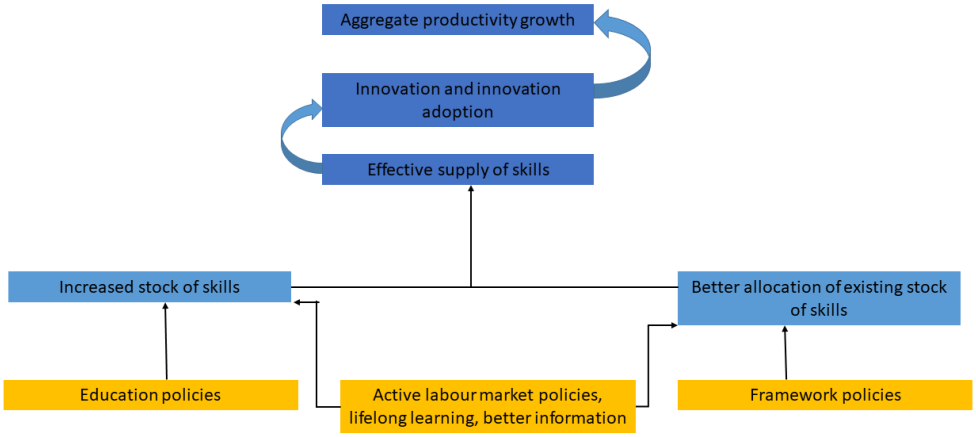
Policies addressing skills mismatch tend to concentrate on developing initiatives aimed at enhancing the responsiveness of the education and training system to emerging labour market needs. This include for instance: a) steps to reform VET education in some countries and enhancing the employability of young people through the Youth Employment Initiative;[27] b) forecasting future skill needs and supply by using occupational models, sectoral or occupational skills councils and commissioning of bespoke qualitative and quantitative research projects. The view that skills mismatch is also a function of asymmetric information between jobseekers, workers and firms has led some countries to improve career guidance and counselling services (McGuiness et al, 2017).

The concerns that firms express about the limited availability of skills as a factor limiting corporate investment are reflected in their views about public policy priorities. When asked about the areas where the public sector should focus in the next three years, 24 percent of the respondents to the EIBIS survey in 2017 chose professional training and higher education as a policy priority. By country, this share tends to be higher where concerns about skills are more pronounced (see Figure 11).

Does the responsibility for developing the skills that employers want fall exclusively onto job seekers and schools or should it be shared by employers? Schools designing curricula are likely to find it difficult to foresee what skills will be in demand three or five years after the programs start (Cappelli, 2014). Pupils investing in vocational programs that may fit future employer demands need to balance the advantages of a rapid school to work transition with the expected costs of skill obsolescence in the medium to long run and may therefore invest in more academic skills (see Brunello and Rocco, 2017).

[27] Policies not discussed here include structural reforms changing labour market institutions. See for instance De Haan and Parlevliet, 2018.

Figure 11. Connecting skill development and aggregate productivity



Source: European Economic and Social Committee (2018) based on McGowan and Andrews (2015).

Along these lines, results from a recent survey on vocational education and training (VET) show that the choice of VET is often guided by the expectation of finding a job quickly, while general education students tend to report their choice as based on the possibility to continue to higher education (Salvatore and Villalba-Garcia in EIB, 2018).[28] A tension exists between firms with skill shortages advocating more vocational education and individuals facing an uncertain professional future and the risks of automation and technical progress, who try to diversify risks by choosing broader educational curricula. Increasing permeability of VET systems and options for life-long learning might be steps to mitigate these tensions.

Schools are not particularly well suited to provide work experience that is better learnt in the workplace using apprentice-like arrangements (Cappelli, 2014). However, implementing well-designed apprenticeship systems where they are less common and keeping firms involved in training apprentices – even where systems have a longstanding history – remains a continuous challenge for many EU Member States (Wieland 2015 for Spain, Wieland 2018 for the UK, Wieland and Haerle 2018 for Italy, Thies in EIB 2018).

Employers can respond to skill shortages by activating several measures, including training, recruitment abroad, improved working conditions to attract qualified applicants and internal re-organizations aimed at increasing the productivity of existing employees. A study by the European Commission (European Commission, 2014a) shows that the relative importance of each measure depends on the occupation experiencing shortages. For instance, training and improving working conditions turn out to be particularly frequent in ICT and sales occupations, respectively. Recruitment efforts outside the country are instead frequent in the health sector (See Directorate General for Internal Policies, European Parliament, 2015).

[28] Results are based on a survey among 35,000 students at upper secondary level in 28 EU Member States.

Persistent skill shortages that are not solved by market mechanisms can be addressed by government policies, which can try to reduce the under-provision of education or training. In Europe, public policies encouraging adult training include co-financing programs targeted at firms, e.g. levy-grant schemes, tax deductions, and co-financing programs targeted at individuals, e.g. vouchers, individual learning accounts (Brunello, Garibaldi and Wasmer, 2007).

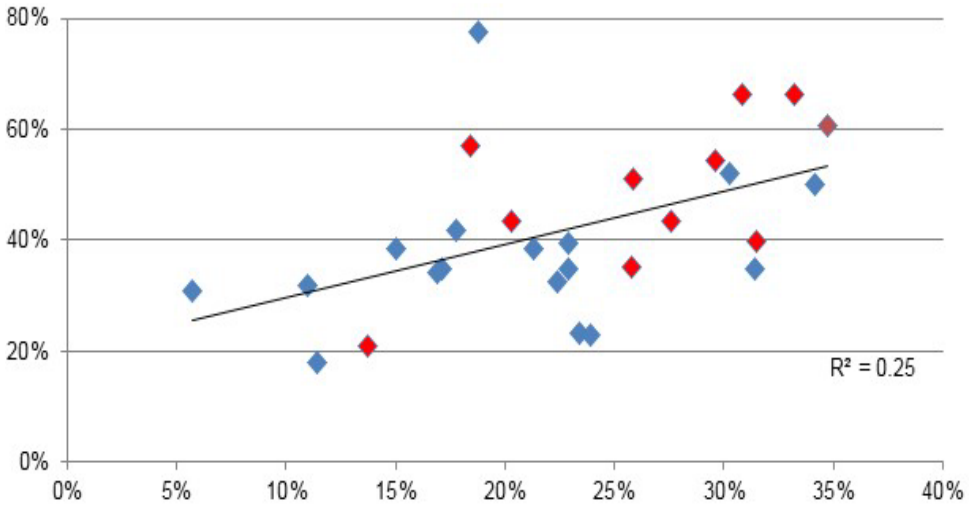
In the EU, policies addressing skill shortages and mismatch are implemented both at the European and at the national level. The former include measures supporting training measures, e.g. via the European Social Fund, promoting employment for young people (European Youth Guarantee) and reducing barriers to labour mobility (e.g. through facilitating recognition of qualifications, targeted mobility schemes or improving labour market transparency). The latter focus also on measures that facilitate the transition from school to work, increase labour market transparency, attract individuals in specific educational choices, provide incentives to train in "bottleneck" occupations and favour geographical mobility.[29]

The combination of EU and national policies raises questions on how well these measures fit together, and on whether there are gaps that are not addressed at either level. Second, do these policies work in reducing skill mismatch and shortages? The evaluation of the impact of funding arrangements on targeted outcomes cannot be limited to counting the number of participants to these programs but needs to compare outcomes when policies are in place with counterfactuals – or outcomes that would apply had the same policies not been switched on. A proper evaluation should also consider the economic costs and benefits and carefully distinguish the contribution of these policies from other concurrent causes. Also, it is important to understand whether the potential effects are only temporary or have a persistent impact on labour market outcomes, including employment and earnings.

Finally, skill policies at national and European level can also provide a way to proactively respond to structural trends such as digitalisation and the challenges that come with it, notably rising polarization in labour markets and inequality. To that extent, having policies in place that support a smooth transition between jobs and the development of qualifications required by the labour market will be increasingly important – both for firms requiring different skillsets as well as for job seekers in European labour markets. How this can best be achieved against the backdrop of the ongoing technological changes remains an area for future research. However, since skill development interacts with labour market and broader policies (e.g. competition, housing, migration policies), the links across policy areas should clearly be considered.

[29] Several examples of national policies targeted at combating skill shortages are reported by Directorate General for Internal Policies, European Parliament, 2015

Figure 12. Limited availability of skills and policy prioritisation



Notes: data points refer to EU-member states. Red squares indicate CESEE countries. Horizontal: Share of firms selecting higher education and training for public sector to prioritize. Vertical: Share of firms citing availability of staff with the right skills as major impediment to investment.

Source: EIBIS 2017.

Concluding remarks

This paper has reviewed the recent economic literature on skill mismatch and shortages with a focus on Europe. The key points can be summarized as follows:

1. There are different approaches to measure skill mismatch, that produce substantially different results. Measures relying on self-reported mismatch produce a much lower share of well-matched individuals than statistical measures that compare individual skills with average skills in the occupation;

2. Employers and managers are likely to have more accurate information than employees about skill requirements. Asking employers not only about impediments to economic activity and investment behaviour but also about skill mismatch in the firm is a valuable complement (at the firm, industry or occupation level) to the information asked to employees;

3. Indicators of skill shortages derived from employer surveys need to be complemented with indirect measures of the presence of shortages in specific occupations, including price measures (wage growth), volume measures (employment growth, vacancy rates) and work intensity measures (incidence of overtime);

4. Skill mismatch in Europe is counter-cyclical. During economic recessions skilled individuals are willing to take up jobs with lower skill requirements, and this effect tends to prevail on the cleansing effect of recessions, that eliminates poor matches;

5. After the 2008 recession, labour shortages have increased in many European countries, yet real earnings growth has remained subdued, with the exception of Eastern Europe. This casts some doubts that all the declared shortages are genuine;

6. In the long run, the adoption of new technologies creates the demand for new skills that are not immediately available in the labour market, giving rise to skill shortages until the broad education system (including employer training) is able to meet the new skill requirements. The importance of these shortages and the length of the adjustment process can be exacerbated if wages and working conditions fail to provide adequate signals of relative scarcity;

7. Skill shortages and mismatch are costly to individuals, firms and society because they negatively affect earnings, productivity, innovation and productivity growth. The effects on earnings can be quite persistent;

8. The responsibility for developing the skills that employers want – which includes financing skill development – should fall both onto job seekers and schools and onto employers. Persistent skill shortages that are not solved by market mechanisms can be addressed to some extent by government policies. Importantly, the effects of these policies need to be accurately evaluated.

References

Acemoglu, D. and Autor, D., 2011. Skills, Tasks *and Technologies: Implications for Employment and Earnings,* NBER Working Paper n. 16082.

Allen J., van der Velden R., 2001, Educational mismatches versus skill mismatches: effects on wages, job satisfaction, and on-the-job search. *Oxford Economic Papers* 53(3):434–52.

Altonji, J., Kahn, L. and Speer, J., 2016, Cashier of Consultant? Entry Labour Market Conditions, Field of Study and Career Success, *Journal of Labor Economics*, 34, S361-401.

Arsenau, D. and Epstein, B., 2014, The Welfare Costs of Skill Mismatch Unemployment, mimeo.

Autor, D., Levy, F., & Murnane, R., 2003, The skill content of recent technological change: An empirical exploration, *Quarterly Journal of Economics*, vol. 118, no. 4, pp. 1279-1333.

Autor, D., Dorn, D. and Hanson, G., 2013, The China Syndrome: Local Labor Market Effects of Import Competiton in the United states, *American Economic Review*, 103, 2121-2168.

Baley, I., Figueredo, A. and Ulbright, R., 2018, Mismatch Cycles, mimeo.

Barron, J., Berger, M. and Black, D., 1997, How Well Do We Measure Training? *Journal of Labor Economics*, 15, 3, 507-28.

Batsaikhan, U., Darvas, Z. and Raposo, I., 2018, *People on the Move: Migration and Mobility in the European Union*, Bruegel, Brussels.

Bellman, L. and Hubler, O., 2014, Skill shortages in German establishments, IZA Discussion Paper no. 8290, Institute for the Study of Labor, Bonn.

Belot, M., 2007, Why is Employment Protection Stricter in Europe than in the US?, *Economica*, 74, 295, 397-423.

Bennet, J. and McGuiness, S. 2009, Assessing the Impact of Skill Shortages on the Productivity Performance of High-Tech Firms in Northern Ireland, *Applied Economics*, Vol. 727-737

Bonthuis, B., Jarvis, V. and Vanhale, J., 2016, Shifts in Euro Area Beveridge Curves and their Determinants, *IZA Journal of Labor Policy*, 5, 20.

Boswell, C., Stiller, S. and Straubhaar, T. 2004: Forecasting Labour and Skill Shortages: How Can Projections Better Inform Labour Migration Policies? Hamburg Institute of International Economics, Paper prepared for the European Commission, DG Employment and Social Affairs.

Brynjolfsson, E., & McAfee, A., 2014. *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.

Brunello G., Garibaldi P. and Wasmer, E., 2007, *Education and Training in Europe*, Oxford University Press.

Brunello G. and Rocco L., 2017. The Labor Market Effects of Academic and Vocational Education over the Life Cycle: Evidence Based on a British Cohort, *Journal of Human Capital*, University of Chicago Press, vol. 11(1), pages 106-166.

Budria, S. and Moro-Egido, A. 2005. Education, Over-education and Wage inequality: Evidence for Spain. Studies on the Spanish Economy 211, FEDEA.

Cappelli, P., 2014, Skill Gaps, Skill Shortages and Skill Mismatches: Evidence from the US, NBER Working Paper 20382.

Cazes, S. and Tonin, M., 2010, Employment protection legislation and job stability: A European cross - country analysis, *International Labour Review*, Vol. 149, No. 3, pp. 261–285.

CEDEFOP, 2015, *Skill Shortages and Gaps in European Enterprises*, Luxembourg.

CEDEFOP, 2016, *Future Skills Needs in Europe: Critical Labour Force Trends*, Luxembourg.

CEDEFOP, 2016b, *Skill Shortage and Surplus Occupations in Europe*, Briefing note.

CEDEFOP, 2018, *Insights into Skill Shortages and Skill Mismatch*, Luxembourg.

Clarke, L. and Winch, C., 2006, A European Skill Framework? But what are Skills? Anglo-Saxon versus German Concepts, *Journal of Education and Work*, 19(3), 225-69.

Das, M. and Hilgenstock, B. 2018, Labor Market Consequences of Routinization in Developed and Developing Economies, manuscript.

Dauth, W., Findeisen, S. and Suedekum, J., 2014, The Rise of the East and the Far East: German Labor Markets and Trade Integration, *Journal of the European Economic Association*, 12, 1643-1675.

Danmarks National Bank, 2019, Intra-EU labour mobility dampens cyclical pressures.

De Haan J. and Parlevliet, J. 2018, *Structural Reforms Moving the Economy Forward*, Springer.

Deming, D., 2017, The Value of Soft Skills in the Labour Market, NBER Reporter, n.4.

Desjardins, R. and Rubenson, K., 2011, An Analysis of Skill Mismatch using Direct Measures of Skills, *OECD Education Working Papers n.63*, Paris.

Directorate General for Internal Policies, European Parliament, 2015, *Labour Market Shortages in the European Union*, Brussels.

Donoso V., Martın V. and Minondo, A.,2014. Do differences in exposure to Chinese imports lead to differences in local labour market outcomes? An analysis for Spanish provinces. *Regional Studies,* Vol.49(10), pp.46–64.

European Central Bank, 2012, *Euro Area Labour Markets and the Crisis*, Frankfurt.

European Commission, 2014, *European Vacancy and Recruitment Report*, Luxembourg.

European Commission, 2014a. *Mapping and Analysing Bottleneck Vacancies in EU Labour Markets*. Overview report. Prepared by Karin Attström, Sebastian Niedlich, Kees Sandvliet, Hanna-Maija Kuhn, Edmund Beavor. Luxembourg: Publications Office of the European Union.

European Commission, 2017, *Skill Mismatch and Productivity in the EU*, Brussels.

European Commission, 2018. Labour Market and Wage Developments in Europe 2018. Annual Review, European Commission, Brussels.

European Commission, 2018a*, Employment and Social Developments in Europe*, Brussels.

European Economic and Social Committee (2018). *Skill Mismatches – An Impediment to the Competitiveness of EU businesses*. European Economic and Social Committee, Brussels.

European Investment Bank, 2017, General Module Questionnaire, Survey of Investment and Investment Finance, Luxembourg.

European Investment Bank, 2018, *Investing in Europe's Future: The Role of Education and Skills*, Luxembourg.

European Investment Bank (2018a). *Investment Report* 2018. Retooling Europe's economy. European Investment Bank, Luxembourg.

Eurostat, 2016, *Statistical Approaches to the Measurement of Skills*, Luxembourg.

Farber, H. S., 2010, 'Chapter 6: Job loss and the decline in job security in the United States', in Abraham, K. G., Spletzer, J. R. and Harper, M. (eds.), *Labor in the new economy*, University of Chicago Press, Chicago, pp. 223–262.

Foley, P., H. Watts and Wilson, B. 1993, New Technologies, Skill Shortages and Training Strategies, in P. Swann (ed.), *New Technologies and the Firm: Innovation and Competition*, Routledge, London and New York.

Forth, J. and Mason, G. 2006, Do ICT Skill Shortages Hamper Firms' Performance? Evidence from UK Benchmarking Surveys, National Institute of Economic and Social Research, Discussion Paper No. 281.

Frey, C. B., & Osborne, M. A., 2017. The future of employment: how susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, *114*, 254-280.

Goerlitz, K. and Tamm, M. 2017. Information, Financial Aid and Training participation: Evidence from a randomized field experiment. *Labour Economics*, Vol.47, pp.138-148.

Goos, M., Manning, A., and Salomons, A., 2009. Job Polarization in Europe, *The American Economic Review Papers and Proceedings*, 99, 2, 58-63.

Goos, M., Manning, A., and Salomons, A., 2014. Explaining job polarization: Routine-biased technological change and offshoring. *The American Economic Review*, *104*(8), 2509-2526.

Green, A. and Owen, D., 1992, Skill Shortages: The Local Dimension, in Bosworth, D., Dutton, P. and Lewis, J. (Eds.). *Skill Shortages: Causes and Consequences*, Avebury: Aldershot.

Green F. and McIntosh, S., 2007. Is there a genuine under-utilization of skills amongst the over-qualified?. *Applied Economics*, 39(4-6), 427-439.

Hartog, J., 2000, Over-education and earnings: where are we, where should we go? *Economics of Education Review*, 19,2, 131-147.

Haskel, J. and Martin, C, 2001, Technology, Wages, and Skill Shortages: Evidence from UK Micro Data, *Oxford Economic Papers*, vol. 53(4), pages 642-658.

Haskel, J. and Martin, C. 1993, Do Skill Shortages Reduce Productivity? Theory and Evidence from the United Kingdom, *The Economic Journal*, Vol. 103, pp. 386-394.

Healy, J, Mavromaras K. and Sloane, P., 2015. Adjusting to skill shortages in Australian SMEs, *Applied Economics*, Taylor & Francis Journals, vol. 47(24), pages 2470-2487, May.

Katz, L, and Autor, D., 1999, Changes in the Wage Structure and Earnings Inequality, in Ashenfelter, O and Card D, *Handbook of Labor Economics*, vol.3, 1463-1568.

International Monetary Fund, 2018, *World Economic Outlook*, Washington.

Kiss, A., Vandeplas, A., 2015. Measuring skills mismatch. DG EMPL Analytical webnote 7/2015, European Commission.

Liu, K., Salvanes, K. and Sorensen, K. 2012, Good Skills in Bad Times: Cyclical Skill Mismatch and the Long-term Effect of Graduating in a Recession, IZA Discussion Paper n. 6820.

Livanos, I. and Nunez, I., 2017, Re-thinking Under-skilling: Evidence from the First European Skills and Jobs Survey, Cedefop/IZA Workshop on Skills and Skills Mismatch, Thessaloniki.

Margolis, D., 2014, Defining and Measuring Techni cal, Cognitive and Non-Cognitive Skills, The World Bank.

Mavromaras, K., McGuinness, S. and M. Wooden (2007). Overskilling in the Australian Labour Market. *The Australian Economic Review*, Vol.40, pp.307-312.

McGowan MA and Andrews, D, 2015a, Labour Market Mismatch and Labour Productivity: Evidence from PIAAC Data, *The Future of Productivity: Main Background Papers*, OECD.

McGowan MA and Andrews, D, 2015b, Skill Mismatch and Public Policy in OECD Countries, *The Future of Productivity: Main Background Papers*, OECD.

McGuiness, S, Pouliakas, K and Redmond, P, 2017, *How Useful is the Concept of Skill Mismatch*? ILO, Geneva.

McGuiness, S and Ortiz, L, 2014, Who Should we Ask? Employer and Employee Perceptions of Skill Gaps within Firms, ESRI Working Paper n.482.

McKinsey Global Institute, 2015. *A labour market that works: connecting talent with opportunity in the digital age.*

Monti, P and Pellizzari, M, 2016, Skill Mismatch and Labour Shortages in the Italian Labour Market, *Policy Brief* n.2, Bocconi University.

Nedelkoska, L. and Quintini, G. 2018, Automation, Skills Use and Training, OECD Social, Employment and Migration Working Papers No. 38. Technical Report 38, 2018.

Nickell, S. and D. Nicolitsas, 2000, Human Capital, Investment and Innovation: What are the Connections in R. Barrell, G. Mason and M. O'Mahoney (eds.) *Productivity, Innovation and Economic Performance*, National Institute of Economic and Social Research Economic and Social Studies No. 40, Cambridge University Press, Cambridge, pp. 268-280.

OECD, 2017, *Getting Skills Right: Skills for Jobs Indicators*, Paris.

Oreopoulos, P, von Wachter, T and Heisz, A, 2012. The Short- and Long-Term Career Effects of Graduating in a Recession," *American Economic Journal: Applied Economics*, American Economic Association, vol. 4(1), pages 1-29, January.

Pellizzari, M and Fichen, A, 2017, A New Measure of Skill Mismatch: Theory and Evidence from PIAAC, *IZA Journal of Labor Economics*, 6,1,1-30.

Pissarides, C. 2000, *Equilibrium Unemployment Theory*, MIT Press.

Pouliakas, M and Sekmokas, M., 2018, Automation, Skills demand and Adult Learning, in European Investment Bank, *Investing in Europe's Future: the Role of Education and Skills*, Luxembourg.

Quintini, G, 2011, Right for the Job: Over-qualified or Under-skilled?, *OECD Social, Employment and Migration Working Papers n.120*, Paris.

Quintini, G, 2017, What skills are needed for tomorrow's digital world?, OECD Medium.

Salvatore, L. and Villalba-Garcia, E., 2018. Investing in Europe's future education and skills: Public Opinions on Vocational Education and Training. In EIB (2018).

Savšek, S. 2018. "What are the main obstacles to hiring after recessions in Europe?," ECB Working Paper Series n. 2153.

Schmidpeter, B. and Winter-Ebmer, R, 2018. How do Automation and Off-shorability influence unemployment duration and subsequent job quality? Economics Working Paper 2018-08, Department of Economics, University of Linz.

Slonimczyk, F., 2009. Skill Mismatch and Wage inequality in the US. Open Access Dissertations, University of Massachusetts, Amherst.

Summerfield, F., 2015, Matching Skill and Tasks: Cyclical Fluctuations in the Over-qualification of New Hires, mimeo, University of Aberdeen.

Tang, J. and W. Wang, 2005. Product Market Competition, Skill shortages and Productivity: Evidence from Canadian Manufacturing Firms. *Journal of Productivity Analysis*, Vol.23, pp.317-339.

Tamm, M, 2018, Training and Changes in Job Tasks. *Economics of Education Review,* forthcoming.

Thies, L., 2018. What is there to learn from the German apprenticeship system? In EIB 2018: *Investing in Europe's future: the role of education and skills.*

Verhaest, D. and Omey, E., 2006, The Impact of Over-education and its Measurement, *Social Indicators Research*, 77, 419-448.

Yashiv, E, 2007, Labor search and matching in macroeconomics, *European Economic Review*, 51, 1859-95.

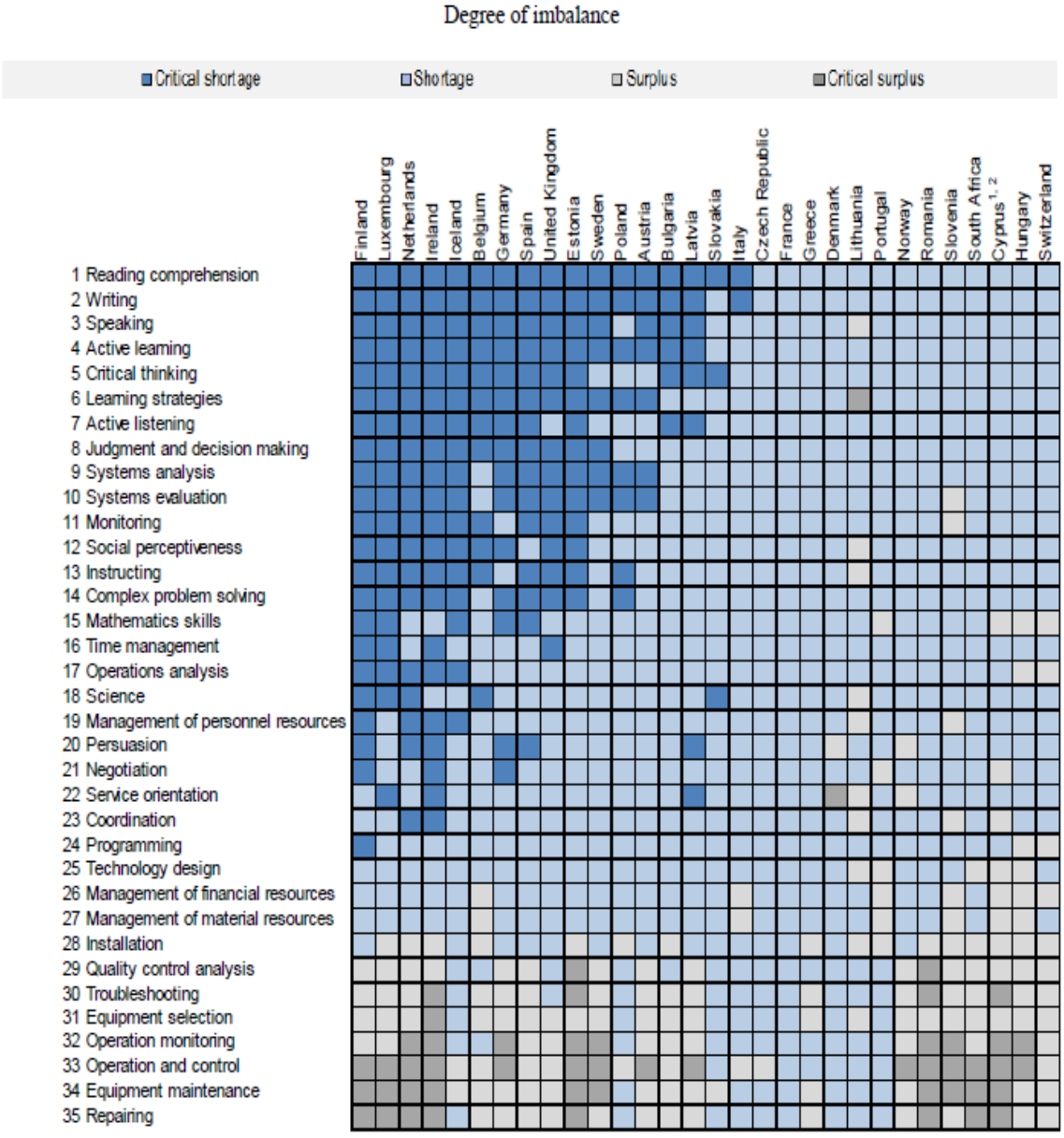
Wieland, C., 2016. Apprenticeship training in Spain – a cost effective model for firms? Bertelsmann Foundation, Guetersloh.

Wieland, C., 2018. Apprenticeship training in Italy – a cost effective model for firms? Bertelsmann Foundation, Guetersloh.

Zago, R., 2017. Job Polarization, Skill Mismatch and the Great Recession. Working Paper, Sciences Po, Paris.

Appendix

Figure A1. Skill needs across Europe



Note: Critical shortage (darker blue) is defined as the observations in the top quartile of the positive skill imbalance values across countries and skills. Critical surplus (darker grey) is defined as the observations in the bottom quartile of the negative values.

Source: OECD, 2017.