Getting Skills Right

Skills for Jobs Indicators

OECD

Getting Skills Right: Skills for Jobs Indicators

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Please cite this publication as:
OECD (2017), *Getting Skills Right: Skills for Jobs Indicators*, OECD Publishing, Paris.
http://dx.doi.org/10.1787/9789264277878-en

ISBN 978-92-64-27786-1 (print)
ISBN 978-92-64-27787-8 (PDF)

Series: Getting Skills Right
ISSN 2520-6117 (print)
ISSN 2520-6125 (online)

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Foreword

Across countries, tackling skill mismatch and skill shortages is a major challenge for labour markets and training policies in the context of rapid and substantial changes in skill needs. In most countries, a substantial share of employers complain that they cannot find workers with the skills that their businesses require. At the same time, many graduates face difficulties in finding job opportunities matching their qualifications.

In light of this challenge, OECD has undertaken an ambitious programme of work on how to achieve a better alignment or skill supply and skill demand, with a focus on: i) understanding how countries collect and use information on skill needs; ii) investigating cost-effective training and labour market policies to tackle skill mismatch and shortages; iii) studying the incentives of training providers and participants to respond to changing skill needs; and iv) setting up a database of skill needs indicators.

This work builds on the extensive programme of work of the OECD in the area of skills, including the OECD Skill Strategy and its follow up national implementation strategies, the Survey of Adult Skills (PIAAC) and its rich analyses in the areas of skill mismatch, vocational education and training and work-based learning.

This report describes the construction of the database of skill needs and mismatch indicators, i.e. the *OECD Skills for Jobs Database*, and presents initial results and analysis. It identifies the existing knowledge gaps concerning skills imbalances, providing the rationale for the development of the new skill needs and mismatch indicators. Moreover, it explains the methodology used to measure skill shortage, surplus and mismatch, and provides key results and insights from the data.

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This report is published under the responsibility of the Secretary-General of the OECD, with the financial assistance of the JP Morgan Chase Foundation. The views expressed in this report should not be taken to reflect the official position of the JP Morgan Chase Foundation.

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Executive summary

The demand for skills in the labour market is undergoing substantial change as a result of technological progress, globalisation and population ageing. At the same time, developments such as increased labour market participation of women and greater migration flows have altered the supply of skills. In light of these changes, it is increasingly important to ensure that the skills of each country's workforce are well matched to the skill needs of its labour market. Skills imbalances, such as shortages, surpluses and mismatch, can result in poorer labour market outcomes for individuals, weak firm performance and lower aggregate demand.

To prevent and address these skills imbalances, policy makers, education and training providers, firms, trade unions and individuals need access to timely and high-quality labour market information. Most countries regularly undertake skills anticipation and assessment exercises to understand better skill needs and how these match the skills of the workforce. However, the way these exercises are implemented and the extent to which the outcomes are used in policy making vary considerably across countries. Cross-country comparisons of skills imbalances are important in the context of increasingly globalised labour markets. Moreover, information on cross-country differences in skills imbalances allows studying some key determinants and identifying common policy challenges.

The goal of the new *OECD Skills for Jobs Database* is to fill this knowledge gap, by providing regularly-updated international evidence on skill shortages, surpluses and mismatch. By looking at skills – i.e. the set of competences mobilised to perform the tasks related to a job – rather than occupations or field of study, the new indicators go beyond the traditional measures of imbalances. Three domains of competence are measured and presented – *skills, knowledge and abilities* – based on the occupational information from the O*NET database. Furthermore, unlike the generally subjective information on skill needs available from employer surveys, the *OECD Skills for Jobs* indicators are based on quantitative data from large-scale household surveys. The indicators measuring shortage and surplus are constructed using a multidimensional set of quantitative signals of skills pressure, including wage growth, employment growth and unemployment. Similarly, mismatch indicators use formalised criteria for assessing the match between an individuals' qualification level or field and the competences required on the job.

The *OECD Skills for Jobs Database* identifies skills, knowledge and abilities in surplus and shortage across European countries and South Africa:

- Shortages in the *skills* domains 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). Skill shortages are most

pronounced in Finland, Luxembourg, the Netherlands, Spain or Germany while less pronounced or in surplus in Switzerland, Hungary, Cyprus or South Africa.

- In the k*nowledge* domain, the most common shortages are found in computers and electronics, education and training as well as in some mathematics and science fields (e.g. chemistry, biology) and in the healthcare field (i.e. therapy and counselling, psychology and medicine and dentistry). Shortages of this kind are most common in Finland, the Netherlands but also Ireland and Belgium. Surpluses, on the other hand, are mainly found in the areas of transportation, manufacturing and production as well as in the knowledge area of building and construction. Surpluses of this kind are found across most countries and particularly in Estonia, Bulgaria and Romania as well as in the Netherlands, Ireland and Belgium.
- Among *abilities*, verbal and reasoning abilities as well as perceptual and quantitative abilities are most commonly in shortage. Surpluses, are more frequent in manual and routine abilities such as physical strength, flexibility, balance and co-ordination, endurance or control movement and fine manipulative abilities.

In addition to identifying the type of skills that are in shortage or surplus in an economy, the OECD *Skills for Jobs Database* can be used to analyse how economies and jobs use and combine these skills. Jobs differ widely in the type of skills that they use, with elementary workers requiring, for instance, a different set of skills than managers. Occupations also differ in the skill specialisation that is needed to carry out job tasks. While some jobs may make use of a wide range of skills, others use only a few very specific skills. The results of this occupational analysis can be used to identify training priorities and key skills that would be needed for workers employed in occupations in surplus (whose employment prospects are poor) to move to occupations that are in high demand (or shortage), thus improving their labour market outcomes. Based on the database:

- The strongest shortages are found in occupations that use several different skills simultaneously, with high intensity, and across multiple knowledge areas. This evidence seems to support the hypothesis that workers with high-skills intersecting different knowledge areas are scarce in the labour market but, generally, in high demand. The biggest surpluses occur, instead, in relatively low-skill intensive occupations.
- For the average country analysed, for instance, the *OECD Skills for Jobs Database* shows that "Building and related trades workers" are in surplus, but have a very similar *skills* profile to "Metal, machinery and related trades workers" which are in shortage. The two occupations differ, however, in that workers in the latter occupation have more technical skills than those in the former. Additional training, designed to reinforce specific technical skills of building and related trades workers could be useful for them to move into metal and machinery trades jobs that have better labour market outcomes. Training profiles can be developed for all European countries and South Africa, providing crucial information for policy makers on how to adjust training programmes to labour market needs.

Technological progress, the transition towards a digital economy and the introduction of several new disruptive technologies are reshaping the content and tasks of many occupations. Computing power of ever-smaller devices has steadily increased

in the past decade, allowing the development and implementation of a range of new digital technologies such as 3D printing, Internet of Things (IoT) and advanced robotics. The accelerated pace by which these new technologies are developing is raising concerns that these innovations could make labour redundant through the increasing automation of jobs and tasks. The results from the *OECD Skills for Jobs Database* confirm the changing demand for skills:

- There are substantial shortages in a variety of cognitive skills. These shortages are likely to be related to automation processes that are making routine skills redundant and cognitive ones increasingly more important. Deductive reasoning (i.e. the ability to apply general rules to specific problems), fluency of ideas (i.e. the ability to come up with a number of ideas about a topic) or information ordering (i.e. the ability to arrange things or actions in a certain order or pattern according to a specific rule) are only some examples of the abilities that are found to be in shortage in all countries and that are difficult for machines to replicate adequately.
- The database confirms the existence of surpluses in routine manual and physical skills and abilities. Control precision abilities (e.g. the ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions) used for example in mining occupations such as roof bolters or mine shuttle car operators are shown to be in considerable surplus across many of the countries examined. Similarly, evidence shows a negative correlation between the increase in robots per hours worked between 1993 and 2007 and the shortages of control precision abilities and of physical strength needs across countries.
- The shortages in cognitive skills have become more acute over time and the same is true for the surpluses which have become larger in manual/physical skills, leading to increasing polarisation in skill demands.

Adapting to rapid technological change is likely to require substantial adjustment in how work is organised. Competitive pressures stemming from innovation and the speed of technological progress imply that the modern workplace is in a state of continual change. Across the OECD and EU countries, a substantial proportion of workers are in workplaces that have introduced new technologies and/or undergone significant restructuring in the way jobs and tasks are carried out. Results from the *OECD Skills for Jobs Database* show that:

- Countries that underwent substantial restructuring in the workplace (e.g. Finland, Sweden or Denmark and Estonia) are also showing stronger shortages in administration and management knowledge as well as in other key skill dimensions requiring workers to develop autonomy in making decisions and independence in the organisation of tasks.
- Similarly, the demand for skills such as co-ordination with others and ability to lead others is on the rise in countries where organisational restructuring in the workplace has been stronger.

Among non-routine skills that cannot be replaced by technology are “soft” skills, such as leadership and adaptability. Earlier evidence shows that employment growth has been strongest in jobs that require both high cognitive and soft skills. The *OECD Skills for Jobs* data confirm that occupations that use soft skills more intensively are more likely to be in shortage, and the impact of soft skills on shortages is found to be

stronger in occupations with intensive cognitive skill use. Soft skills, such as leadership and adaptability, are found to be in shortage in most countries, and the degree of shortage is higher in countries with lower employment shares in routine jobs.

The new *OECD Skills for Jobs* indicators can also help trace out the implications of population ageing for skill gaps. Evidence shows that healthcare and personal care related skills are in shortage in the large majority of countries, and the largest shortages of healthcare professionals are found in countries experiencing more rapid population ageing. Population ageing also has an impact on the supply of skills, as the average age of the employed population is rising, and the cognitive skills of older workers are generally lower than those of their younger counterparts. The evidence suggests that countries in which the skills gap between older and younger workers is the biggest have stronger shortages of key information-processing skills. Adult training and lifelong learning are, therefore, fundamental. The *OECD Skills for Jobs Database* can help policy makers identify training priorities for adult and older workers to develop the necessary skills to face the challenges of a rapidly changing labour market.

The increasing labour market participation of women is another factor that contributes to both skills demand and supply, as greater numbers of women in the workforce supply additional skills to the labour market but also create demand for services, such as childcare and cleaning, which gives rise to their own skill needs. The evidence from the *OECD Skills for Jobs* indicators suggests that countries with higher female employment rates show stronger shortages of cleaners and helpers as participation of women in the formal labour market is likely to increase the demand for these jobs. In contrast, no clear link is found between female labour market participation and smaller shortages in female-dominated occupations.

Finally, the *OECD Skills for Jobs Database* also provides information on qualification and field of study mismatch faced by workers across the economies analysed. Results show that the degree of over- and underqualification as well as field-of-study mismatch differ widely across countries. In countries like the Czech Republic and the Slovak Republic less than one out of five workers are mismatched in terms of qualifications, whereas this is the case for over half of South African workers. The probability of being mismatched is strongly influenced by socio-economic characteristics, such as age and migrant background, but also by job characteristics, such as working hours and contract type.

Chapter 1

Introduction to the *OECD Skills for Jobs* indicators

As a result of globalisation, technological change and demographic shifts, the types of skills demanded by employers have changed considerably over past decades and continued change is expected. The OECD's Skills for Jobs *indicators can help facilitate the response to changing skill needs thanks to skill imbalances information that is comparable across countries and regularly updated. This chapter takes stock of existing measures of skills imbalances and provides the rationale for the development of the OECD's new indicators of skill mismatch and skill shortages.*

The rationale for measuring skill imbalances

The skills required in the workplace are changing continuously as a result of a number of so-called "mega trends": technological innovation; changes in the global division of labour; changes in the way firms are organised; demographic change; and changes in consumption models. Rapid improvements in computer technology over the last few decades have provided employers with cheaper machines and software that can potentially replace humans in many middle-skilled activities such as accounting, clerical work and repetitive production tasks. These improvements in technology have also enabled employers to offshore jobs or individual tasks that do not require face-to-face interactions, thus affecting skill requirements in each country over and above the direct effect of automation. As a result of these trends, new sectors and jobs are emerging while others are shrinking, changing the skills needed in today's economies. Even within existing occupations, the tasks performed by workers and the skills needed to carry them out have undergone significant change.

The supply of skills has also changed as a result of the expansion of compulsory and higher education (Meyer et al., 1992; Schofer and Meyer, 2005), improvements in the quality of education (OECD, 2013a, 2013b), increases in female labour force participation, and migratory flows, as well as changes in retirement behaviour (Dixon, 2003; OECD, 2012, 2013c).

The dynamism of both skill demand and supply raises the question of how economies achieve a good match between the two. In a perfectly competitive labour market, price and quantity adjust until the market clears: firms adapt production processes to the available stock of human capital and workers seek the amount and type of training currently required (or foreseen) in an economy (Hartog, 2000). The perfectly competitive model relies on the assumption that perfect information on skill needs is available and that skills supply and demand can change instantaneously as well as the returns to skills. In reality, however, credit and technology constraints slow down demand-side changes in response to the availability of higher-level skills. Similarly, students, workers, employers and training institutions may not be well-informed about the skills required in the short-, medium- and long-term and, even when they are, it takes time to go through the necessarily training or education courses as well as to change the content of these courses. For instance, as a result of the time lag between the decision to enrol in education (or, for adult workers, in training programmes) and the moment when skills are used in the labour market, individuals may under- or overestimate employment prospects and this could lead to skill shortages, surpluses and mismatch.

Information asymmetries, the lack of geographical mobility and the macro-economic situation may also generate skill mismatch. For instance, skill mismatch may arise if skills are not easily assessed at hiring. Similarly, workers who are not geographically mobile or who are looking for a job in periods of weak aggregate demand may accept jobs for which they are over-skilled or over-qualified. Finally, barriers to training provision or participation may generate mismatch among existing workers because of skills obsolescence generated, for example, by the adoption of new technologies or by changes in production processes.

Finally, skill shortages may stem from "structural factors" such as an ageing or shrinking work force as well as entry barriers to the labour market. Unattractive working conditions or inadequacies in corporate recruitment systems can also play a

role (Shah and Burke, 2005). Similarly, countries vary in their institutional arrangements, industrial structure, average firm size and hiring practices (European Commission, 2015). There may also be rigidities in the extent to which returns on skills adjust to changes in skill demands and supplies.

All these factors imply that lengthy periods of job search might be required by both parties before a good match between the skills of job seekers and those required in vacant positions is achieved, suggesting that skill shortages (and mismatch) can persist considerably over time (Mortensen and Pissarides, 1999).

To a certain extent, skill mismatch and shortages are to be expected as workers are not always in a position to know with certainty what their careers will be. Personal interests and ambitions may change and, as such, career paths. Short periods of mismatch are likely to arise in those cases. Thus, some "frictional" degree of skill mismatch and skill shortage is also to be expected in any dynamic economy. However, persistently high skill mismatch and skill shortage over the longer term can have adverse economic consequences for individuals, firms and the aggregate economy. At the individual level, skill mismatch has a negative impact on job satisfaction and wages (Montt, 2015; OECD, 2014). At the firm level, skill mismatch has been associated with lower productivity, and increased on-the-job search and turnover, while skill shortages have been shown to increase the cost of hiring and hinder the adoption of new technologies (OECD, 2012). At the macroeconomic level, mismatch increases structural unemployment, reduces economic output relative to potential output (Sattinger, 1993), and reduces GDP growth via misallocation of human capital, while skill shortages have equally adverse effects on labour productivity (Adalet McGowan and Andrews, 2015; OECD, 2012). In light of these costs, many countries and international organisations are paying increased attention to finding ways to better align skill demand and skill supply (ILO, OECD, World Bank, 2014).

To prevent and address skill mismatch and skill shortages, policy makers and individuals need to have access to timely and high-quality labour market information. Indeed, promoting the collection and use of such information is one of the priorities listed in the employment plans of G20 countries (ILO, OECD, World Bank, 2014) and plays a central role in the European Union's New Skills Agenda for Europe (European Commission, 2015). Developing robust labour market intelligence and comparable indicators to monitor the emergence and existence of skill shortages and mismatch is, therefore, of fundamental importance to steer employment, education, science and technology as well as migration policies. While most countries do collect labour market information through skill anticipation and assessment exercises, a number of knowledge gaps remain.

The aim of the *OECD Skills for Jobs* indicators is to partly fill this knowledge gap by monitoring the evolution of skill mismatch and skill shortages in a way that:

- Is *comparable* across countries.
- Can be *regularly updated*.
- Is available *at a sufficient level of skill-disaggregation* to be useful to policy makers.
- Allows mapping occupational shortages into *skill needs*.

This chapter takes stock of the data that is currently available to understand skill mismatch and skill shortages, and identifies where the knowledge gaps lie.

Main messages

- Many countries and international organisations have identified the need for high-quality labour market information to address skill mismatch and skill shortages.
- The *OECD Skills for Jobs* indicators fill an important knowledge gap by developing measures of skill mismatch and skill shortage which are based on objective data, are comparable across countries and will be updated regularly.
- Rather than using qualifications or occupations to describe skill needs, the *OECD Skills for Jobs* indicators use the occupational skills classification database, O*NET, to translate occupations in shortage into a measure of skills in shortage.
- The *OECD Skills for Jobs* indicators can be used by policy makers to inform the design of education and training policies, as well as employment and migration policies. They will also be useful to individuals making decisions about education and training investment.

Measuring skills and the use of skill proxies

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. The term "skill" can refer to generic cognitive and non-cognitive abilities (e.g. information-processing skills, teamwork, self-organisation) as well as to skills that are specific to a particular job, occupation or sector (e.g. accounting or hair colouring) (OECD, 2016). The empirical literature looking at the impact of human capital on economic performance dates back several decades and has increased exponentially by subsequent refinements of what is commonly understood by "human capital" or "skills". The countless number of empirical studies on human capital and skills reflects the many ways that skills have been approximated in the literature and, as such, highlights the difficulty of coming up with a shared definition of what skills are or a good proxy or indicator for measuring them.

Previous studies, for instance, have focused on analysing the differences in so-called "cognitive abilities" and on their impact on economic performance (see Leuven et al., 2004; Autor et al., 2003; Hanushek and Woessmann, 2009; Blau and Kahn, 2001; and Devroye and Freeman, 2001). More recent studies instead, have focused on the identification of "knowledge types". For instance, Gabe and Abel (2011a) analysed the diverse pattern of US occupations' knowledge requirement profiles relative to the average US occupation by linking the different knowledge requirements to the existence of employment clusters in metropolitan areas.[1] Similarly, Gabe and Abel (2011b) studied the impact workers' clustering in jobs with similar knowledge requirements and wage dynamics.

While education levels and average years of schooling[2] have also been commonly used in the literature to proxy for the skill levels of workers in national labour markets, other strands of this literature (Hanushek and Kimko, 2000; and Hanushek and Woessman, 2009) highlighted how the *quality* of the education systems, and not just the *quantity* of completed education, should be taken into account when measuring human capital and skills.[3] Other studies have focused on underlying skills such as the ability to innovate or creativity. In that vein, for instance, Florida (2002) associates the economic performance of a metropolitan area with the presence of a "creative class" where individuals with underlying creative knowledge would be ultimately boosting economic growth. The basic idea of a creative class, however, tells little about the type(s) of knowledge that underpins "creativity" itself and highlights the difficulties to come up with a unique definition for skills.

All in all, although some sources differentiate,[4] terms such as knowledge, skills, abilities, competences and, to a lesser extent, even education are often used interchangeably. In what follows, the term "skills" will be used to encompass all these concepts, and the distinction will be made only where relevant. That being said, the various skill dimensions differ in their interpretation, as pointed out, for instance, in the Qualifications and Evaluations framework used by the US Government to select its personnel:

- *Knowledge* statements refer to an organised body of information usually of a factual or procedural nature which, if applied, makes adequate performance on the job possible. A body of information applied directly to the performance of a function.
- *Skill* statements refer to the proficient manual, verbal or mental manipulation of data or things. *Skills* can be readily measured by a performance test where quantity and quality of performance are evaluated, usually within an established time limit. Examples of proficient manipulation of things are skill in typing or skill in operating a vehicle. Examples of proficient manipulation of data are skill in computation using decimals; skill in editing for transposed numbers, etc.
- *Ability* statements refer to the power to perform an observable activity at the present time. This means that abilities have been evidenced through activities or behaviours that are similar to those required on the job (e.g., ability to plan and organise work). Abilities are different from aptitudes as the latter only relate to the potential to perform the activity.

It can be broadly argued, therefore, that knowledge types represent the "kind" of education/training investments made by individuals who will acquire knowledge spanning in different areas such as humanities, science, arts etc. Skills, instead, are acquired through both experience and training and represent the power of an individual to make that knowledge investment productive in the job or in real life. Abilities, though similar to skills, refer to the power to perform an activity which does not necessarily link to a job-task. For the sake of simplicity, in the remainder of this study, the term skills will be used when referring to these different dimensions globally. On the other hand, when referring to the skill dimension specifically – as opposed to the *knowledge* and *abilities* dimensions – italic will be used.

Beyond semantics and given the many dimensions mentioned above,[5] skills are generally hard to quantify and alternative measures are commonly used in skills anticipation and assessment exercises and empirical studies to approximate for them. As a result, exercises trying to measure skill needs in the labour market commonly approximate them by reverting to occupations, qualifications or fields of study (e.g. law, medicine, economics, catering).

Current data gaps about skill mismatch and shortage

Adding to the complexity of identifying reliable measures of skills, the challenges associated to measuring skill *shortages* and *mismatch* in the labour market lie in identifying what level or type of skills are required by firms and in measuring the gap between these needs and the skills of the workforce.

Although there is no universally agreed definition, *mismatch* can be measured with reference to different dimensions, whether skills, qualifications or fields of study. *Skill mismatch* describes situations in which workers' skills exceed (overskilling) or fall short (underskilling) of those required for their job under current market conditions (Handel, 2003; Shah and Burke, 2005; OECD, 2016). *Qualification mismatch*

describes a situation for which a worker has qualifications that exceed (over-qualification) or do not meet (underqualification) those generally required for the job. *Field-of-study mismatch* arises when workers are employed in a different field from what they have specialised in. While the information needed to calculate qualification and field-of-study mismatch is available in many surveys, including most labour force surveys, skill mismatch can only be calculated from specialised skill surveys, such as the OECD's Survey of Adult Skills (PIAAC) (see Box 1.1).

Box 1.1. Measuring qualification, skill and field-of-study mismatch

Skill mismatch arises when workers have a level of skills that is higher or lower than that required by their job. If their skill level is higher than that required by their job, workers are classified as over-skilled; if the opposite is true, they are classified as underskilled (Krahn and Lowe, 1998). Skill mismatch in the OECD Survey of Adult Skills is calculated by defining a range of skill levels that are appropriate for the job, based on the skill levels of individuals who self-report being well-matched. Individuals with skill levels outside this range are said to be skill-mismatched (see Pellizzari and Fichen, 2013).

Qualification mismatch arises when workers have an educational attainment that is higher or lower than that required by their job. If their education level is higher than that required by their job, workers are classified as over-qualified; if the opposite is true, they are classified as underqualified. Generally, the required qualification level is obtained by looking at the average or most common qualification level of individuals working in a specific occupation. In the OECD Survey of Adult Skills, workers are asked what would be the usual qualifications, if any, "that someone would need to get (their) type of job if applying today". The answer to this question is used as each worker's qualification requirement and compared to their actual qualification to identify mismatch. While biased by individual perceptions and period or cohort effects, self-reported qualification requirements along these lines have the advantage of being job-specific rather than assuming that all jobs with the same occupational code require the same level of qualification.

Field-of-study mismatch arises when workers are employed in a different field from what they have specialised in. The matching of occupations and fields of study generally follows a normative approach, in which occupations are linked to fields of study based on what educational specialisation is deemed to be appropriate for the jobs in that occupation (Wolbers, 2013; Montt, 2015). Workers who are not employed in an occupation that is considered a good match for their field are counted as mismatched.

Source: Krahn, H. and G. Lowe (1998), "Literacy Utilisation in Canadian Workplaces"; OECD (2014), *OECD Employment Outlook 2014*; Pellizzari, M. and A. Fichen (2013), "A New Measure of Skills Mismatch: Theory and Evidence from the Survey of Adult Skills (PIAAC)"; Wolbers, M. (2003), "Job Mismatches and their Labour Market Effects Among School-leavers in Europe"; Montt, G. (2015), "The Causes and Consequences of Field-of-study Mismatch: An Analysis Using PIAAC".

All three forms of mismatch can have negative consequences for workers. For instance, previous literature points to over-qualified workers suffering a wage penalty on average in comparison to well-matched counterparts with the same qualifications (Quintini, 2011a). Other studies show that field-of-study mismatched workers earn lower salaries on average when compared to their well-matched peers (Robst, 2008; Wolbers, 2003; McGuinness and Sloane, 2011), even after accounting for workers' heterogeneity (Nordin et al., 2010). Furthermore, field-of-study mismatch explains lower levels of satisfaction at work (Wolbers, 2003; Béduwé and Giret, 2011) as the content of the job does not match the worker's educational background and is correlated with lower wages (Kelly et al, 2010; Quintini, 2011b; OECD, 2014). Because of reduced job satisfaction, both over-qualified and field-of-study mismatched workers have strong incentives to search for a job that better matches their skills. Montt (2015), using the OECD survey of Adults Skills (PIAAC), shows that this is the case but only when field-of-study mismatched workers are also over-qualified.

Skill shortages occur when the skills sought by employers are not available in the pool of potential recruits, whereas *skill surpluses* occur when the supply of certain

skills is higher than the demand for them. The most common measures of skill shortages are derived from employer surveys which include questions on hiring intentions and recruitment difficulties. While employers are potentially well placed to assess their own skill needs, difficulties in filling vacancies may be related to the wage and working conditions being offered, and the effectiveness of the recruitment process rather than reflect a real lack of suitable candidates among job seekers. As no direct objective measure of skill demand exists, indirect measures must instead be used as signals of shortages in specific occupations (see Box 1.2), including: volume measures (employment growth, unemployment rate, vacancy rates), price measures (wage growth), work intensity measures (growth in hours worked, incidence of overtime), and quality measures (incidence of underqualification and training). Skill shortages can lead to skill mismatch, as employers unable to find the skills they need, may end up recruiting workers who are underskilled for a specific job (OECD, 2016).

Box 1.2. Measures of skill shortages and some of their limitations

Employer surveys: Employer surveys can provide a direct source of information on skill shortages. That being said, these surveys are usually subjective and their comparability low. As a result, employer survey results tend to be inconsistent with one another. They tend to provide a subjective assessment of shortages which may, in some cases, be equated with recruitment difficulties, irrespective of the reason for these difficulties. Instead of representing true skill shortages (e.g. lack of skills in the available workforce), hiring difficulties may reflect poor working conditions, inadequate remuneration or poor HR policies.

Wage pressure analysis: As markets should assign a higher price to scarce skills, wage growth by occupation is a commonly-used signal of skill shortages. While wages are a useful predictor of potential shortages, several issues make them a "fuzzy" indicator. As an example, when facing shortages, employers may increase working hours or intensity to meet skill needs, rather than raise wages. In certain sectors, particularly the public sector, wage changes may follow pre-assigned rules – rewarding seniority or following rules detailed in collective bargaining agreements – rather than reflecting hiring difficulties. Compositional effects may also cloud the interpretation of wage movement as, for example, retirements of more senior workers with higher pay may depress average wage growth in an occupation.

Employment pressure analysis: Employment growth within an occupation signifies increased demand and may be an indicator of rising skill shortages, when the supply of skills cannot keep up with this increased demand. Instead of increasing the number of workers, however, employers may raise the number of hours worked or try to increase workforce "quality" by investing in training. Also, differences in employment protection legislation (EPL) and hiring standards across countries may impact employment dynamics and, as such, weaken the shortage-signal that one can extract from it. In addition to employment growth, occupational unemployment rates can be used to extract signals on skills demand and supply.

Vacancy analysis: Prolonged unfilled vacancies or high job vacancy rates can signal that employers are facing difficulties in finding the required skills to fill a position at a given wage. Big-data can be used to extract information about vacancies posted online. The use of real-time job vacancy data to measure skill shortages is still limited by the different ICT penetration rates across countries and segments of the labour market such that jobs advertised on the internet may not be representative of the whole labour market. To date, public employment service vacancy data has been the most common source for vacancy data analysis, in spite of the potentially limited representativeness of the vacancies.

Source: Healy, J. et al. (2012), "Skill Shortages: Prevalence, Causes, Remedies and Consequences for Australian Businesses"; Veneri, C.M. (1999), "Can Occupational Labour Shortages Be Identified Suing Available Data?"; Richardson, S. (2009), "What Is a Skill Shortage?"; Shah, C. and G. Burke (2005), "Skill Shortages: Concepts, Measurement and Policy Response"; MAC (2008), "Skilled, Shortage, Sensible"; OECD (2015), "New Skills for the Digital Economy: Measuring the Demand and Supply of ICT Skills at Work"; Rothwell, J. (2014), "Still Searching: Job Vacancies and STEM Skills"; Brown, P. and M. Souto-Otero (2016), "Changing Conceptions of Merit: The Use of Labour Market Analytics in the Study of Educational Attainment and Social Mobility"; European Commission (2015), "Measuring Skill Mismatch".

Most countries carry out their own national skill anticipation and assessment (SAA) exercises to evaluate existing and future skill needs of their labour markets (OECD, 2016) as well as the extent of potential skill mismatch and shortages. The quality and comparability of these existing SAA exercises, however, varies considerably from one country to the other.

Exercises in most countries measure skill needs in terms of qualification level, type of qualification or field of study at the occupational level.[6] One advantage of this approach is that these variables are easily understood by a variety of stakeholders and are readily available from national labour force survey data. Other common quantitative sources of information include analyses of labour market information (e.g. flows in and out of employment by occupation and sector, trends in wages by occupation, trends in hours worked by occupation, etc.), vacancy surveys, employer surveys, surveys of recent graduates, and administrative data (e.g. data on enrolments in, and graduation from, various levels of education).

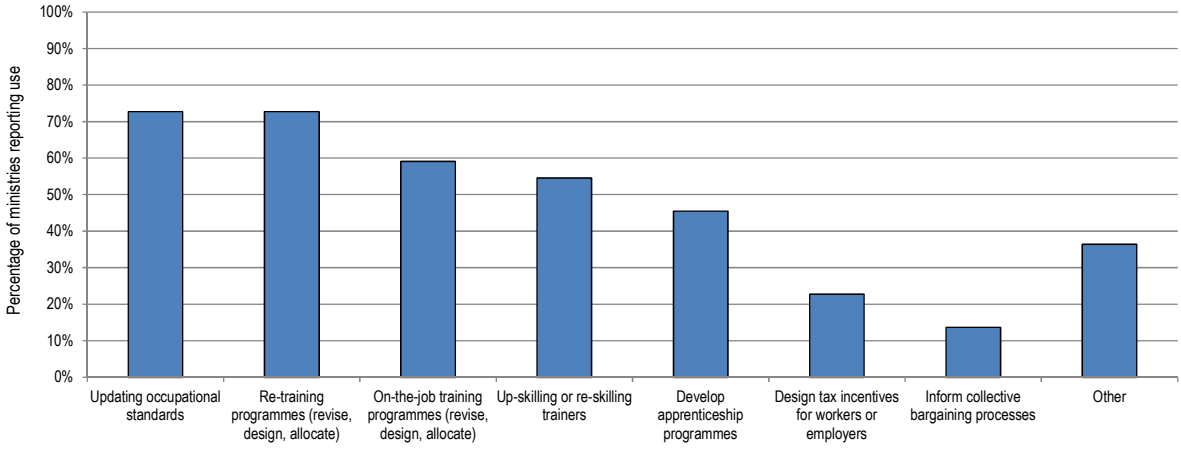
As highlighted in OECD (2016), each of these inputs serves a different analytical purpose and is designed to provide information on what skills are (or will be) needed in the labour market so as to inform a wide array of different policies. Figure 1.1 shows that SAA exercises are used for a range of employment policies, such as updating occupational standards and designing and revising re-training programmes, as well as for multiple education policies (e.g. design and update of qualifications and curricula, and provision of information about labour market prospects to students). In addition, the SAA information is used in several countries to inform migration policies. For example, the United Kingdom's Migration Advisory Committee uses labour market information to identify high-skilled occupations experiencing shortages to advise the government on immediate skill needs that might be addressed through immigration policy (MAC, 2008).

This information is extremely useful for policy makers and other stakeholders in each individual country and, if anything, it is often underused to inform employment, education and migration policies in view of achieving a better use of existing stills. On the other hand, country-specific assessments of skill shortages and mismatch are hardly comparable across countries limiting their use in several ways. For instance, in the context of increasingly globalised labour markets where firms compete for talent internationally and jobs and tasks (hence, skills) are spread through global supply chains over several countries, cross-country comparisons of skill shortages and surpluses are important. In addition, information on how skill shortages vary across countries and over time can be used to identify some key determinants and common policy challenges.

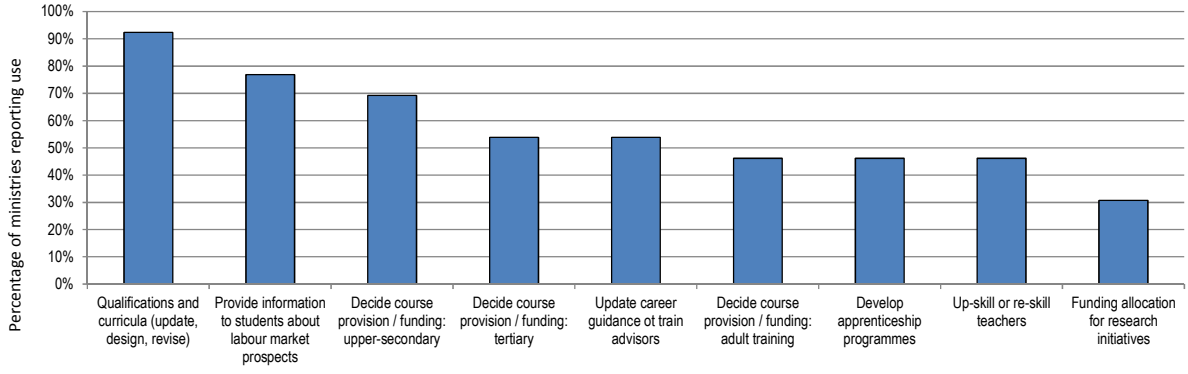
To quantify and compare the level of skill shortages across countries, employer surveys are often used both at the national and international level. Surveys of employers are a direct source of information on skill shortages and labour market pressures. This type of data has proven to be particularly useful in a range of country-specific analyses as well as in several cross-country studies that, however, have a specific time-dimension (usually of five years spans). Survey results, however, tend to be empirically inconsistent with one another (see Figure 1.2), leading to different rankings across countries depending on the survey (European Commission, 2015). For example, Greek employers report among the highest level of skill shortages in the Manpower Talent Shortage Survey, but among the lowest level of shortages in the Employer Business Indicators survey (European Commission, 2015).

Figure 1.1. The uses of skills assessment and anticipation exercises in employment and education policy

Panel A. Employment policies



Panel B. Education policies

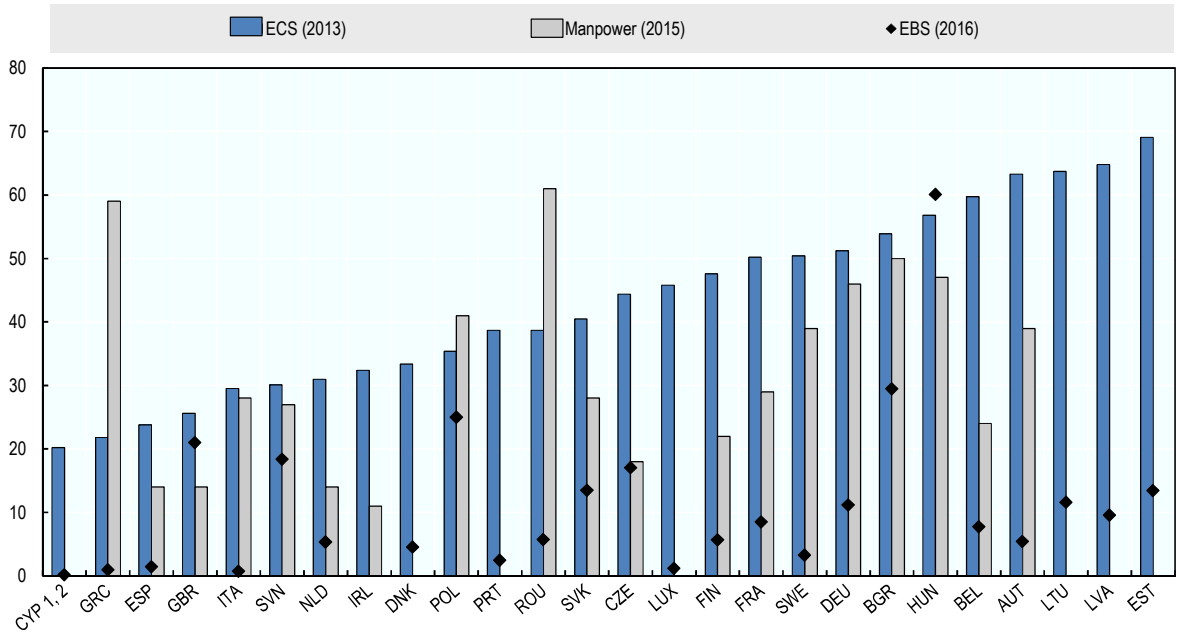


Note: Percentages based on information provided by 21 OECD countries for Panel A, 13 countries for Panel B.

Source: OECD (2016), *Getting Skills Right: Assessing and Anticipating Changing Skill Needs*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264252073-en.

Inconsistency of findings across surveys is partly due to the subjective nature of employer and employee self-reports. One downside of these sources of information is, as argued by the Migration Advisory Committee in the United Kingdom, that employers do not always have a consistent and accurate assessment of skill shortages and, as such, they may tend to provide very subjective estimates of where (and how extensive) shortages are in the labour market. All in all, the lack of an objective cross-country comparison makes it difficult to put the intensity of national skill shortages into international perspective. In addition to that, many cross-country surveys are run at a very aggregated level (usually at the country level) and are updated only irregularly limiting the possibilities to monitor changes over time and/or to identify specific skills or occupations in shortage.

Figure 1.2. Skill shortages reported by employers, various surveys



Note: Countries sorted by European Company Survey (ECS) indicator. The ECS indicator reflects the share of employers who answer affirmatively to the question "Do you encounter difficulties in finding employees with the required skills?". The Manpower Talent Shortage Survey indicator measures the share of employers responding affirmatively to the question "How much difficulty are you having filling jobs due to lack of available talent?". The European Business Indicator (EBS) considers the share of employers in the industry reporting that labour shortage is a major factor limiting production.

1. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

2. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: Adapted from "Measuring Skills Mismatch", *Analytical Web Note,* No. 7/2015.

A second limitation is that most existing skill needs data focus on occupations as proxies for skills. While this is useful, the use of occupational dynamics to approximate for skill needs does not usually provide the necessary granularity to truly understand the phenomenon. While occupations are commonly understood to be linked to certain skills and job-specific requirements, most SAA exercises do not develop a comprehensive and robust mapping between the two (see Box 1.3).

The *OECD Skills for Jobs* indicators are intended to fill these information gaps as well as the need for an objective, comparable cross-country set of indicators of skill needs, which can be updated regularly. Given the high economic cost of skill mismatch and skill shortage, for individuals as well as for the aggregate economy, policies that improve the matching of skill demand and skill supply can enhance welfare significantly. Therefore, these indicators also aim to provide key information to policy makers to design more reactive and timely policy interventions tailored to inform curriculum development, workforce training programmes, re-skilling and lifelong

learning programmes, and other education, employment and migration policies. Workers, job seekers, students and families will also be able exploit this new dataset to optimise their human capital and training investment decisions.

Box 1.3. Mapping occupations to skill requirements

Most countries use occupations as a proxy for skills when assessing skill needs. Others focus on the most common education credential of incumbents in a given occupation. In addition to being easily understood by a variety of stakeholders, measuring skill needs in terms of educational credentials like qualification types, qualification levels or fields of study has the added advantage of being more readily available in existing datasets. This facilitates the use of comparable data sources in skills assessment and forecast exercises. However, the disadvantage of relying on education credentials as a measure of skill needs is that they do not necessarily map to skills on the job and there is variability among individuals with the same credentials in terms of their skills and readiness to perform a job (Quintini, 2011a).

While the approach is not widespread, some countries do have comprehensive occupational standards or descriptions of what skills are required by each occupation. Some examples are Canada's National Occupational Classification, the United States' O*NET database, Italy's Occupations, Employment and Needs survey (*Professioni, Occupazione, Fabbisogni)*, France's Operational Repository of Occupations and Jobs (*Répertoire Opérationnel des Métiers et des Emplois*), and Germany's BIBB-IAB-Qualification and Occupational fields (OECD, 2016). These exercises are run at country level and have not been used jointly, if not in ad-hoc empirical studies. At the European level, the European Skills, Competences, Qualifications and Occupations framework (ESCO) links occupations to the knowledge, skills and competences that are essential or optional when working in a specific occupation but differently from other databases such as O*NET, ESCO does not provide categorical information on the importance of skills in each occupation.

Source: OECD (2016), *Getting Skills Right: Assessing and Anticipating Changing Skill Needs*; Quintini, G. (2011a), "Over-Qualified or Under-Skilled: A Review of Existing Literature".

Notes

1. Results seem to suggest the two to be positively associated.
2. A large and robust microeconomic empirical evidence (see Psacharopoulos, 1994; Psacharopoulos and Patrinos, 2004; Ichino and Winter-Ebmer, 1999; or Cohn and Addison, 1998) analysed the returns to average years of schooling across countries by regressing wages on education attainment as well as experience and other control variables.
3. Hanushek and Woessman (2009) and Hanushek and Kimko (2000) argue, for example, that the use of average years of schooling as a proxy for human capital may still hide the effect of the differences in the quality of education systems across countries by imposing the same return to an additional year of education in the United States and, for instance, in Peru. The authors provide robust evidence of the statistical significance of cognitive skills (proxied by international achievement test scores) on economic growth arguing that adjusting for the quality of education helps restoring the (missing) positive relation between human capital and economic growth
4. See O*NET or https://www.usajobs.gov/.
5. Furthermore, there is no widely-accepted standard classification for job-skill requirements across countries comparable to International Standard Classification of Occupations (ISCO) or the International Standard Classification of Education (ISCED) (Handel, 2012).
6. Measures of skill mismatch, for instance, usually compare the most common (i.e. the statistical mode) qualification level across all workers in a specific occupation and the qualification of each individual.

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Chapter 2

Skill needs and mismatch indicators: Methodology

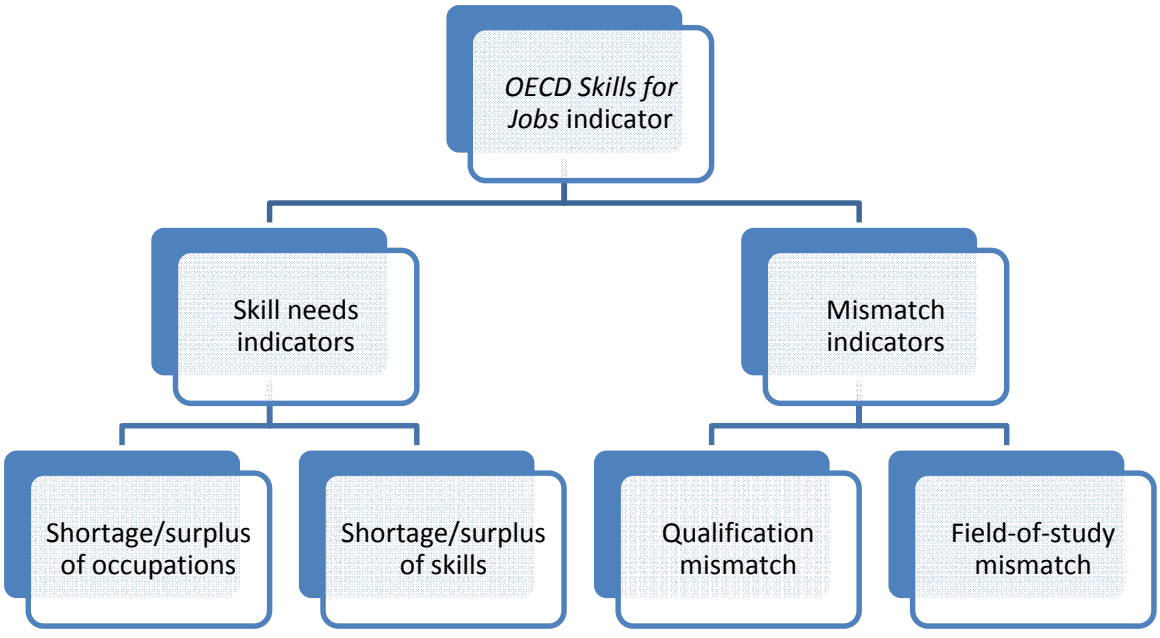
This chapter describes the methods used to develop the OECD Skills for Jobs *indicators. It presents the structure of the different indicators as well as the data used in the computations, the assumptions that give grounding to each index and sub-index as well as the stages involved in the creation of the complete dataset of skills imbalances across countries. The chapter also discusses the challenges that were encountered and the solutions presented in the various steps of the construction of the composite indicators of skills imbalances.*

Dataset structure

The *OECD Skills for Jobs Database* consists of two sets of indicators (Figure 2.1). The first set, the *skill needs* indicators, includes measures of occupations in shortage and surplus by country and year. Starting from those results, the skill needs indicators map the extent of shortage/surplus at the occupational level into skill needs across countries and over time. The second set, the *mismatch* indicators, includes measures of qualification and field-of-study mismatch across countries.

The different components of these indicators are complementary and provide a complete picture of the skills imbalances experienced in each country examined. Nevertheless, the two measures (shortages and mismatch) are distinct as skill mismatch can exist in the absence of shortages. Similarly, shortages can still emerge in a labour market with high degree of skill matching. The terminology used in the *OECD Skills for Jobs* indicators and throughout this chapter is described in Box 2.1.

Figure 2.1. The structure and components of the *OECD Skills for Jobs* indicators



Box 2.1. Terminology

Occupations

A worker participates in the labour market in a given employment setting engaging in a set of activities which are referred to as occupations, professions or jobs. There are different ways of classifying occupations into comparable categories. For example, the United States government uses the Standard Occupational Classification (SOC) System, while Canada uses the National Occupational Classification (NOC). An international classification, the International Standard Classification of Occupations (ISCO), has been developed by the International Labour Organization (ILO).

Skills

In most of the literature as well as in policy-relevant work, *knowledge*, *skills*, *abilities* and, to a lesser extent, even education are often used interchangeably. In this report, the term skills is used to indicate all types and facets of competences needed by workers to perform their jobs. Distinctions between different dimensions are made only where relevant. This is done partly for the sake of simplicity but also because of a general lack of agreement on what each of these terms refers to. Indeed, although there are some conceptual differences between them, all terms refer to the interactions between workers and their jobs and relate to the same problematic of shortages and surpluses in the labour market, with similar methods applied to estimate their imbalances.

Imbalances

- *Skill shortages* arise when employers are unable to recruit staff with the required skills in the accessible labour market and at the going rate of pay and working conditions due to a lack of an adequately skilled workforce. They can be broadly defined in terms of an inadequate supply of workers in high-demand occupations and/or an inadequate supply of skills required to perform the daily tasks associated to such occupations.
- *Skill surpluses* are characterised by a relatively high supply and low demand for a given skill. They can be identified by high unemployment.
- *Mismatch* either refers to the inadequacy of a worker's skills relative to the requirements of the job he/she is currently in (e.g. having a lower level of qualification than generally required for the job, or being trained in a field of study other than the one generally required for the job), or to the opposite phenomenon whereby a worker's skills exceed those required by the job (e.g. having a higher level of qualification than generally required for the job). Mismatch can be measured relative to qualification level, field of study or skills.

Situations of shortage, surplus or mismatch are generically referred to in this report as imbalances.

Skill needs indicators

Composition of the skill needs indicators

In order to draw a multidimensional picture of the surplus and shortage of workers in specific occupations (as well as of the underlying skills associated to those occupations), the *OECD skill needs* indicator is made up of five complementary sub-indices capturing different signals of mismatch (see Figure 2.2). As a result, the composite indicator provides a holistic interpretation of skill imbalances in the labour market than focusing on the impact of each sub-index independently.

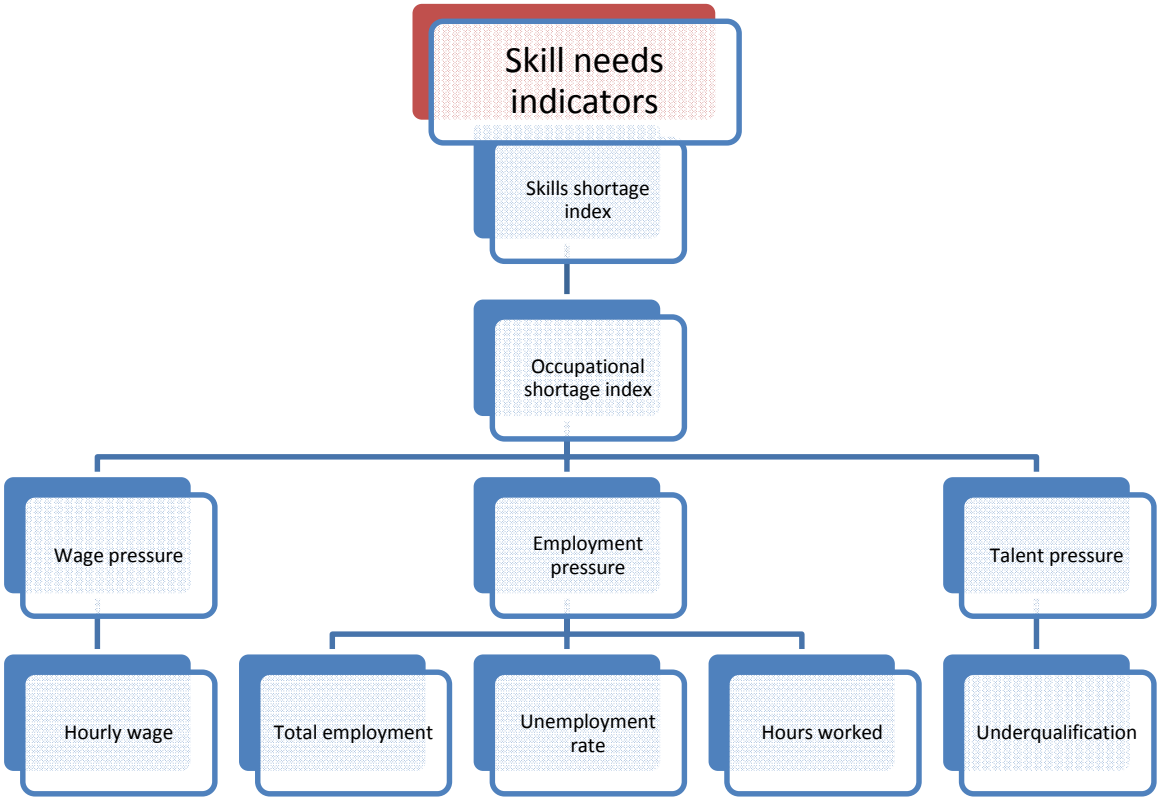
The skill needs indicator is constructed in two consecutive steps. In the first step, sub-indices for hourly wage growth, employment growth, the unemployment rate, hours worked and underqualification are used to provide a quantitative indication of

the extent of the labour market pressure on each one of the occupations analysed. The result of this analysis returns a ranking of occupations ordered from the one most in shortage to the one most in surplus in each country (i.e. the occupational shortage index, see Figure 2.2).

In a second step, the evidence from the occupational shortage index (i.e. the ranking of occupations in shortage/surplus) is used to map occupations that are in shortage/surplus into the underlying skill requirements associated with those occupations. To do so, the occupation-skills taxonomy developed by O*NET (see below) is used. The skill needs indicators, therefore, provide information on both occupational and skill shortages/surpluses in a comparable manner for European Countries as well as for South Africa. Information is provided at the 2-digit ISCO occupation level as well as disaggregated into several skills dimensions.

Previous literature highlighted that the use of a single indicator/dimension is not sufficient to capture the complexity of skills imbalances and shortages. Experts maintain that an accurate measurement of the existence and extent of skill shortages must rely on the results of several indicators that, if possible, are aggregated into a composite one. Composite indicators have several strengths. For instance, they allow summarising complex, multi-dimensional realities. They are also easier to interpret than a battery of many separate indicators and can help to assess progress of countries over time. They also smooth over random fluctuations in any one indicator. At the same time, composite indicators suffer from issues related to the choice of the weighting structure applied to the aggregate sub-indexes as well as to the decision taken on the inclusion/exclusion of specific components and variables. As for the challenges related to the inclusion/exclusion of variables in the analysis, it is important to recall that the objective of the *OECD Skills for Jobs Database* is that of providing comparable and objective information on skills imbalances across all EU countries and South Africa with a view to supporting decision makers. Such information, moreover, has to be updatable on a regular basis and the results are meant to be provided at the most disaggregated occupational level possible. Achieving these goals simultaneously substantially restricts the number of suitable data sources and variables that can be used.

Figure 2.2. The structure of the skill needs indicators



Main data sources used throughout the analysis

The European Union Labour Force survey (EU-LFS)

Raw data from EU-LFS is used to calculate employment and unemployment rates, number of hours worked and mismatch. The EU-LFS is conducted in member states and partner countries of the European Union. It collects data from a household survey conducted for persons aged 15 years and over. For the skill needs indicators, annual data between 2003 and 2015 is exploited, corresponding to the years for which other series from different data sources are available.

The European Union Statistics on Income and Living Conditions (EU-SILC)

The data for wages is extracted from the EU-SILC survey for all years of the survey, subject to country availability.[1] The EU-SILC survey collects timely and comparable cross-sectional and longitudinal multidimensional micro data on income, poverty, social exclusion and living conditions. The first annual data collection took place in 2003 in some EU member countries and rapidly expanded to others.

South African data sources

The data for all of the indicators for South Africa comes from the South African Labour Force Survey (SA-LFS). This is a national household-based sample survey conducted by Statistics South Africa (Stats SA). It collects data on the labour market activities of individuals living in the country. As the data is not collected in the exact same way as for European countries, some methodological adaptations to the calculation of the indicators were needed. Those discrepancies and the means to overcome them are described throughout the chapter. Because of a methodological change, consistent SA-LFS data is only available from 2008 onwards.

*The Occupation Information Network (O*NET)*

O*NET describes *knowledge*, *skills* and *abilities* required from workers participating in each occupation in the labour market.[2] It is used to map occupational surpluses/shortages into skills. The database is sponsored by the US Department of Labour/Employment and Training Administration (USDOL/ETA). The O*NET database was initially populated by data collected from occupation analysts. The dataset is continuously updated by ongoing surveys of workers in each occupation and occupation experts.

Variables used to extract signals on shortages and surpluses

Hourly wage growth

The analysis of wage dynamics, usually referred to as "wage pressure" analysis, is one of the most powerful tools available to measure the tightening of the labour market in specific occupations and, as such, to detect skills imbalances. *Ceteris paribus*, wages can be interpreted as the *price* measure attached to the scarcity of workers and to the skills they possess, which vary according to supply and demand pressures. With this logic in mind, *wage growth* functions as a signal for employers to attract candidates with a certain set of skills when those skills are not easily found in the labour market, that is, when they are in shortage.[3] Accordingly, occupation-specific wage growth points in the direction of shortage of skills used in that occupation, while stable wages in an occupation seldom signal a growing demand for workers in that occupation relative to the supply. Cross-country comparable and updatable information on hourly wage growth is extracted from EU-SILC and the SA-LFS.[4]

Several issues, however, can affect the extent to which wage pressure analysis can be provide a reliable signal of occupational and skill shortages. On the one hand, wage growth may accelerate independently from the emergence/absence of skill shortages. Wages and their evolution over time may be linked to other contemporaneous macroeconomic dynamics/trends and these latter may bear no relationship with skill shortages. Wages, for instance, may grow as a result of economic recovery after a recession period without such recovery implying the emergence of simultaneous skill shortages. As an example, while wage growth may be driven by positive expectations on production, trade, inflation and/or other macro-economic fundamentals, the supply of skills (that may have remained unutilised during the recession period) may be sufficient to fill the demands of employers during the expansionary period. As a result, unless wage drivers that are unrelated to skills are discounted for in the analysis, positive wage dynamics can end up being disconnected from the difficulties

experienced by firms in finding adequate skills in the labour market and become a "noisy" indicator of labour market and skill pressures.

In addition, wage growth may be modest despite the existence of skill shortages if employers are slow to adjust to imbalances. Richardson (2009) and Veneri (1999) note that, even if wages do move in response to shortages and surpluses of particular skills, these movements can be limited and many other forms of "non-wage adjustments" may occur instead. Veneri (1999) argues, for instance, that employers often have a wide range of possibilities to address skill shortages and that they will generally try the least expensive response first. As an example, employers facing skill shortage may tend to increase the number of overtime hours or the intensity of work imposed on their current workforce before increasing wages. Furthermore, the existence of minimum wages can put some limits as to how much wages can decrease in certain occupations, and minimum wage adjustments can lead to wage growth that is unrelated to skills imbalances. Similarly, collective bargaining arrangements in some countries may limit the short-term flexibility of employers to adjust wages to changes in skill demands.

Total employment growth

"Employment pressure" analysis infers the existence/emergence of labour market pressure from the evolution of employment levels over time. If wages can be understood as the *price* attached to workers' skills, employment levels are the *volumes* or quantities.[5] The idea behind employment pressure analysis is that an increase in the quantity of employed workers in the economy can be interpreted as an indication that demand is rising for a particular occupation which could generate shortages in the relevant skills.

Employment growth, however, is yet another "noisy" indicator of shortages. Increasing employment levels in the economy (or in one specific occupation) do not immediately imply the existence or emergence of skill shortages (e.g. difficulties to fill vacancies due to lack of skills) as long as the demand for labour (and for the associated skills) is satisfied by the current supply. In other words, while employment may grow as a result of an increased demand for workers, this does not immediately imply shortages (though, it does not exclude them).

Similarly, slower recruitment in one occupation can signal either a reduction in economic activity – and therefore a potential surplus of skills – or a situation where employers are not able to find candidates with the adequate skills to fill the vacancies, eventually signalling the existence of difficulties in finding well-matched candidates.

All in all, when considered on its own, employment pressure analysis cannot unambiguously indicate the existence/absence of skill shortages but it can help detect the pre-condition under which skill shortages are *likely* to occur. In addition, the sign of employment growth (being this positive or negative) cannot be used to predict the sign of shortages/surpluses given that positive/negative employment growth in one occupation is compatible with either skill-balance (when supply is just sufficient to satisfy the increasing demand), shortage (when supply in inferior to employer demands) or even surplus (when supply is larger than demand).

In order to infer more clearly whether employment growth is signalling a tightening of the labour market or if, instead, the supply of labour and skills is sufficient to fill the demand one can analyse the co-movement of wages and employment and interpret them as the price and quantity of skills respectively in a

simple demand-supply context (see Table 2.1). As long as the *quantity* of skills demanded grows (positive employment growth) but its price (wage) falls, this can be interpreted as a signal of *surplus* of skills. In that context, firms are able to fill their vacancies in a relatively easy manner and, though production may have increased leading to faster hiring, the supply of workers with adequate skills is still sufficient to fill such demand as employers do not have incentives to raise wages to attract talent. On the contrary, a situation in which wages increase but hiring remains stable or even decreases can be interpreted as a signal of shortages as employers may be forced to raise wages due to their difficulty to fill vacancies with adequate skills, and these difficulties are also reflected in slower recruitment from the pool of available candidates. In all other cases, when wages and employment have the same positive (negative) sign, the interpretation of shortages (surpluses) is straightforward.

Table 2.1. Interpreting wage and employment growth

Wage growth	Employment growth	Labour market pressure
-	+	Surplus
+	-	Shortage
+	+	Shortage
-	-	Surplus

Growth in hours worked

As pointed out by Richardson (2009), statistics about the number of employed individuals are only an imperfect proxy for the volume of services supplied as workers in different jobs often also work different hours. In several occasions, when facing shortages, employers may respond by incentivising over-time or by increasing the hours worked of the available workforce, rather than hiring new workers and attracting them with wage incentives. For this reason, relying exclusively on the growth of employed workers in certain occupations may lead to over- or underestimating the demand for skills, ultimately, biasing the signals about the existence of shortages. A solution to this challenge is to extend the skill shortage indicator to take into account the dynamics in hours worked. An increase in the total number of hours worked by individuals employed in a certain occupation is interpreted as a signal of stronger demand for that occupation and for the associated skills.

Unemployment rate

Information about skill shortages or surpluses can be extracted from the analysis of unemployment rates at the occupation level. These unemployment rates are based on the previous occupation of unemployed individuals. This indicator provides information on the relative difficulty for specific workers in re-entering the labour market, providing a proxy of the relative demand for the skills associated with that occupation. As such, low unemployment rates signal shortages.[6]

Underqualification growth

The evolution of the share of underqualified workers can be used to capture the emergence of skill shortages. Pronounced increases in the share of workers with qualifications that are lower than those required by their jobs can be interpreted as a situation where employers are unable to find well-matched candidates and, as a result,

revert to hiring underqualified workers. To put it differently, a sustained increase in underqualification in specific occupations can be signalling the existence of a relatively small pool of candidates with the *adequate* skills.[7]

Using underqualification at the occupation level to measure the existence of skill shortages has some shortcomings. The most important is that, by nature, certain occupations are more or less likely to experience qualification mismatch. Occupations requiring a very specialised set of skills (e.g. surgeons) and formal credentials are, for instance, less likely to employ underqualified workers. Other occupations that rely, instead, on a broader yet less specialised set of skills (e.g. business professional) may be more prone to experience high levels of underqualification as their workers may be more easily substituted and a lack of qualifications compensated by experience. Using the growth of underqualification rather than its level reduces this potential bias.

Cross-country data comparability challenges

Occupational classifications

Information at the occupation level is available in several European data sources and it is usually coded using the International Standard Classification of Occupations (ISCO) designed by the International Labour Organization (ILO). The ISCO classification allows for the disaggregation of the occupational information from a more generic one-digit level to a more granular four-digit level. A trade-off exists between granularity of the information (e.g. its level of disaggregation) and the robustness of the information given the underlying sample size of the survey used to collect the information.

In order to maintain a sufficiently large sample size and an adequate level of detail, the *OECD skill needs* indicators were constructed using occupations at a two-digit disaggregation level. This is also the highest level of disaggregation available in the EU-SILC dataset. In order to preserve the robustness of the information, the occupations with relatively smaller sample sizes were merged with larger ones within the same broad one-digit level.[8] The full list of occupations used in the *OECD skill needs* indicators is presented in Table 2.2.

Table 2.2. List of occupations

ISCO-08 classification

Code	Occupation name
10	Managers
21	Science and engineering professionals
22	Health professionals
23	Teaching professionals
24	Business and administration professionals
25	Information and communications technology professionals
26	Legal, social and cultural professionals
31	Science and engineering associate professionals
32	Health associate professionals
33	Business and administration associate professionals
34	Legal, social, cultural and related associate professionals
35	Information and communications technicians
41	General and keyboard clerks
42	Customer services clerks
43	Numerical and material recording clerks
44	Other clerical support workers
51	Personal service workers
52	Sales workers
53	Personal care workers
54	Protective services workers
60	Skilled agricultural, forestry and fishery workers
71	Building and related trades workers, excluding electricians
72	Metal, machinery and related trades workers
73	Handicraft and printing workers
74	Electrical and electronic trades workers
75	Food processing, wood working, garment and other craft and related trades workers
81	Stationary plant and machine operators
82	Assemblers
83	Drivers and mobile plant operators
91	Cleaners and helpers
92-93	Agricultural, forestry, fishery, mining, construction, manufacturing and transport labourers
94	Food preparation assistants
95-96	Street and related sales and service workers; refuse workers and other elementary workers

Recent European surveys code occupations using ISCO-08, the most up to date framework within the ISCO classification. In contrast, data prior to 2011 in the EU-LFS and EU-SILC are coded in ISCO-88, an older version of the current ISCO-08 classification. The reclassification of occupations in the ISCO framework leads to a substantial break in the time series, leading to comparability issues across years. To ensure comparability over time, the ISCO-88 occupations are reclassified into the ISCO-08 codes. The main challenge for this reclassification is that not all occupations in ISCO-88 find a one-to-one equivalent in ISCO-08, and the information of some occupations in ISCO-88 is spread over multiple occupations in ISCO-08. Details on the methodology used for correcting the ISCO break are provided in Box 2.2.

Box 2.2. Adjusting for the ISCO classification break

Occupations in the ISCO-88 classification whose information falls entirely in one occupation of ISCO-08 are easily converted into the most recent framework. However, for occupations in ISCO-88 that do not have a single match in ISCO-08 the reclassification is more difficult. The strategy for mapping information from ISCO-88 to ISCO-08 uses the double-coded occupational information from EU-SILC for the year 2011. This information allows identifying how employment from one ISCO-88 occupation is split over multiple ISCO-08 occupations.[1] These employment shares are, therefore, used as weights to transform ISCO-88 information prior to 2011 into the ISCO-08 classification. The same set of weights is used to reclassify the ISCO-88 data in EU-LFS and EU-SILC.

While the double-coded data from EU-SILC provides information that is useful to minimise the effect of the ISCO-reclassification, this may not be sufficient to fully correct for the observed break. The relatively small sample size of EU-SILC data can lead to the calculation of imperfect employment shares for the double-coded data. As a result, a second step was necessary to correct for the remaining break in the times series. In order to fix the remaining implausible breaks in the data, the growth of each sub-index for each occupation between 2010 and 2011 was substituted by the growth of the overall economy in that sub-index. This counter-factual exercise provides an estimation of the 2010 values by deducting from the 2011 values the economy-wide growth rate in the year. The levels of sub-indices in years prior to 2010 were then estimated discounting the actual growth rate reported for that year from the level calculated for the following year. Using this correction, the growth rate of all years bar 2011 is the actual reported one, while the level of sub-indices in 2010 are estimated discounting the average growth rate of the economy in that year, and the levels of sub-indices prior to 2010 are estimated discounting the reported growth from the value of the subsequent year.[2]

1. The occupational breakdown for years prior to 2011 is estimated using country-level employment level as weights except for countries for which EU-LFS 2011 is not double-coded. In those cases, the ISCO breakdown is estimated using the average for the European Union countries for which double-coding is available.

2. The same approach was used to correct a country-specific ISCO classification break in France between 2012 and 2013.

Data for South Africa are collected in a nationally designed four-digit occupational coding that is very similar – though not identical – to ISCO-88. To make the data comparable to the European data, the occupational information was recoded into ISCO-08, based on the official crosswalk between ISCO-88 and ISCO-08.[9] As the national coding is used across all years, there was no ISCO break in the dataset.

As mentioned above, information at the occupational level is used to map the extent of occupational shortages into skill needs. The occupations described by O*NET follow the Standard Occupational Classification (SOC), which is different from the ISCO classification that is used for the occupational shortage indicator. Details on how the O*NET data were reclassified into ISCO and aggregated to the 2-digit level are provided in Annex A.

Education level classification

Educational systems vary substantially between countries. International data on education should therefore be based on a classification which allocates education programmes to levels which can be considered as comparable.[10] The European Labour Force Survey follows the International Standard Classification of Education (ISCED) to classify education programmes and related qualifications by levels and fields.[11]

The ISCED classification provides many layers of disaggregation of educational attainment. For the purpose of the analysis, these were combined into five categories of highest level of education attainted: primary education or less, lower secondary

education, upper-secondary education, post-secondary non-tertiary education and tertiary education.

The ISCED classification was redesigned in 2011, and European surveys have been using the new classification since 2014. As a result, the coding of education levels in years prior to 2014 differs slightly from the one in later years. The most substantial changes following the ISCED reclassification are the creation of new educational categories within early childhood education (ISCED level 0) and the rearrangement of educational levels in tertiary education (spreading from ISCED levels 5 to 8). These two changes do not affect the way education levels are treated in the *OECD skill needs* indicator given that primary and pre-primary education are combined into one broad category and the five abridged educational levels used in the indicator do not differentiate between levels of tertiary education. Although the ISCED reclassification *per se* should not, at least in principle, create any unexpected break in the information, the new guidelines for collecting information on qualifications substantially increased data precision. As a result, these new guidelines led some countries to rearrange and recode their programmes and this is reflected in certain breaks in the data.[12]

The South African LFS does not use the ISCED classification for educational variables, but because numerous detailed educational categories are provided, their grouping into the larger categories discussed above is relatively straightforward with no loss in comparability with the ISCED classification used for European countries.[13]

Construction of the skill needs indicators

As mentioned above, the skill needs indicator is computed in two different stages. The first step carries out the wage (hourly wages), employment (employment, unemployment and hours worked) and talent (underqualification) pressure analyses separately, and combines the sub-indices in a final occupational shortage index. The value of this index signals the extent of shortage or surplus in the occupation. In a second step, this information is used to weight skill requirements associated to each occupation through the use of the O*NET data. The intensity of the occupational shortage is, therefore, used to provide information about the extent of skill needs in each national labour market.

Step 1: Occupational shortage index

Accounting for macro-economic trends

One major challenge when trying to measure the existence and extent of skill shortages through the analysis of wage, employment and talent pressures is that the variables used in the analysis are noisy and indirect indicators of labour market pressure. Generally speaking, the variables used to measure occupational shortages (see above) react not only to changes in the demand for skills but also to several other fundamental economic drivers that are related to the expansion or contraction of economic activity in periods of boom or recession which may bear only a weak relationship with skill imbalances.

Wage growth, for instance, may accelerate independently from the emergence of unmet skill demands (i.e. shortages) but simply as economic recovery unfolds from a period of recession through brighter expectations, inflation hikes, international trade recovery, increases in confidence and aggregate demand etc. The interconnectedness of economies and labour markets also plays a role in shaping economic performance as

both domestic and international demand may stimulate or depress growth nationally. Similarly, financial crises may depress economic growth, with no real impact on the supply of skills or on perceived shortages. The same is true for employment levels which may recover in the aftermath of an economic crisis as a consequence of restored long-run economic fundamentals without the emergence of shortages.

Therefore, the challenge is that of trying to extract from raw-variables the part of the signal that is related to skill shortages (unmet skill demands) and distinguish that information from the one that is related, instead, to the economic fundamentals that govern the long-run trend (expansion or recession) of the economy. At the same time, and closely related to the above-mentioned issue, in order to be able to meaningfully speak about shortages as a "*difficulty*" to fill vacancies due to the lack of skills, such difficulty has to be benchmarked to a situation where, instead, hiring is not difficult (e.g. to a situation for which skill demand and supply are in balance).

One way of approaching this challenge is to directly compute the long-run economy-wide trends[14] for the variables of interest and analyse how these differ from the trends at the occupation level. The empirical strategy followed in the *OECD skill needs* indicator is one of measuring how the "*trend behaviour*" of each occupation (e.g. the long-run trend in wages in a specific occupation) differs from the long-run trend of the whole economy. Whenever the trend at the occupational level is detected to evolve at a speed that is different from the one at which the whole economy is evolving, this situation is interpreted as a signal of shortage or of surplus depending on whether the trend at the occupation level is growing faster or slower than the evolution of the whole economy.

Such an approach allows decoupling the part of the sub-index that is related to the economy-wide trend from the one that is more likely related to each occupation's labour market pressure. At the same time, it also allows benchmarking the information at the occupational level to a time-varying economy-wide point of reference.

From an operational point of view, the trend behaviour of the variables of interest can be extracted from their time series features by applying a Hodrick-Prescott (HP) filter (Box 2.3) to each variable both at the occupation and at the economy-wide level. The HP filter is, therefore, used to separate each time series' short-term and cyclical component from its long-run trend. The long-run trend of each variable at the 2-digit occupation level is then compared to the long-run trend of the whole economy to detect whether the long-run behaviour of a variable in a specific occupation differs significantly from that of the economy. This procedure, as mentioned above, provides a time-varying benchmark for the behaviour of variables at the occupational level. The difference in growth rates returns information on the existence and the extent of pressure (shortage) for each occupation/variable in each labour market considered. This exercise is repeated for each sub-index and for each country examined in the *OECD skill needs* indicator respectively. The results of the separate sub-indices are then aggregated into a composite measure of occupational shortage. The aggregation strategy is described below.

Box 2.3. The Hodrick-Prescott filter to extract trends

The Hodrick-Prescott filter is a mathematical tool that is commonly used in macroeconomics to separates a time series Y(t) into its trend component T(t) and its cyclical component C(t). The objective function for the filter has the form

$$\sum_{t=1}^{m} C_t^2 + \lambda \sum_{t=2}^{m-1} ((T_{t+1} - T_t) - (T_t - T_{t-1}))^2$$

where m is the number of samples and λ is the smoothing parameter. The programming problem is to minimise the objective over all T(1), ..., T(m). The first sum minimises the difference between the time series and its trend component (which is its cyclical component). The second sum minimises the second-order difference of the trend component (which is analogous to minimisation of the second derivative of the trend component).

The HP filter requires an uninterrupted time series to smooth the data. As a result, in situations where one of the sub-components was not available for a certain year in the *OECD skill needs* indicator, but available for the previous and the next year, the sub-component was estimated through a simple average of the other years. In cases of a gap of more than two years, the missing values were filled with an interpolation. In the calculation of the indicator, as it refers to annual data, the smoothing parameter used for the HP filter was of 6.25.

Source: Hodrick, R.J. and C.E. Prescott (1997), "Postwar U.S. Business Cycles: An Empirical Investigation", *Journal of Money, Credit, and Banking*, Vol. 29/1, pp. 1–16.

Standardising and aggregating the *OECD skill needs* sub-indicators

The aggregation of various sub-indicators into a composite one requires sub-indicators to be first measured on the same scale and standardised. [15] That is to say that, whenever sub-indicators are proxies for different concepts (e.g. employment, underqualification or wages) these need to be brought back to a "common denominator" before they are aggregated into higher-level components.

As mentioned above, information about the existence and extent of shortages is extracted from the comparison of the evolution of variables' trends at the occupational level with that of the same variable at the economy-level. In order for the different variables to be aggregated into the same composite indicator these are standardised by dividing each indicator by its weighted standard deviation in each considered year. Once obtained, the standardised values computed for each sub-index and year are aggregated into the composite occupational shortage index using the following weighting scheme:

$$OS_{c,i,t} = w(\Delta W_{c,i,t} - \Delta\overline{W}_{c,t}) + 0.5w(\Delta E_{c,i,t} - \Delta\overline{E}_{c,t}) + w(\Delta H_{c,i,t} - \Delta\overline{H}_{c,t}) + w(U_{c,i,t} - \overline{U}_{c,t}) + w(\Delta UQ_{c,i,t} - \Delta\overline{UQ}_{c,t}) \quad (1)$$

where OS refers to the occupational shortage index and $\Delta W_{c,i,t}, \Delta E_{c,i,t}, \Delta H_{c,i,t}, \Delta UQ_{c,i,t}$ refer to the yearly change in the estimated long-run trends of wages, employment, hours worked and underqualification in country c and 2-digit occupation i and year t respectively, and $U_{c,i,t}$ to the inverse of the unemployment rate. As for the interpretation of each sub-indicator in the composite index, positive values point to shortages while negative ones indicate surplus.[16]

Each element is weighted, with the sum of weights equalling one.[17] As argued by Sharpe (2004), the weighting process of a composite indicator is of "arbitrary nature" and it represents a challenge for the analyst. The *OS* composite indicator is calculated as a weighted average of the five sub-indexes.[18] Details on the chosen weighting structure are provided in Box 2.4.

As the *OS* indicator is calculated as the sum of normal distributions, its values varies around zero for a given country and a given year. The extent of shortages and surpluses is therefore expressed in relative terms to the overall economy considered along its long-run balanced path.

Box 2.4. Skills imbalances through skill prices and quantities

The occupational shortage (OS) index assigns a lower weight to the employment sub-indicator when aggregating all its components into the composite index. The reason for that choice lies in the ambiguous information that can be extracted from "employment pressure" analysis relative to that extracted from all the other variables used in the composite index. As argued above in the text, while wages are expected to increase as a response to skill shortages as employers use pecuniary incentives to attract talent that is scarce in the labour market, the sign associated to the evolution of employment levels provides only ambiguous information on the existence of shortages. When shortages arise, for instance, as a consequence of economic growth, employment levels may increase (signaling a stronger demand for the underlying skills). However, if the shock to the economy is one that leads to requiring skills of a specific type that cannot be easily found in the labour market, employers may not be able to find them or to substitute them with similar ones. When shortages are strong, therefore, they can represent a considerable bottleneck to employment growth and the speed by which recruitment evolves may slow down or decrease in deep shortages. All in all, the sign of employment growth, when considered alone, is unable to clearly predict the sign of shortages. As such, the weight assigned to the employment sub-indicator is lower than for the rest of indicators used.[1]

1. Annex A provides further information on the interaction between supply and demand for occupation and skills in the labour market. It also clarifies how this model plays out in defining the weights of the indicators, particularly the weaker weight of employment.

Step 2: Skill shortages index

Interaction with O*NET

Unlike other international indicators of skill shortages, most of which are based on the subjective self-reported information coming from employers' surveys (see Chapter 1), the *OECD skill needs* indicators provide a novel strategy to quantitatively estimate *skill* shortages and surpluses. The information contained in the indicators is provided so as to ensure comparability across countries of regularly updated results.

Another major strength of these indicators lies in the detailed mapping that is made from results of occupations in shortage to measures of skills required in each occupation considered. This mapping is carried out by attaching to occupational results the information provided by O*NET on both the level and importance of different skill dimensions for each one of the occupations analysed.

O*NET covers both cognitive and non-cognitive skill requirements, as well as tasks, work context and work activities (see Box 2.5 for a summary of some of the dimensions presented in O*NET). The database is updated annually for new and emerging occupations. O*NET is widely considered to be the most detailed and comprehensive assessment of skills used in employment that exists (Beblavy et al.,

2016; Dickerson et al., 2012). Two European surveys have closely followed the O*NET approach to develop similar tools nationally – the Italian survey on Occupations, Employment and Needs (*Professioni, Occupazione, Fabbisogni)* and the Czech survey *Kvalifikace2008* (Castiglioni and Tijdens, 2014; Lepic and Koucky, 2013). The United Kingdom has also begun exploring the feasibility of systematically mapping between the occupational classification used in O*NET and the UK SOC in order to develop a UK database of occupational skill profiles (Dickerson et al., 2012). In addition, the international Survey of Adult Skills (PIAAC) provides task-based information on skill requirements in 34 countries. However, PIAAC data on skill requirements are not as detailed as those provided in O*NET and, for this reason, are not exploited in the *Skills for Jobs Database*.

O*NET is developed by the Bureau of Labor Statistics in the United States and, as such, is geared towards the occupational content of jobs in the labour market in the United States. Despite this, O*NET has been regularly used for the analysis of countries other than the United States (e.g. Aedo and Walker, 2012; Aedo et al., 2013; Arias et al., 2014; Cully, 2003; Goos and Manning, 2007), and other analyses have used the *Dictionary of Occupational Titles* (DOT), which is the predecessor of O*NET (Goos et al., 2014). The assumption that skill measures from one country can be generalised to other countries has been tested and largely holds (Cedefop, 2013; Koucky et al., 2012; Lepic and Koucky, 2013). The cross-country validity of O*NET scores has also been formally tested by Handel (2012), who found that occupational titles refer to very similar activities and skill demands across different countries. Specifically, Handel (2012) found high correlations between O*NET scores and parallel measures from the European Social Survey (ESS), EU-LFS, Canadian skill scores, the International Social Survey Program (ISSP), and the UK Skill Survey (UKSS), with average correlations of 0.80. Other than a handful of occupational skill requirements that exhibited significant cross-national variation (i.e. prior experience required, training required, and job learning times), Handel found that most skill scores can be generalised to other countries with a reasonable degree of confidence.

A caveat should, however, be raised about the use of O*NET to describe skills and tasks of occupations in low-income countries. While several studies have applied O*NET to the assessment of occupations in low-income countries (Aedo and Walker, 2012; Aedo et al., 2013; Arias et al., 2014), the authors stress that the skill content of certain occupations might differ between low- and high-income countries like the United States, as these two types of countries differ significantly in terms of technology and regulatory context. Another challenge with using O*NET is that the estimated skill requirements of occupations may be biased upwards. Handel (2016) raises the possibility that, due to their potentially higher response rates, the sample may include an over-representation of highly-educated individuals. This hypothesis is not testable since socio-economic information about respondents is not made publicly available by O*NET.

Despite possible challenges involved in using the O*NET database, this remains the most comprehensive assessment of skills in employment that exists and it is, undoubtedly, a crucial source of information for mapping occupations to skill needs.

Box 2.5. O*NET dimensions

The O*NET database contains detailed information for occupations on a range of dimensions related to worker characteristics, worker requirements, experience requirements, occupational requirements, workforce characteristics and occupation-specific information. The following dimensions are used in the *OECD Skills for Jobs Database*:

- *Abilities* (52 categories): Enduring attributes of the individual that influence performance (e.g. originality, depth perception, finger dexterity).
- *Knowledge types* (33 categories): Organised sets of principles and facts applying in general domains (e.g. business and management, engineering and technology, mathematics and science).
- *Skills* (35 categories): Developed capacities that facilitate learning or performance, including basic skills (e.g. active listening, writing, critical thinking) and cross-functional skills (e.g. negotiation, programming, time management).
- *Work styles* (15 categories): Personal characteristics that can affect how well someone performs a job (e.g. persistence, leadership, attention to detail).

While occupational analysts provide information on *skills* and *abilities*, information on *knowledge* and *work styles* is obtained from job incumbents.

Each knowledge, skill and ability dimension in O*NET is codified by assigning categorical values to their "importance" for the job and "level" by which the dimension is used, while work styles and contexts are classified solely based on "importance". Respondents indicate the importance of a given skill for their job (on a scale from 1, not important, to 5, extremely important) and the level of the skill needed for their job (on a scale from 0 to 7). Although some analysist found both measures to be very strongly correlated (Peterson et al., 1999; Handel, 2016), there could potentially be substantial difference in the level of similarly important skills. The O*NET website exemplifies the skill "speaking", which is important for both lawyers and paralegals. However, lawyers (who frequently argue cases before judges and juries) are required to have a higher "level" of speaking skills, while paralegals only need an average "level" of this skill.

Source: https://www.onetcenter.org; Handel, M.J. (2016), "The O*NET Content Model: Strengths and Limitations"; Peterson et al. (1999), "An Occupational Information System for the 21st Century: The Development of O*NET".

O*NET codes occupations along two dimensions – importance and level – depending on the characteristics concerned (see Box 2.5). The approach followed to summarise the skill requirements at the occupational level is inspired by previous literature such as Feser (2003) and Gabe and Abel (2011a, 2011b) that highlighted how "*…taking the product of the two dimensions has the effect of weighting more heavily knowledge that is both of a high level as well as central to the occupation concerned*". The product of the two dimensions, therefore, provides a synthetic measure of both importance and level of each skill dimension for the observed occupation, and represents the skill-specific requirements of each occupation. These values are then normalised through Min-Max scaling to assume values in between 0 and 1, and are referred to as the skill intensities of the occupations.

Weighting of skill requirements

The final skill shortage indicator multiplies these different skill dimensions for each occupation by the extent of the shortage in the occupation computed in Step 1. In order to aggregate the information at the country level, and to keep consistency with the different sizes of different occupations, the country average is calculated using employment shares as weights for the occupational values.

As a result, strong shortages in certain occupations (say in science and engineering professionals) that use certain skills more intensively (say engineering skills) will point

to a shortage in those skills when aggregating the information at the country level in the final skill shortage indicator. *Vice versa*, occupations that are detected to be in surplus and that use intensively a certain skill, will contribute to that skill appearing in surplus in the final skill shortage indicator. Results for both occupational shortages and skill shortages are presented in the next chapter.

Mismatch indicators

Along with the set of indicators on skill shortages, the *OECD Skills for Jobs* indicators provide information on the misalignment of skills for those who are employed. As discussed in Chapter 1, skill mismatches differ from shortages. While shortages refer to the difficulty of finding adequate skills in the labour market, mismatches measure the extent by which the skills of workers are aligned to those that are required by their jobs. The mismatch indicators proposed in the *OECD Skills for Jobs Database* are calculated following the standard strategies developed in the substantial empirical literature on mismatch.

Qualification mismatch

The qualification mismatch index calculates the share of workers in each economy/occupation that are under- or overqualified to perform a certain job. This is done by computing the modal (i.e. most common) educational attainment level for each occupation in each country and point in time, and use this as a benchmark to measure whether individual workers' qualifications match the "normal" education requirement of the occupation.[19] Thus, over-qualification (under-qualification) depicts a situation for which the highest level of education achieved by an individual worker in an occupation is above (below) the modal level for all workers in that occupation.

Field-of-study mismatch

As pointed out by Montt (2015), "*field-of-study mismatch occurs when a worker, trained in a particular field, works in another field*" (e.g. a worker trained in the law, business and social sciences field works in the services sector, or, as Sloane (2003) illustrates, that of an English major working as a statistician). From both a conceptual and empirical standpoint, field-of-study mismatch is distinct from qualification or skill mismatch as a worker may be well matched to her/his job in terms of the key information-processing skills possessed (skills match) or educational attainment (qualifications match) but not by the *type* of education and knowledge received during her/his official training and education (Robst, 2008; Sloane, 2003; Quintini, 2011a; Quintini, 2011b). Such differences are captured in the measure of field-of-study mismatch proposed in the *OECD Skills for Jobs* indicators.

Field-of-study mismatch is calculated in this dataset following Montt's (2015) methodology, which assumes that certain fields of study (ISCED) prepare workers to participate in certain occupations (ISCO). As a result, individuals are considered well-matched if they work in the occupation that is considered to be a good fit for their field of study and mismatched otherwise. This type of mismatch can come from labour market pressures that force workers into accepting jobs in occupations unrelated to their fields of study, showing a relative surplus of individuals with degrees in those fields. It is worth noting, however, that the need for specialised education varies across occupations, which leads to naturally different levels of field-of-study mismatch across them.[20]

Notes

1. Table A.2 in the annex describes availability for the wage sub-index using EU-SILC data across time.
2. See https://www.onetonline.org/ for more information on the O*NET database.
3. In contrast, employers have no incentive to increase wages in a specific occupation beyond macroeconomic pressure (e.g. inflation, expectations or technology shocks) when the skills associated to that occupation are, instead, in surplus.
4. Hourly wages for European countries are calculated using EU-SILC information on annual earnings, months in employment and hours worked. Annual earnings and months in employment refer to the year before the survey, whereas hours worked as well as occupation refer to the moment of the survey. For unemployed or inactive individuals with non-missing annual earnings and months in employment, hours worked are imputed based on occupation-specific averages.
5. Another point to be considered in cross-country comparisons is the presence of different employment protection legislation (EPL) in different national contexts. EPL explains how employers in some countries are able to react faster to shortage and surplus pressures, whereas in other contexts there is very high stickiness.
6. Because of unemployment and shortages are negatively related, the inverse of the employment rate is used in the final indicator.
7. In contrast, a persistently high share of overqualified workers in a certain occupation may signal a surplus of skills among those workers as they fail to move to a more adequate job despite their skills.
8. Armed forces occupations (group 0) are excluded from the indicator because of small sample size.
9. The mapping between the two ISCO-classifications was done on a one-to-one basis, matching the most similar occupations.
10. http://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_(ISCED)
11. This is a statistical framework maintained by the United Nations Educational, Scientific and Cultural Organization (UNESCO).
12. These ISCED reclassification breaks, as well as other country-specific education level breaks, are generally corrected by grouping multiple education level groups. These country specific education regroupings are detailed in the annex (Table A.3).
13. Due to small sample size, post-secondary non-tertiary and tertiary education in South Africa were grouped together. This resulted in four big educational categories, rather than five across European countries.
14. Approximating for the behaviour of the economy in periods of recession or boom.
15. OECD (2008) defines a “composite indicator” as one resulting from individual indicators combined into a single index, on the basis of an underlying model of the

multi-dimensional concept that is being measured. A composite indicator, hence, measures multi-dimensional concepts (e.g. competitiveness, e-trade or environmental quality).

16. Although all sub-indices are positively correlated with shortages, the correlations between the different sub-indices vary. Most correlations between the five sub-indices are positive and significant with some exceptions. Underqualification is not correlated with wages or unemployed and is negatively correlated with hours worked. Moreover, the correlation between wages and employment and wages and hours worked are both significantly negative.

17. In the case of equation (1), this implies that w=1/4.5

18. The indicator is ideally calculated using its five sub-indices, but one or more sub-indices can be missing in certain countries and years. In countries where one or two components were missing in one year, notably wages and unemployment, the indicator was estimated by using the three or four remaining components and reweighted accordingly. More information on missing data points is available in the annex (Table A.2).

19. The modal educational attainment level is calculated for each 3-digit ISCO occupation that has at least ten observations, and different modes are calculated for each country and year.

20. Field-of-study in the EU-LFS is only available for individuals age 34 or below, and for individuals age 35 or above who obtained their highest education degree at most 15 years ago. To ensure comparability, the field-of-study sample in South Africa was similarly restricted to individuals aged at most 35 years old.

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Chapter 3

Skill for jobs indicators: Data overview and analysis

The OECD Skills for Jobs Database *provides crucial information to understand better how ongoing shifts in societies and labour markets are changing the demands for different sorts of skills, knowledge and abilities. The results of the* database*, presented in this chapter, show that technical and technology-intensive skills are becoming increasingly more important while more traditional and less technology-intensive skills are increasingly in surplus. Consistent with the literature on labour market polarisation, the results suggest that abstract and soft skills are more in demand than routine skills, and this gap has increased over recent years. Population ageing has resulted in stronger demands for healthcare services, as evidenced by shortages in care-related skills. Increased female labour market participation and population ageing have changed the composition of the skill supply. The results also suggest that countries where the skill gap between young and older workers is bigger face stronger shortages of key information-processing skills. Finally, this chapter shows that there are big differences in mismatch between countries, but also between workers with different socio-economic and job characteristics within countries.*

Skill needs indicators: Results and analysis

A cross-country overview of shortage and surplus

Following the steps outlined in Chapter 2, the degree of shortage and surplus in a wide range of skills types is calculated for European countries and South Africa. Tables 3.1 to 3.3 provide an overview of a selection of the imbalances for *skills*, *knowledge* and *abilities*.[1] Blue cells indicate shortages and grey cells surpluses, with darker colours reflecting bigger imbalances in both dimensions. Countries with critical shortage of a skill are defined as the countries whose value of the skill need indicator is above the 75th percentile of all positive values across countries and skills in each dimension. Similarly, countries with critical surpluses are the ones that show values of the skill need indicator below the 25th percentile of all negative values across countries and skill in each dimension.[2]

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). The shortages are biggest in Finland, Luxembourg, the Netherlands, Spain or Germany while smaller (or even in surplus) in Switzerland, Hungary, Cyprus[3,4] or South Africa (Table 3.1). Surpluses are more common for technical skills, such as equipment maintenance and repairing. While some *skills* are in shortage in all countries, there are no *skills* that are in surplus across all countries. Some technical skills are in surplus in the majority of countries, but in some, like for example France, Denmark, the Czech Republic, the Slovak Republic, Portugal, Romania and Lithuania a range of them are also found to be in shortage.

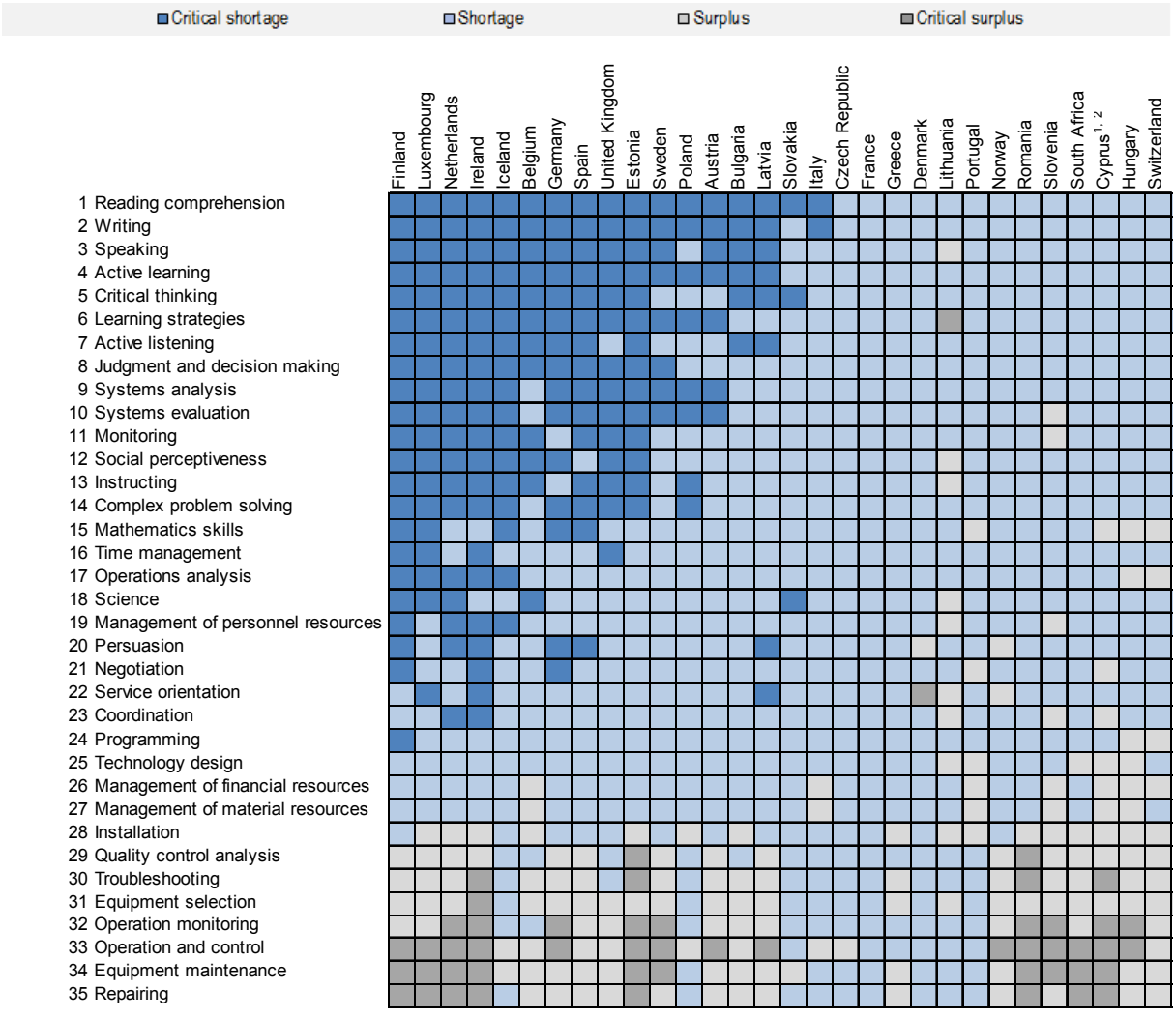
The most common *knowledge* shortages are found in computers and electronics, education and training as well as in some mathematics and science fields (e.g. geography, biology) and in the healthcare field (i.e. therapy and counselling, psychology and medicine and dentistry; see Table 3.2). For these knowledge types almost all countries have shortages. Shortages of this kind are most common in Finland, the Netherlands but also Ireland and Belgium. Surpluses, on the other hand, are mainly found for transportation, manufacturing and production, building and construction, and mechanical knowledge. While these technical knowledge types are in surplus in most countries, shortages of these knowledge types can be observed in countries like France, Denmark, Iceland and Lithuania.

The shortage in *abilities* in most countries occurs mainly for cognitive abilities, as well as auditory and speech abilities (Table 3.3). These shortages are biggest in Spain, Luxembourg, Finland and Germany. Surpluses are mainly found for physical (e.g. endurance, physical strength) and psychomotor (e.g. fine manipulation, control movement) abilities. While all countries have surpluses of physical abilities, some countries have some degree of shortage for multiple psychomotor abilities (i.e. France, Denmark, Portugal and Lithuania). Overall, *ability* imbalances are more similar across countries than the imbalances observed for *skills* and *knowledge*.

While these colour-coded tables provide a clear overview of which *skills*, *abilities* and *knowledge* types are most commonly in shortage or surplus, and in which countries the shortages and surpluses are biggest, they do not provide a detailed ranking of countries and skills. Specific "Country Profiles", providing the ranking of each country's own needs across all *skills*, *abilities* and *knowledge* types can be found at http://oe.cd/skills-for-jobs.

Table 3.1. *Skill* needs across European countries and South Africa (latest available year)

Degree of imbalance



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.

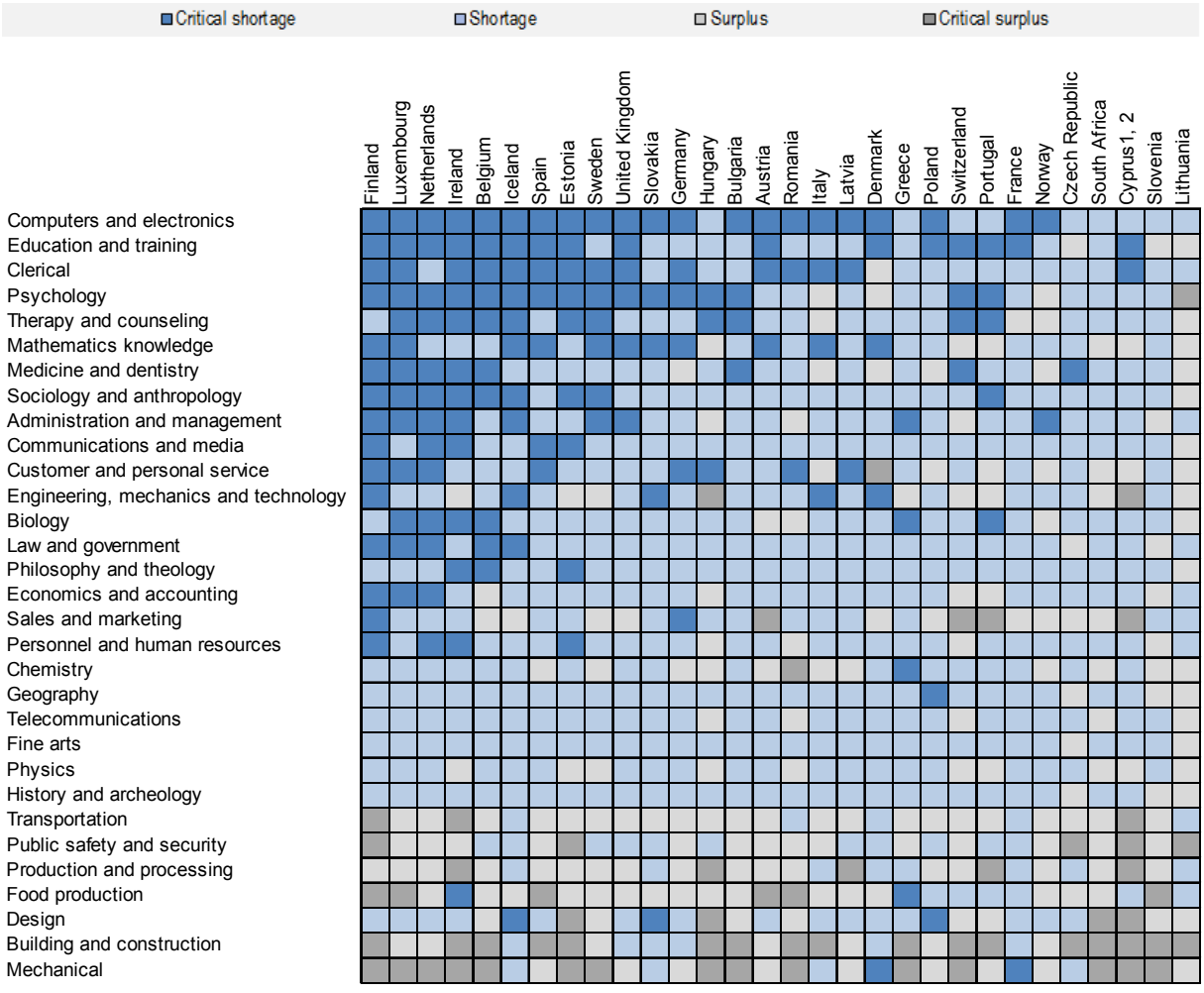
1. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

2. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: *OECD Skills for Jobs Database.*

Table 3.2. *Knowledge* needs across European countries and South Africa (latest available year)

Degree of imbalance



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.

1. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

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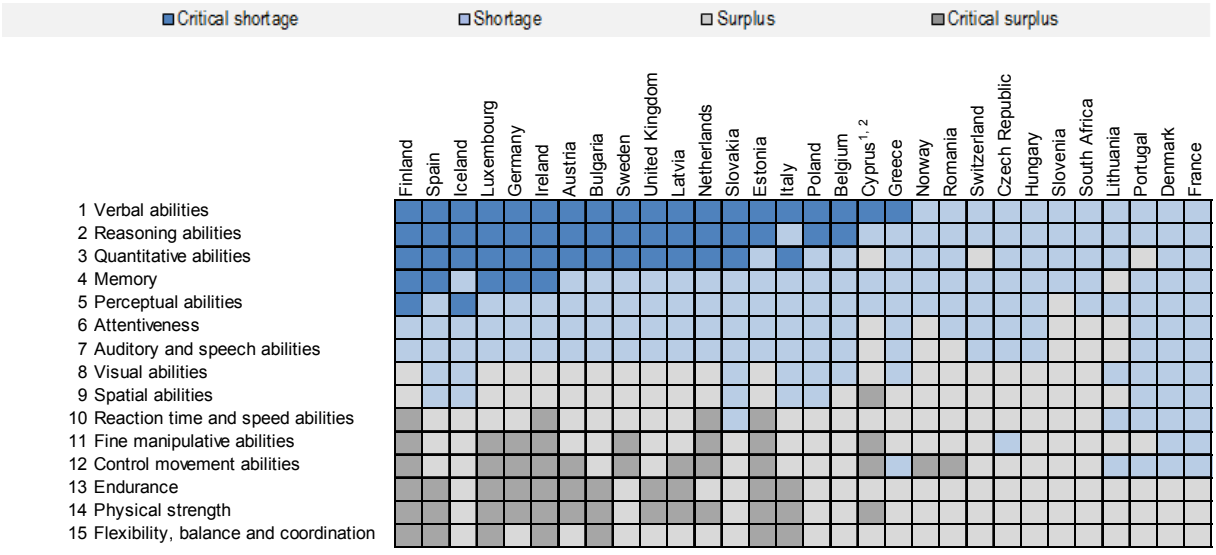
Source: OECD Skills for Jobs Database.

Table 3.3. *Abilities* needs across European countries and South Africa (latest available year)

Degree of imbalance



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.

1. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

2. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: OECD Skills for Jobs Database.

Skills concentration

In addition to understanding the type of skills that are in shortage or surplus in an economy, the *OECD Skills for Jobs Database* identifies how economies and jobs require, use and combine these skills. Occupations differ in the type of skills that they require, with elementary workers requiring a different set of skills than managers. Also, jobs differ in the degree of skills concentration, meaning that some use a wide range of skills, while others will use only a few very specific skills to carry out their tasks.[5] An occupation showing a highly-concentrated set of skills is one that uses many different skills with a relative low intensity and other, fewer, skills with high intensity.[6] These occupations are referred to as being *skill-specialised*. In contrast, less skill-specialised occupations make a relative more homogenous use of all skills. Importantly, the skill-specialisation measure is built so as to express the concentration of skills independently from the average skill intensity of an occupation, with intensity being measured as the combination of skill level and importance. This allows capturing the measure of skill specialisation and to disentangle it from that of average skill intensity of each occupation. Occupations with low levels of concentration can require many skills at high intensity, or alternatively, they can have low skills intensity across

the board. Similarly, skill-specialised occupations can have low or high average skill intensity.

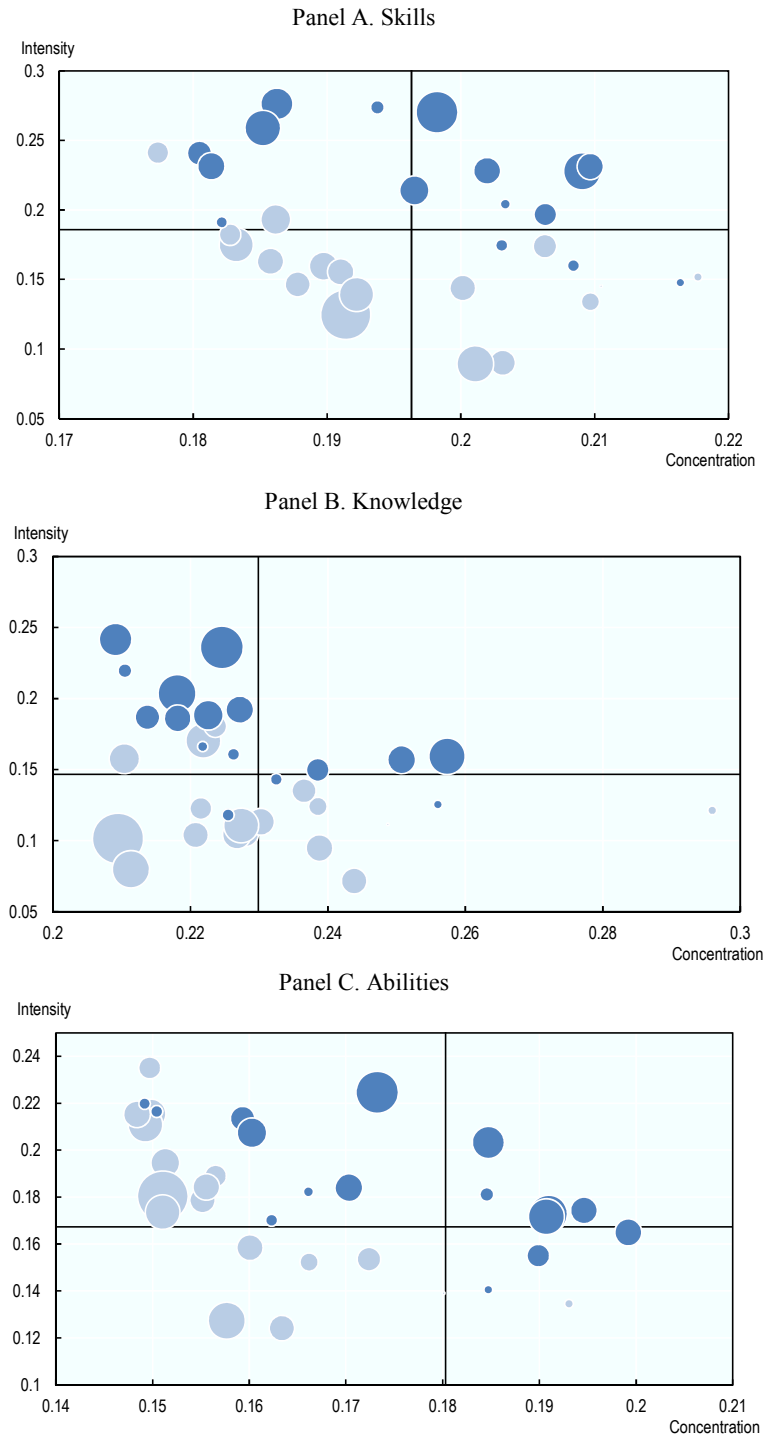
Skill specialisation may be related to overall skill imbalances (e.g. shortages or surpluses). As an example, it may be the case that certain occupations are found in shortage in the labour market as they require a very specialised and narrow set of skills to be performed, making it especially difficult to find a sufficient number of adequately prepared candidates for the available vacancies. Similarly, however, workers with a broad set of skills, i.e. those who are easily employable across several different occupations, may be in short supply and, as such, occupations making use of a such broad set of skills end up showing signs of shortages. Theoretically, both these situations (e.g. shortages in skill-specialised or skill-unspecialised occupations) can be found simultaneously in a country's labour market. To better understand the nature of skill imbalances in the analysed labour markets, it is useful to investigate whether occupations showing signs of shortage are associated with skill concentration/specialisation as well as whether they differ significantly from occupations in surplus in the average intensity with which they use skills.

Figure 3.1 shows, for each occupation, the degree of skill imbalance (size of the bubble), the degree of skill specialisation as well as the average intensity with which skills are used. Darker bubbles represent occupations in shortage, while lighter bubbles refer to occupations in surplus. The results are shown for *skills*, *abilities* and *knowledge*.[7] Panel A shows that the biggest *skill* shortages are found in occupations that have high *skill* intensity, regardless of *skill* specialisation. The biggest surpluses occur, instead, in low-*skill* intensive occupations. For *knowledge*, Panel B shows that, on average across the countries analysed, occupations in shortage make a more intense use of *knowledge*, while *knowledge* concentration does not seem to bear a direct relationship with occupations being in shortage. Occupations more often in surplus, instead, use lower levels of *knowledge*. Again, the results do not show any evident pattern linking occupations in surplus to *knowledge* specialisation. Similarly, Panel C shows that occupations in shortage have high *abilities* intensity, at both high and low levels of specialisation. On the contrary, surpluses are found among occupations that have low *ability* specialisation, irrespective of the *ability* intensity.

Interestingly, while the level with which *skills* and *knowledge* types are used across occupations seems to bear a positive relationship with these occupations being more in shortage or surplus, Figure 3.1 also seems to suggest only a weak relationship between *skills* and *knowledge* concentration and occupations being either in shortage or surplus. A strong relationship emerges, instead, between occupations being in surplus and their use of specialised *abilities*. The difference in the results between, on the one hand *skills* and *knowledge* types and, on the other *abilities* may lie in the nature of the dimensions analysed. *Skills* and *knowledge* are intimately linked with the acquisition and use of knowledge while *abilities* are defined more closely to the execution of tasks (see Chapter 2).[8]

Overall, while in some occupations it is necessary to have a high degree of skill specialisation, the development of a wide range of skills becomes increasingly important as jobs and skill needs are changing constantly. Moving between jobs and occupations becomes easier when someone possesses multiple skills. The options for occupational mobility are further explored in the next section.

Figure 3.1. Linking imbalances, skill concentration and skill level



1. Size of the bubbles reflects the degree of imbalance. Dark blue bubbles indicate shortages, light blue surpluses. Horizontal and vertical lines represent unweighted average intensity and concentration across occupations.
2. Concentration is calculated based on the Herfindahl index of skill and ability requirements from O*NET.
3. Intensity and concentration levels per occupation are calculated as an unweighted cross-country average (latest available years), see Annex Table A.4.

Source: *OECD Skills for Jobs Database*, O*NET.

Occupational mobility: Identifying occupations with similar skill profiles

Occupations differ in terms of the type of skills that they require, as well as the level of skills that is needed to carry out the associated tasks. Some occupations might have very different skill profiles while others might make use of fairly similar skills. Individuals working in different occupations with similar skill profiles can switch relatively easily between these occupations, as comprehensive (and time-consuming) re-skilling may not be needed.

From a skill-matching point of view, the comparison of occupations' skill profiles is useful for understanding where career moves are relatively easy and where skill matching could be potentially improved. This is particularly interesting for individuals working in occupations that are in surplus, whose employment prospects are poor, and who would benefit from moving to occupations that are in high demand (or shortage).

Using clustering techniques it is possible to group occupations with similar *skills*, *abilities* and *knowledge* profiles.[9] Figure 3.2 shows the occupation groups that were created as a result of this clustering based on *skill* profiles for the average of European countries.[10] The top part of the figure shows how 13 groups were created starting from one single group of all occupations (*dendrogram*). Five groups consist of one single occupation, and the largest group contains six occupations.[11] The *dendrogram* gives an indication of the distance between the different groups in terms of their *skill* profile: groups that were split in one of the final steps of the clustering process are more similar than groups that were split in one of the initial steps. The *dendrogram* shows that the occupations are first split into a manual and a more cognitive group. The cognitive group is then split into high-skilled and middle-skilled occupations. In subsequent steps, smaller groups are formed based on more detailed *skill* requirements similarities. The bottom part of the figure shows occupation groups and the corresponding ISCO codes of each occupation in the group.[12] The height of the bars represents the share of each occupation in total employment, while the colour signals whether the occupation is in shortage or surplus.

Figure 3.2 shows that the occupations in each group can differ widely in terms of their size and as to whether they are in shortage or surplus. Some groups of occupations (e.g. 32, 33 and 34), for instance, are composed only of occupations that are in shortage, while other groups only combine occupations that are in surplus (e.g. 91 and 94). Within groups the intensity of the imbalances across occupations can also vary, with occupations belonging to the same group being in critical or moderate imbalance.[13] Interestingly, the cluster analysis also produces groups that combine occupations in shortage and occupations in surplus.[14] As an example, the *skills* profile of "Building and related trades workers" (71), which are in critical surplus, is similar to the *skills* profile of "Metal, machinery and related trades workers" (72) and "Handicraft and printing workers" (73), which face a shortage.

As *skill* profiles of occupations within the same group are not fully identical, individuals wanting to switch from an occupation in surplus to one in shortage might need to develop some new *skills*. Generally, the *skill* improvement needed to switch from one occupation to another can be achieved through specific retraining in those *skills* that are lacking in the origin occupation but present in the destination. Given that groups have been built based on their *skill*-similarities, the improvements needed to switch within the same group are minor relative to the improvements needed to change to occupations in other groups. Building and related trades workers, for example, have a very similar *skills* profile to metal, machinery and related trades workers, but technical skill requirements

for the former are lower than for the latter. Some technical skill training might therefore be needed for building workers to move into metal and machinery trades jobs. Nonetheless, the degree of re-skilling necessary to move between these two occupations is relatively small compared to moving between occupations from different groups. If, for instance, a building worker wanted to move into shortage occupation of personal care workers, which is in a different group, this would require substantial upskilling in terms of basic content (e.g. writing, speaking, mathematics) and process skills (e.g. critical thinking, active learning), as well as social skills. It is important to note that moving between two groups does not necessarily imply a need for re-skilling or upskilling, as it would be possible to move from an occupation in surplus into occupations in shortage that have an overall lower skill requirement level. However, for an individual with high skills, such a move could lead to over-skilling, a suboptimal allocation of her/his skills.

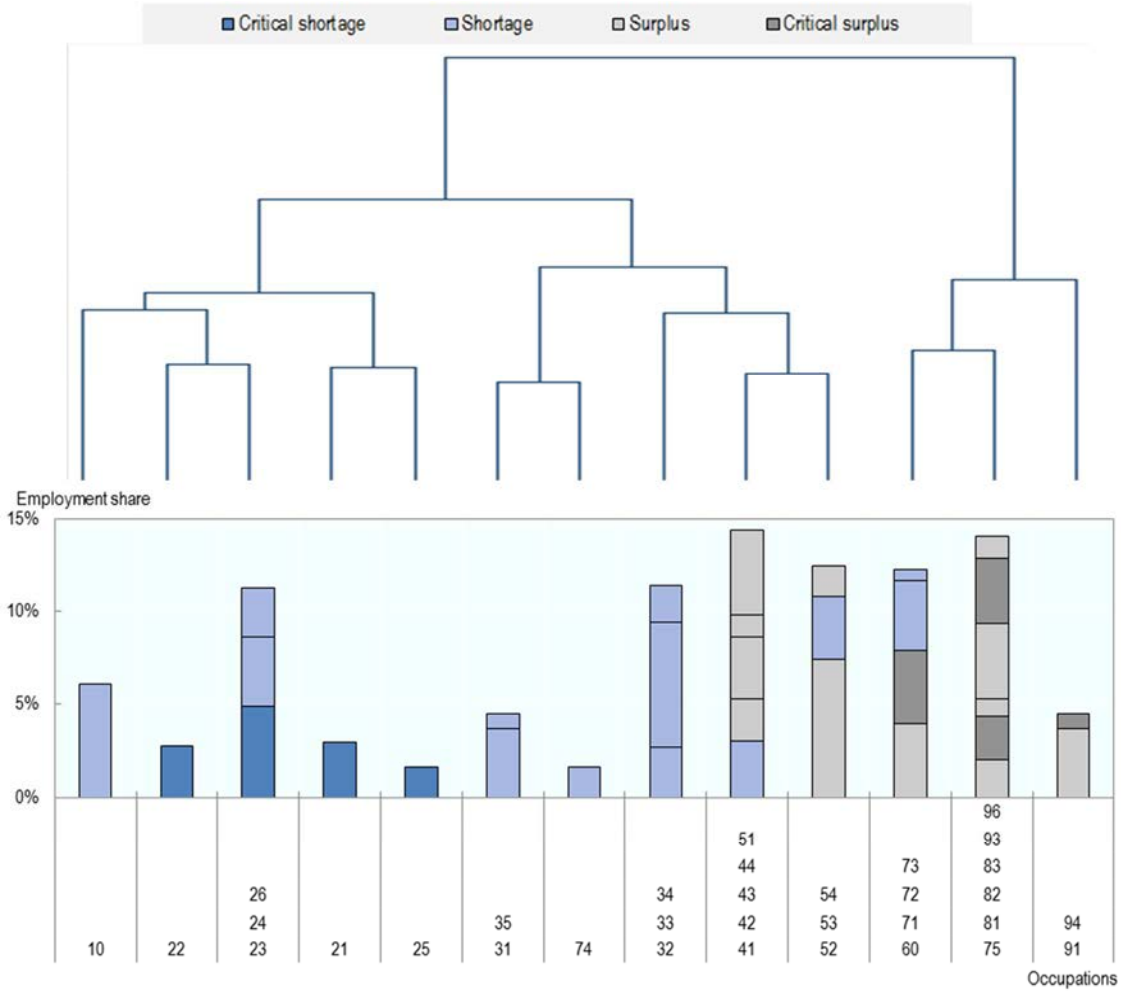
Using the same clustering method, nine groups of occupations with similar *abilities* profiles are identified (Figure 3.3). Three groups consist of only one occupation, whereas the largest group now contains nine occupations. As for *skills*, no group combines critical shortage and critical surplus occupations for the European average. Nonetheless, labourers (93), who are in critical surplus, have similar *abilities* as handicraft and printing workers (53, in moderate shortage). Similarly, the critical surplus occupations of "Building and related trades workers" (71) and "Stationary plant and machine operators" (81), have similar *ability* profiles as the shortage occupations of "Metal, machinery and related trades workers" (72) and "Electrical and electronic trades workers" (74).

Some investment in further improving certain *abilities* might be needed to move between occupations in the same group. Labourers, for example, have lower requirements for cognitive abilities (e.g. reasoning and perceptual abilities) than handicraft and printing workers. These *abilities* could be strengthened through general transversal skill training. Building workers have lower psychomotor (e.g. control precision, manual dexterity) *ability* requirements than "Metal, machinery and related trades workers", and tailored abilities training would therefore ease the transition of building workers into metal and machinery trades jobs.

Finally, applying the same clustering strategy on *knowledge* results in the creation of 14 groups of occupations with similar *knowledge* profiles (Figure 3.4). Seven groups only have one member, implying that these occupations differ strongly from other occupations in terms of the *knowledge* they use. The largest group consists of seven occupations. It is not surprising to find more single-member groups for *knowledge* than for *skills* or *abilities*, as *knowledge* is much more occupation-specific. The higher specialisation of *knowledge* types can also be seen in Figure 3.1, showing that the average *knowledge* concentration across occupations is higher than the average *skills* and *abilities* concentration. For the average of European countries analysed, no groups combine critical shortage and critical surplus occupations. However, two groups combine critical surplus occupations and occupations that have moderate shortages. The critical surplus occupation of "Stationary plant and machine operators" (81) has a similar *knowledge* profile as the shortage occupation of "Handicraft and printing workers" (73). Similarly, "Building and related trades workers" (71, critical surplus) is in the same group as the shortage occupations of "Science and engineering associate professionals" (31), "Metal, machinery and related trades workers" (72) and "Electrical and electronic trades workers" (74).

Figure 3.2. Occupations grouped by skill profile (European average)

Dendrogram, employment shares and imbalance



Note: The occupation labels are stacked to reflect the stacked bars, i.e. the bottom label (e.g. 23 in the third group) corresponds to the bottom bar, and the top label (e.g. 26 in the same group) to the top bar.

The European average is an unweighted average of European countries.

Critical shortage (darker blue) is defined as the occupations in the top quartile of the positive occupational imbalance values. Critical surplus (darker grey) is defined as the occupations in the bottom quartile of the negative occupational imbalance values.

Occupation 93 refers to occupation 92+93, occupation 96 to 95+96. Details on the occupations are provided in Table 2.2.

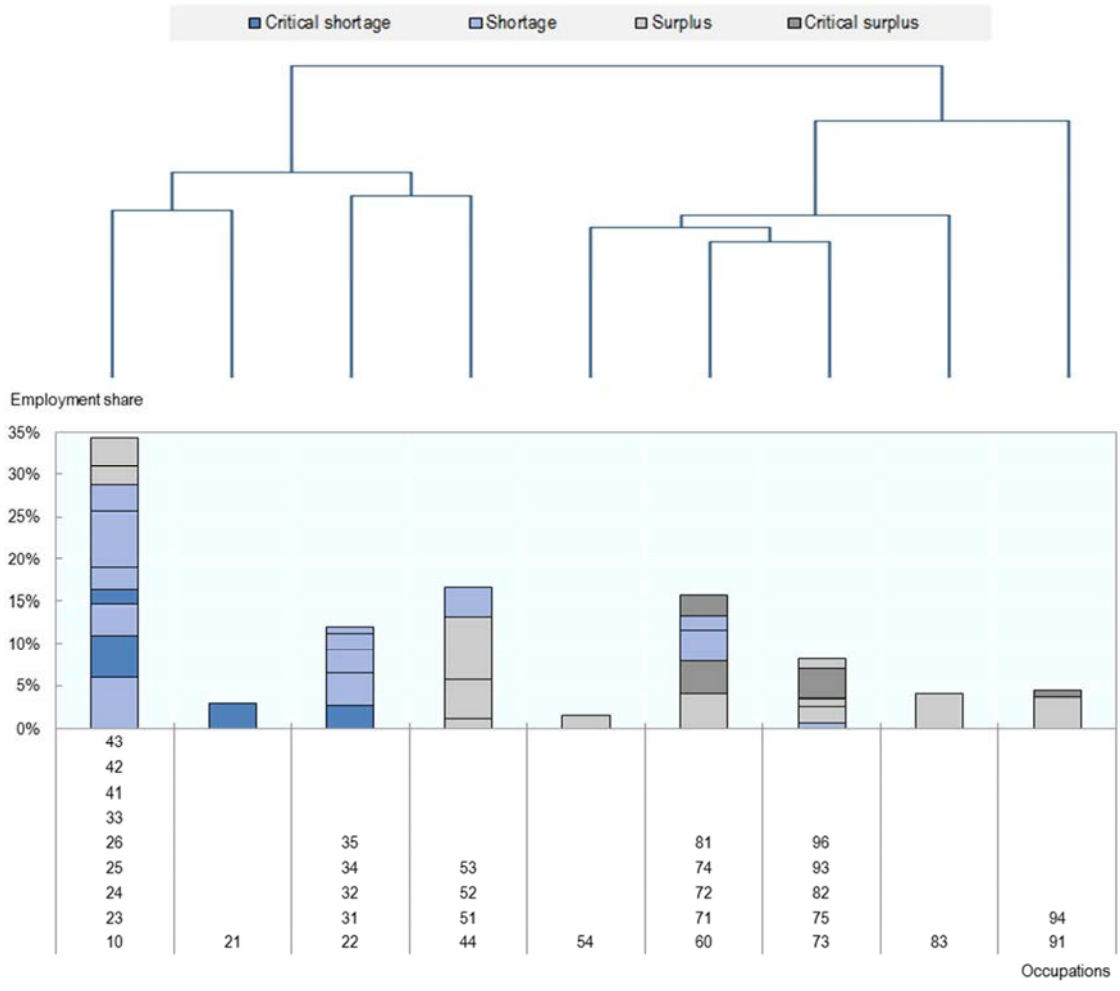
Source: *OECD Skills for Jobs Database*, O*NET, EU-LFS.

The *knowledge* requirements of occupations in the same group are not identical, and individuals wanting to move from one occupation to another might need to invest in improving their existing *knowledge* or developing *knowledge* in new fields. Building workers (71) wanting to get a job as science and technology associate professional (31) would need to improve their manufacturing and production knowledge, as well as their mathematics and science knowledge and their knowledge of transportation.

Figures 3.2, 3.3 and 3.4 show the results for the average of European countries included in the *OECD Skills for Jobs Database*. At the country level, however, much variability exists in the combination of occupations in shortage and surplus within each *skill*, *knowledge* and *ability* group, and therefore also in the extent that tailored training can spur better allocation of talent across jobs in each one of the economies examined and reduce skill imbalances in each labour market. Country-specific cluster graphs are provided in the country profiles.[15]

Figure 3.3. Occupations grouped by ability profile (European average)

Dendrogram, employment shares and imbalance



Note: The occupation labels are stacked to reflect the stacked bars, i.e. the bottom label (e.g. 22 in the third group) corresponds to the bottom bar, and the top label (e.g. 35 in the same group) to the top bar.

The European average is an unweighted average of European countries.

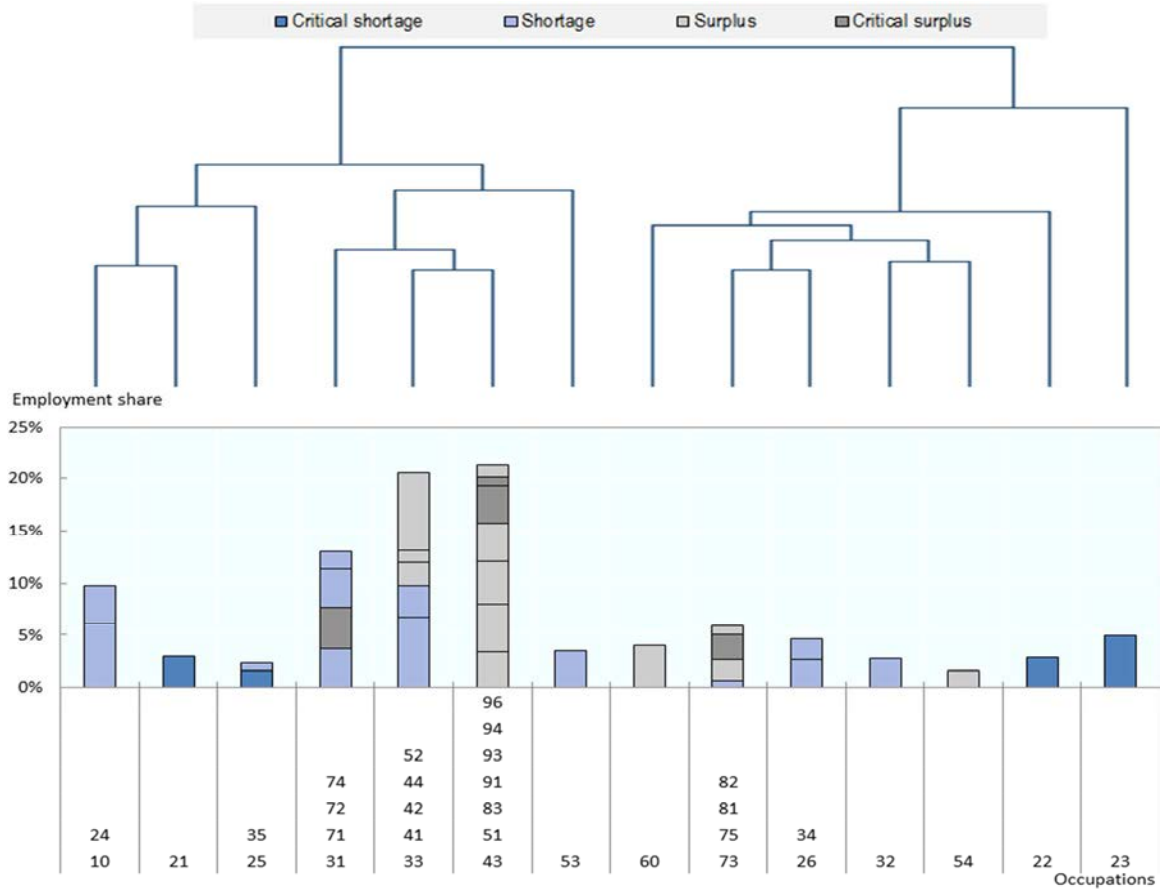
Critical shortage (darker blue) is defined as the occupations in the top quartile of the positive occupational imbalance values. Critical surplus (darker grey) is defined as the occupations in the bottom quartile of the negative occupational imbalance values.

Occupation 93 refers to occupation 92+93, occupation 96 to 95+96. Details on the occupations are provided in Table 2.2.

Source: *OECD Skills for Jobs Database*, O*NET, EU-LFS.

Figure 3.4. Occupations grouped by knowledge profile (European average)

Dendrogram, employment shares and imbalance



Note: The occupation labels are stacked to reflect the stacked bars, i.e. the bottom label (e.g. 25 in the third group) corresponds to the bottom bar, and the top label (e.g. 35 in the same group) to the top bar.

The European average is an unweighted average of European countries.

Critical shortage (darker blue) is defined as the occupations in the top quartile of the positive occupational imbalance values. Critical surplus (darker grey) is defined as the occupations in the bottom quartile of the negative occupational imbalance values.

Occupation 93 refers to occupation 92+93, occupation 96 to 95+96. Details on the occupations are provided in Table 2.2.

Source: *OECD Skills for Jobs Database*, O*NET, EU-LFS.

Skill needs in light of global trends and challenges

This subsection zooms in on a range of specific skill needs related to global phenomena such as technological progress and population ageing. In addition to cross-country comparisons of shortages and surpluses of these skills, some exploratory analysis linking global trends to findings from the *Skills for Jobs Database* is presented. By using the *Skills for Jobs* data to analyse global trends, this subsection serves as a validation of the data and shows how this information can be applied in multiple research domains, complementing and extending existing data sources and providing valuable insights for policy makers, researchers and individual users.

Technological progress

Technological progress is reshaping the content and tasks of many, if not all, occupations in the labour market. The transition towards a digital economy, although underway for nearly half a century, may have become quicker recently (OECD, 2017) with the introduction of several new disruptive technologies. Computing power of ever-smaller devices has steadily increased in the last decade, allowing the development and implementation of a range of new digital technologies such as 3D printing, Internet of Things (IoT) and advanced robotics. The penetration of these new technologies in production processes as well as in the service sector is showing already substantial repercussions on the way jobs and tasks are carried out as well as by whom in the labour market.

Latest estimates show that digital infrastructures and access to devices such as smartphones has grown, from 4% to 40% of the world's population in 20 years (OECD, 2017). Emerging and developing economies are an integral part of this picture. Sharp increases in the use of digital technologies in areas like e-commerce, banking and health are already leading to increased global competition for talent and skills.

The availability of big-data, as well as the increase in computing power and in the interconnectedness of mobile devices, has triggered the development of new "process innovations" such as artificial intelligence (AI). These innovations have the potential to replace humans in several routine cognitive tasks in the near future.

The accelerated pace by which these new technologies are developing has led to concerns that these innovations will make labour redundant (Brynjolfsson and McAfee, 2014; Akst, 2013) through the automation of tasks that were once performed by humans.

The interconnectedness of digital devices, collecting and distributing big-data from (and to) final users is optimising all steps of production. In parallel, the production of goods is also changing. New materials (e.g. bio- or nano-based) are already used in the production of new goods while others will be used soon to improve the quality and quantity of available varieties in the markets of goods. For example, nanotechnology can make plastics electrically conductive. In the automotive industry this can remove the need for a separate spray painting process for plastics, reducing costs by USD 100 per vehicle (OECD, 2017).

New discoveries are putting pressure on countries to develop skills in several different scientific domains. Even more strikingly, the skills and knowledges required by labour markets are increasingly interconnected with each other. Physics, for instance, is increasingly crossing borders with the computer and electronics field as, for instance, recent theoretical results confirm that quantum computing would open the possibility of performing new more efficient and faster calculations, currently out of reach of classical computers.

All of these trends have a substantial impact on the demand for skills and are likely to be a major factor contributing to skill imbalances. Across countries, results in Figure 3.5 based on the *OECD Skills for Jobs Database* confirm the prevalence of skill shortages in several areas that are directly linked to the technological mega-trends discussed above. Shortages of workers with computer and electronics knowledge are, for instance, occuring in all countries examined. The most acute shortages are in Finland, Spain and Austria but critical shortages are also experienced in Luxembourg, Italy and Poland. Hungary, Lithuania, and Switzerland are, instead, showing smaller yet positive shortages of computer and electronics knowledge. Similar results are also found for the

mathematics knowledge for which most countries show shortages and only Cyprus (see endnotes 3 and 4) shows a surplus. France and Denmark also show signs of shortages (though of a relative lower intensity) of workers with knowledge in physics, while Lithuania and Cyprus show signs of surpluses.

While technological change is surely one of the main drivers of global skill imbalances, its impact may vary across countries as the penetration and adoption of new technologies in the productive fabric of each country differ substantially.

The picture for engineering and technology imbalances is, for example, more mixed than the one presented for other skills: several countries show shortages and some of them critical (e.g. Iceland, Denmark). Others show signs of surpluses (e.g. Cyprus, Estonia and Hungary). The differences in the results are in line with the differences in the economic and productive structure of these countries as well as with the labour market outcomes of the occupations that are, in those labour markets, most in shortage/surplus. Estonia, for instance, experiences its most acute shortages in occupations such as managers, personal care workers and legal professionals[16] (see also Cedefop[17]). These occupations are only weakly exposed to engineering and technology skills and, as such, do not contribute to shortages at the country level in that skill. Similarly, Estonia has recently drastically reduced the production of electricity based on oil shale. As such, the employment pressure on engineering occupations that were linked to that sector has also decreased, releasing skilled workers with this knowledge and creating surpluses in engineering and technology related skills.

Along with the analysis of technology-related skill imbalances, it is also interesting to analyse the emergence and prevalence of imbalances across skills and knowledge types that are more related to traditional sectors and that are more likely to be disrupted by technological change, automation and robotics.

Figure 3.5. Technology-related skill needs

Panel A. Computers and electronics

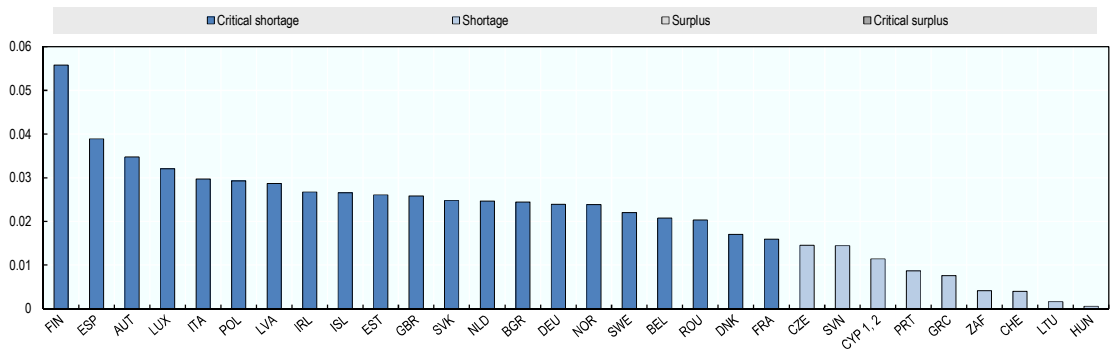
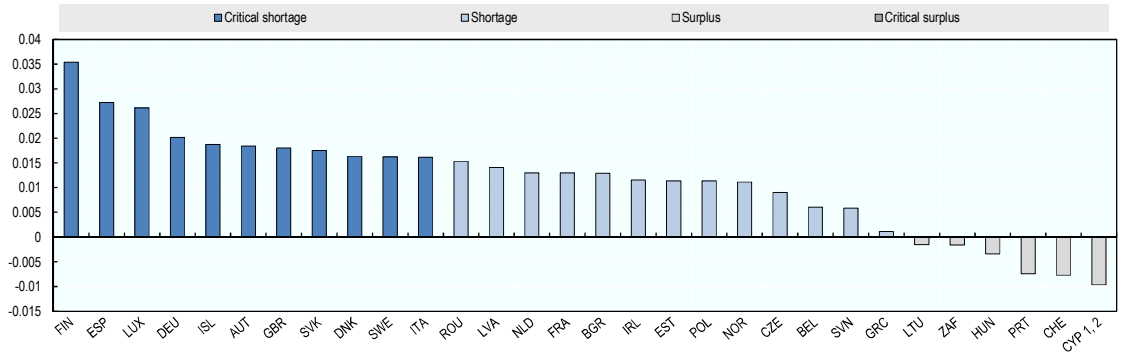
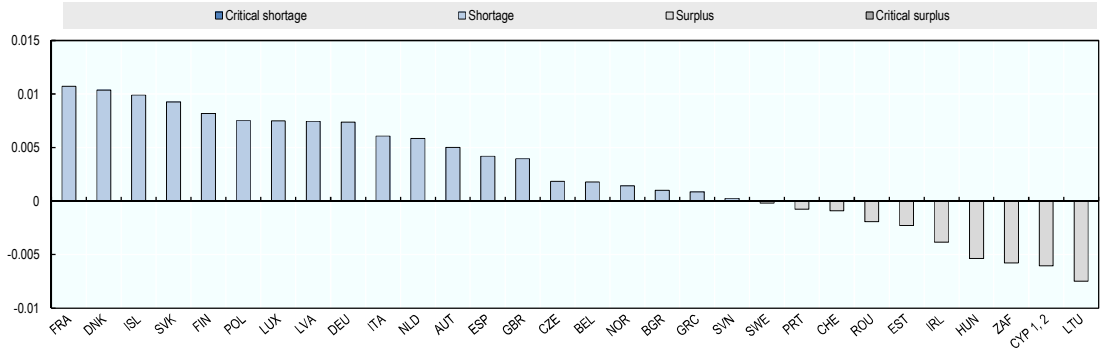


Figure 3.5. Technology-related skill needs *(cont.)*

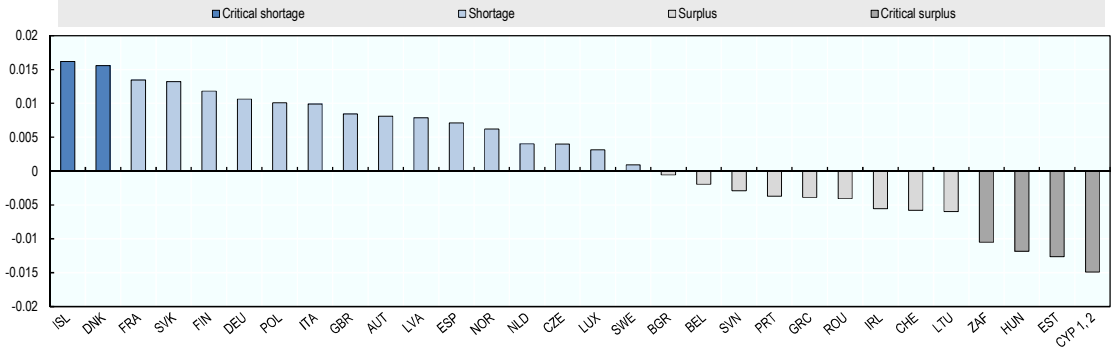
Panel B. Mathematics knowledge



Panel C. Physics



Panel D. Engineering and technology



Note: Latest available year. 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. Values for the knowledge dimension vary between -0.040 and 0.056 across countries.

1. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

2. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: *OECD Skills for Jobs Database.*

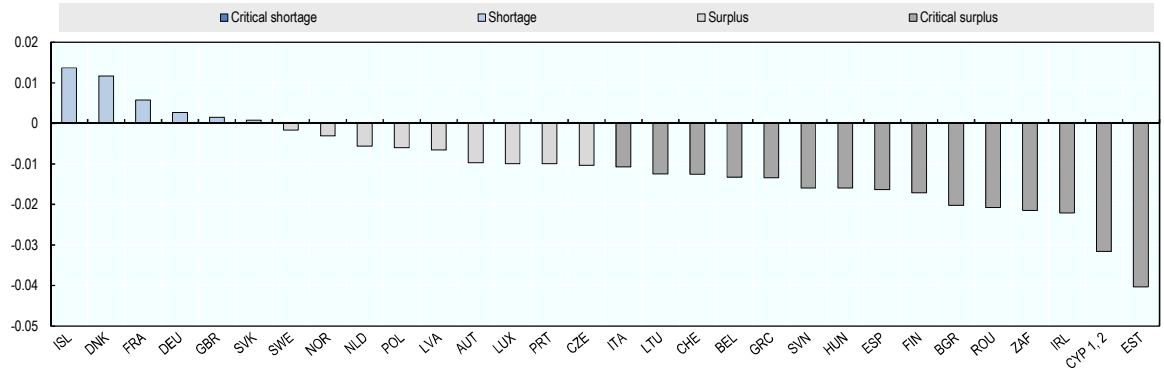
Results in Figure 3.6 show substantial surpluses in skills related to the building and construction sector, production and processing as well as transportation or equipment maintenance skills. These results seem to suggest that technological change and automation may be already playing an important role across all economies, by reducing the needs for manual and routine skills in traditional industrial sectors. As an example, the use of increasingly intelligent and interconnected sensors can drastically reduce errors in production processes as technologically-advanced devices allow every item (and steps in the production chain) to be constantly monitored. These innovations are substantially reducing machines' downtime and the need to repair them as intelligent systems predict maintenance needs (OECD, 2017). Similarly, vehicles like the CAT 797, designed specifically for high-production mining and heavy-duty construction applications worldwide are less prone to break down when operated by computers. Firms are, therefore, already adapting to such technological changes and this is reflected in the observed skills surpluses in occupations employing workers whose skills have been replaced by machines and computers.

Several new technologies are also evidently disrupting the Transportation sector, not only by creating social platforms that optimise and reduce the costs for individuals to move around, but also by reducing the need for workers to be employed in the supervision and actual driving duties of vehicles. Similarly, e-commerce and the use of big data are optimising shipping routes and the delivery of goods by reducing the average distances that products need to travel to reach final customers. Companies like Amazon or UPS, for instance, devote substantial resources in innovative and smart logistics that use big data to anticipate traffic conditions so as to reduce costs and time and personnel needed to deliver the products sold on their online platform.

The patterns of shortages and surpluses emerging from the preliminary analysis of the OECD Skills for Jobs database suggest the specific areas where training and re-training should be boosted in many countries. In the case of shortages in computer and electronics knowledge, for instance, the results highlight that education and training providers should reinforce the supply of courses leading to the development of a series of technology-relevant skills. Among occupations that intensively use computer and electronics knowledge and that are in shortage in most countries, database management technologies[18] and web platform development software[19] are common tools used on a daily basis. Reinforcing the knowledge of these and related core technologies could help fill the gaps observed in multiple countries.

Figure 3.6. Low technology-intensive skill needs

Panel A. Building and construction



Panel B. Production and processing

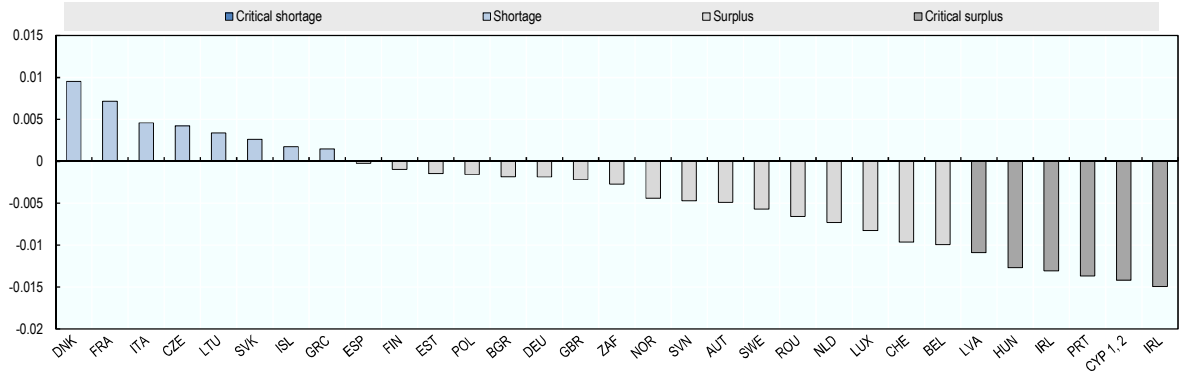
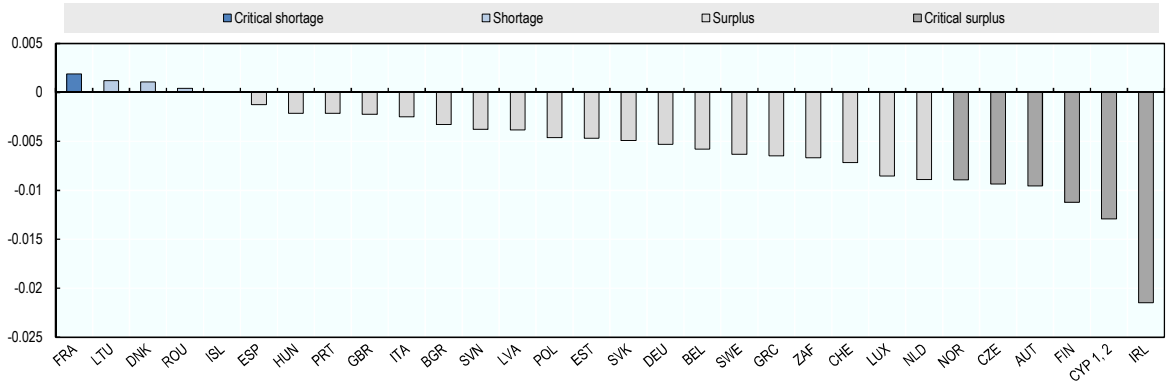
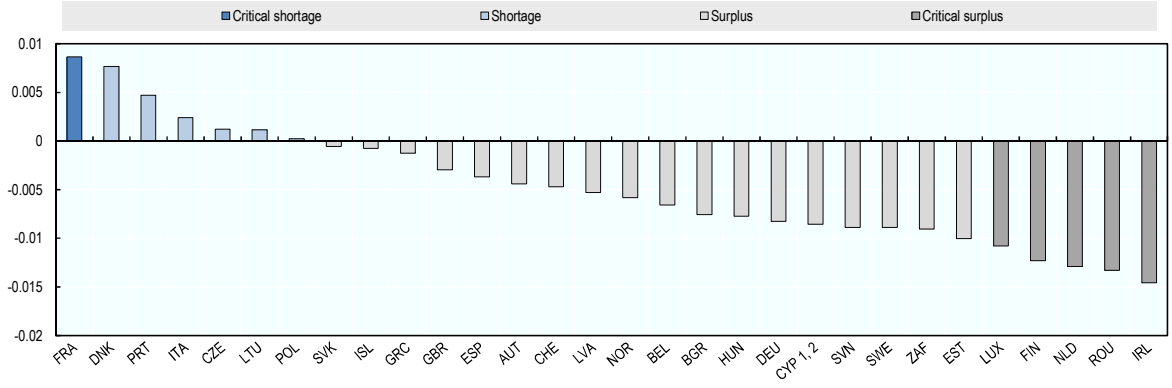


Figure 3.6. Low technology-intensive skill needs *(cont.)*

Panel C. Transportation



Panel D. Equipment maintenance



Note: Latest available year.

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. Values for the knowledge dimension vary in between -0.040 and 0.056 across countries. Values for the skill dimension (equipment and maintenance) vary between -0.019 and 0.042 across countries.

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Source: *OECD Skills for Jobs Database.*

Skill needs and automation

The term "technological change" encompasses a wide range of areas spanning from digital innovations, the production of new materials and advanced robotics, automation and artificial intelligence (AI). Among the different aspects of technological change, the advent of robotics has created special concern as to whether human labour will be eventually replaced by machines that will perform not only

manual routine tasks but also, through AI, increasingly more complex routine cognitive tasks across a wide range of occupations.

In light of these concerns recent influential empirical work (Acemoglu and Restrepo, 2016) has been looking at the impact of automation and the simultaneous decline in the labour share and employment among advanced economies induced by these technological improvements to production. Results for the United States seem to suggest, for instance, that an increase in automation is likely to reduce the cost of producing using human labour, therefore, encouraging the faster creation of new complex tasks.[20] As such, advanced robotics, automation and their penetration in the production stream, is likely to release pressure (create surpluses) on manual and physical skills while, at the same time, creating substantial shortages (or at least increased demand) for non-routine cognitive skills.

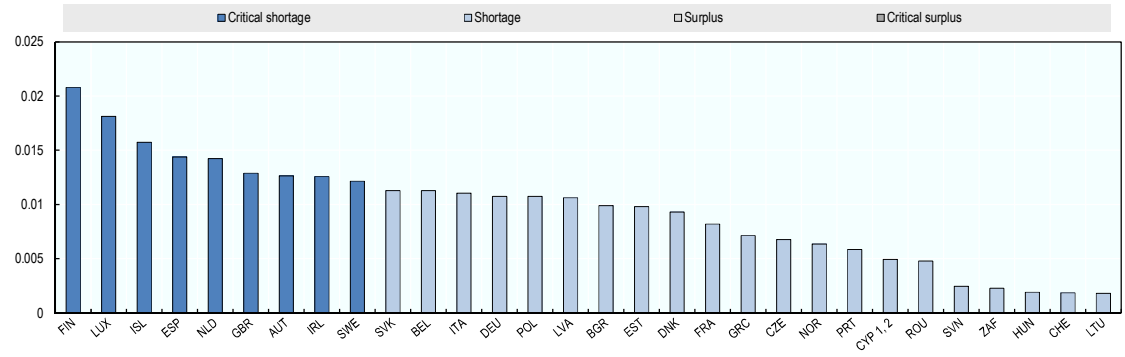
Results in Figure 3.7 confirm the existence of substantial shortages in a variety of cognitive skills across countries. Deductive reasoning (i.e. the ability to apply general rules to specific problems), fluency of ideas (i.e. the ability to come up with a number of ideas about a topic) or information ordering (i.e. the ability to arrange things or actions in a certain order or pattern according to a specific rule) are only some examples of abilities that are shown to be in shortage in all countries and that are yet difficult for machines to replicate adequately.

Interestingly, many of the skills mentioned above are related to the ability of workers to decipher meaningful patterns from apparently unrelated events or schemes. While machine learning algorithms are likely to improve the capabilities of AI in this area in the near future, for now, the human skills related to the ability to work with, process, and interpret insights from big data have been strongly on the rise. According to Burning Glass data,[21] for instance, references to analytical and data-oriented skills appeared in 4 million postings over the last year – and data analysis is one of the most demanded skills by US employers.

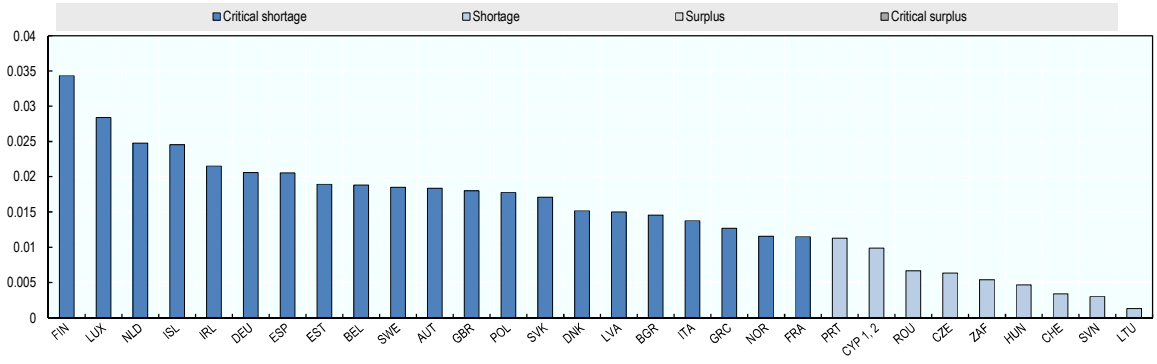
If substantial change is to happen as a consequence of the rapid development of AI, many argue that the supervision of humans will always be an important element (maybe even more important than it is currently) and even despite the potential increase in the ability of machines to *learn* through sophisticated algorithms how to react to unstructured situations. Specialised workers will likely need to extract the full returns from these technologies through a meaningful interaction and complementarity with AI.

Figure 3.7. Cognitive skill needs

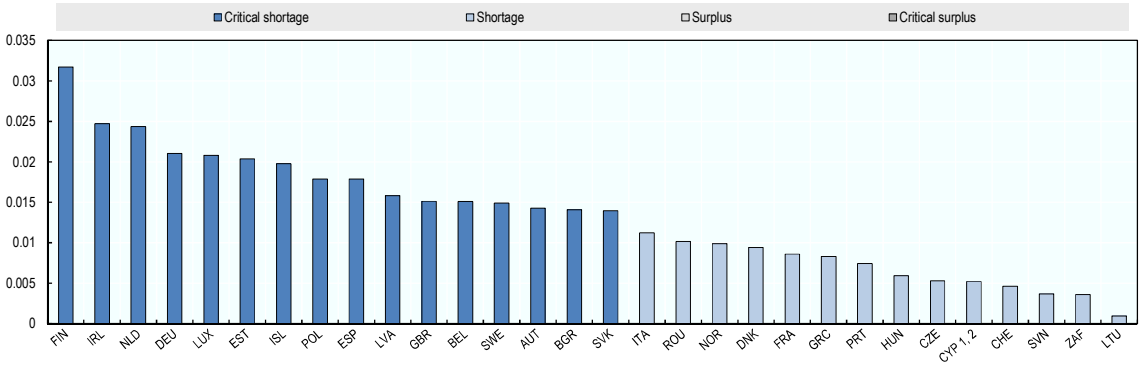
Panel A. Information ordering



Panel B. Deductive reasoning



Panel C. Fluency of ideas



Note: Latest available year.

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. Values for the ability dimension vary between -0.025 and 0.035 across countries.

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Source: *OECD Skills for Jobs Database.*

At the other end of the skill spectrum, robotics and AI are likely to create surpluses in routine manual and physical skills and abilities. Results in Figure 3.8 seem to confirm this hypothesis. Control precision abilities (e.g. the ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions) used, for instance, in mining occupations such as roof bolters or mine shuttle car operators but also in other occupations such as crane and tower operators are shown to be in critical surplus across many of the countries examined. Stronger surpluses are experienced in Ireland, Estonia, Finland and Sweden.

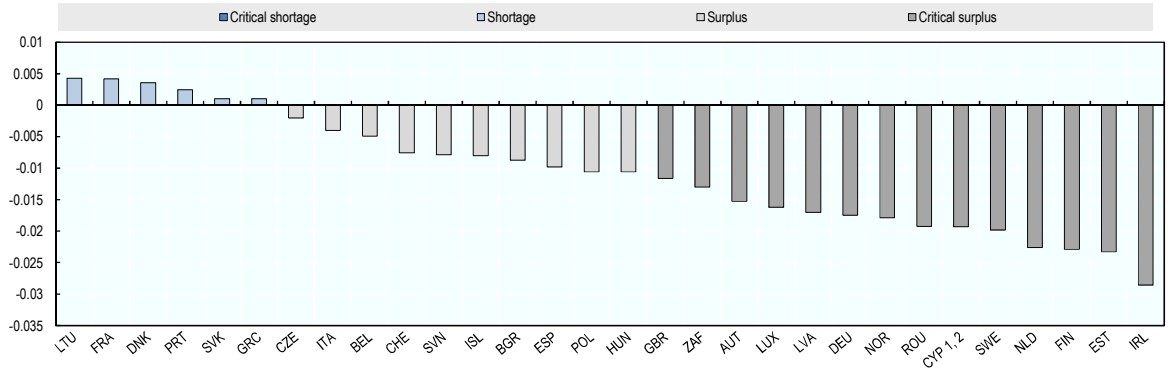
Tasks and jobs requiring routine skills such as control precision are in the process of being automated in many countries. Scania AB, a major Swedish manufacturer of commercial vehicles is, for instance, increasingly using the so-called "communicator" to collect data to monitor and analyse the efficiency of its vehicles (OECD, 2017). Volvo is also investing in R&D and innovation on giant self-driving vehicles and Caterpillar trucks weighing close to a million pounds used in open-pit mines. These trucks are autonomous and can be operated by AI which make human supervision redundant while, at the same time, increasing efficiency and productivity. Other abilities such as finger dexterity, peripheral vision or depth perception, easily and effectively automated through the use of smart sensors of sophisticated robots, are in surplus across a wide set of countries.

As mentioned above, among the many dimensions of technological change, advanced robotics is the one creating the most concerns. Acemoglu and Restrepo (2017a) argue that recent declines in the share of labour in national income and the employment to population ratio in the United States (e.g., Karabarbounis and Neiman, 2014; and Oberfield and Raval, 2014) support the claims that, as digital technologies, robotics and artificial intelligence penetrate the production workflows of many countries, workers will find it increasingly difficult to compete against machines, and their compensation will experience a relative or even absolute decline. Similarly, OECD (2017) shows that by being faster, stronger, more precise and consistent than workers, robots have vastly raised productivity on assembly lines in the automotive industry and that they are likely to keep doing so in an expanding range of sectors and processes as industrial robotics advances.

Evidence from the *OECD Skills for Jobs Database* and data from the International Federation of Robotics and Graetz and Michaels (2015) seems to support this hypothesis showing a negative correlation between the increase in robots per hours worked between 1993 and 2007 and the shortages of control precision abilities and of physical strength needs across countries (Figure 3.9).

Figure 3.8. Routine manual and physical skill needs

Panel A. Control precision



Panel B. Finger dexterity

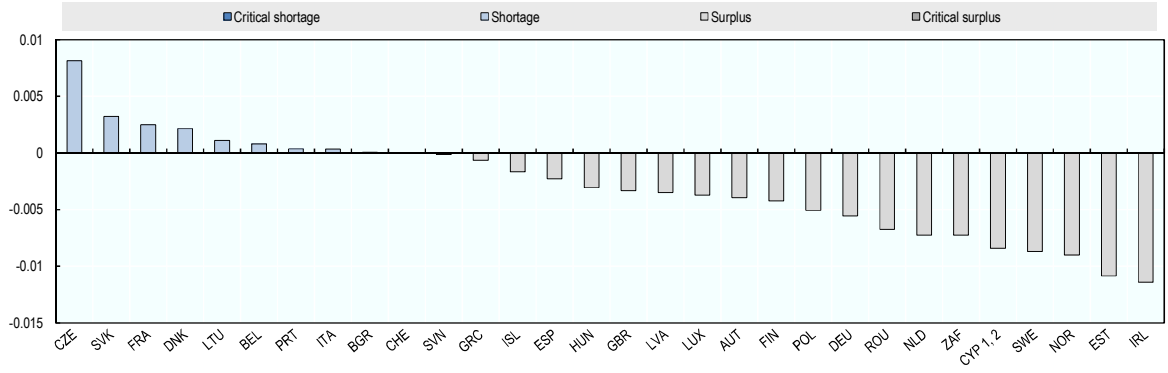
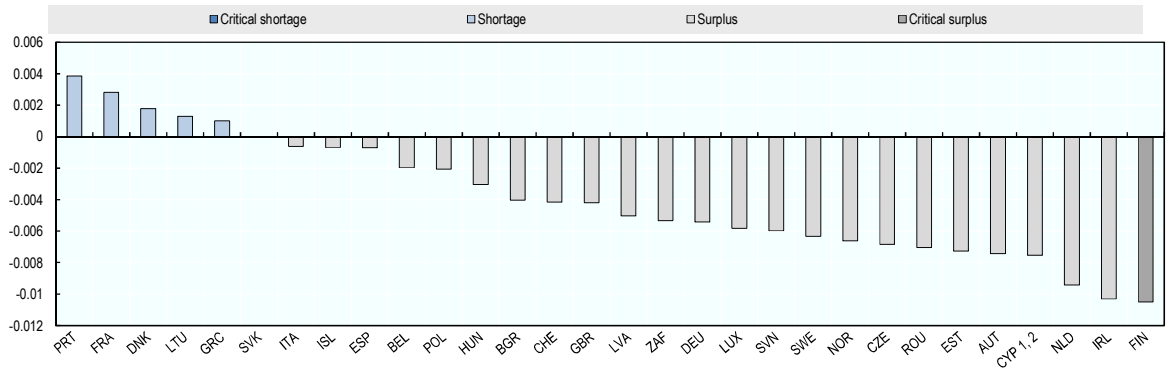
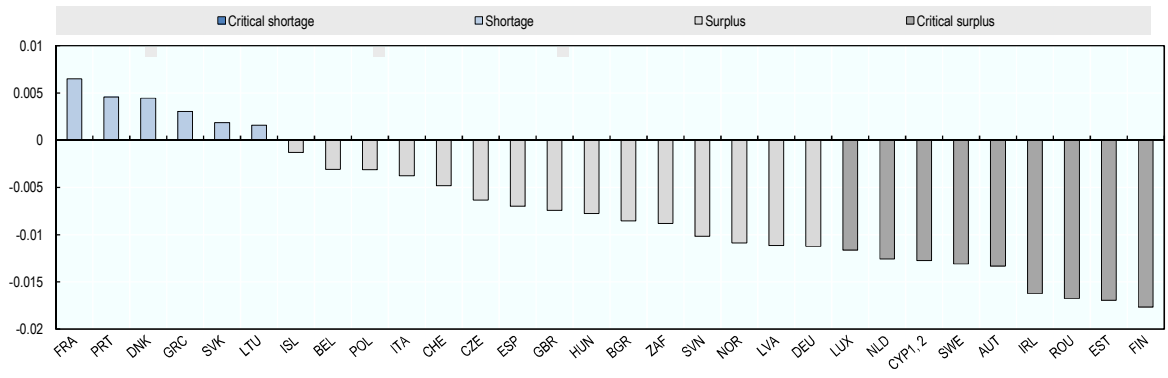


Figure 3.8. Routine manual and physical skill needs *(cont.)*

Panel C. Peripheral vision



Panel D. Depth perception



Note: Latest available year.

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. Values for the ability dimension vary between -0.025 and 0.035 across countries.

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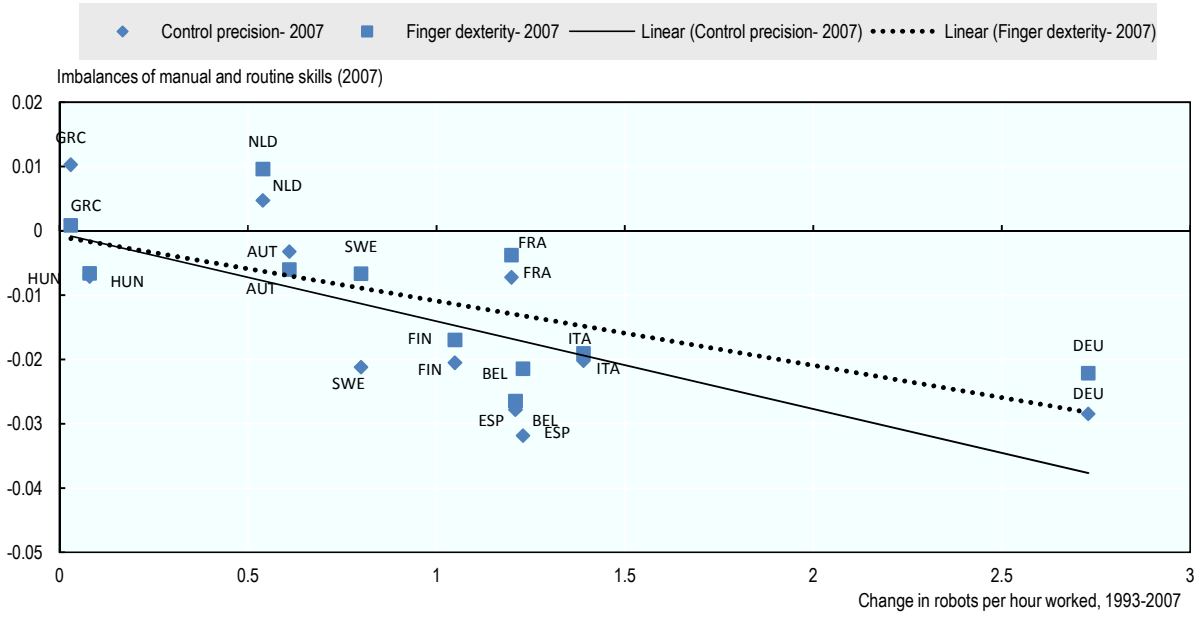
Source: *OECD Skills for Jobs Database.*

Faster growth in the penetration of robotics is associated with smaller needs (if not surpluses in most cases) of skills that are likely to have been replaced by machines. Physical and explosive strength, endurance and stamina are workers' characteristics that are increasingly less rewarded across almost all labour markets, especially in those countries that invested substantially in robots and machines. Though this evidence is suggestive, more analysis is needed to quantify the extent of these dynamics and to understand the mechanisms through which advanced robotics is reshaping the demand for manual and physical skills.

Figure 3.9. The link between robot use and routine and manual skill needs



Source: *OECD Skills for Jobs Database* and Graetz and Michaels (2015).

The time evolution of skill needs: a polarised picture

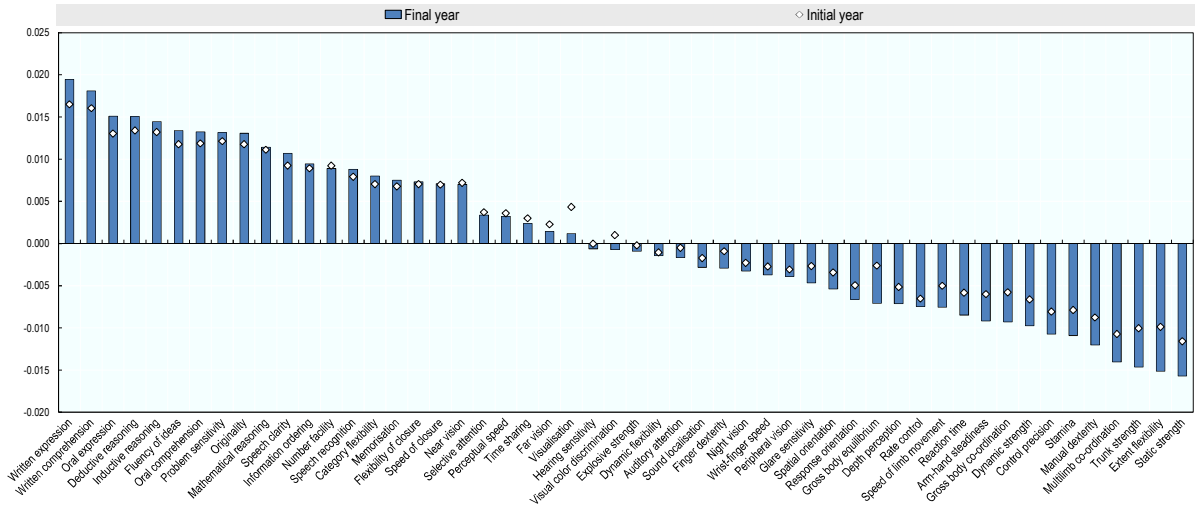
To help understand these dynamics, the *OECD Skills for Jobs Database* can be used to track the growth of skill imbalances over time for those countries for which underlying information is available in a time series format. Results in Figure 3.10 present these changes for a wide range of dimensions.[22]

The results show a strong polarisation between, on the one hand, needs for cognitive skills and manual/physical and routine skills on the other. While cognitive skills are generally in shortage, manual/physical as well as routine skills are instead in surplus across the countries examined. Interestingly, the results seem to suggest that the process by which cognitive skills are (have been) demanded in the labour market has become more acute over time leading to growing shortages in these skills across the economies considered. In a similar way, surpluses of manual/physical skills have become more profound over time leading to an increase in the observed polarisation across skills demands.

The changes in skill imbalances (both shortages and surpluses) have been more intense in those skills that were already at the top/bottom of their distribution (e.g. most in shortage or in surplus), widening the gap between the demand for cognitive skills and that for manual/physical and routine skills over time.

Figure 3.10. Change in imbalances over time

Selection of abstract, routine and manual skills; cross country average, Europe and South Africa



Note: Skills are ordered by their degree of shortage in the final year for which information is available.

Initial year is the first year for which all sub-indices are available. Details on initial and final years per country are available in the Annex Tables A.1 and A.2.

Source: *OECD Skills for Jobs Database.*

Multiple drivers may be behind this result and are likely to affect countries differently. At the aggregate level, however, results seem to hint to rapid technological change reshaping skill demands towards the high-end of the skill spectrum. Similarly, the surpluses of manual/physical as well as those of routine skills have become more acute over time, hinting to substantial changes in the productive patterns, likely linked to technological change and the introduction of advanced robotics as shown in Figure 3.9., that benefitted workers with cognitive skills and worsened the labour market outcomes of those using physical and routine skills in the workplace.

More generally, the results also suggest that, on average across the countries examined, the supply of cognitive skills has not been able to cope with the increasing demand and that education and training systems have been slow in adjusting to technological changes, delivering an insufficient supply of cognitive skills. Similarly, the evolution of skill imbalances and the starkly polarised picture between the strong (unsatisfied) demands for cognitive skills on the one hand, and surpluses of routine skills, on the other, is likely to be related to the failure of training and lifelong learning systems to endow older workers with the adequate skills to face the challenges arising from technological progress. Many older and low-skilled workers may find it difficult to adapt to these rapid changes, all the more because their skills are low and outdated relative to the demands generated by the new technologies.

Technology, organisational change in the workplace and skill needs

Adapting to rapid technological change is likely to require substantial changes in how work is organised in the workplace. Competitive pressures stemming from innovation and the speed of technological progress imply that the modern workplace is

in a state of constant change (OECD, 2013). As a result of these dynamics, tasks and work are likely to be regularly reorganised either to support the introduction of technology or to reduce costs or improve productivity. Changes in the organisation of work are already taking place. Across OECD and EU countries a substantial proportion of workers are in workplaces that have introduced new technologies and/or undergone significant restructuring in the way jobs and tasks are carried out (Eurofound, 2012). These dynamics can have important repercussions on the intensity with which managerial skills are required to organise, monitor and effectively implement such organisational changes.

Evidence in Figure 3.11 shows the relationship between the share of workers who report to have undergone substantial restructuring or reorganisation in their current workplace[23] (Eurofound, 2012) and the needs of a variety of managerial skills, abilities and knowledge types in the labour market. Countries that underwent substantial restructuring in the workplace (e.g. Finland, Sweden or Denmark and Estonia) are, for instance, also those showing stronger pressures (shortages) in Administration and Management knowledge. Results show that, across the economies analysed, the organisational restructuring in the workplace stemming from an increasingly more unpredictable future, is putting pressure on workers to develop autonomy in making decisions and independence in the organisation of tasks. Similarly, other skills such as co-ordination with others and ability to lead others are on the rise in countries where organisational restructuring has been deeper.

Figure 3.11. Link between organisational change and management-related skill needs (European countries)

Panel A. Administration and management knowledge

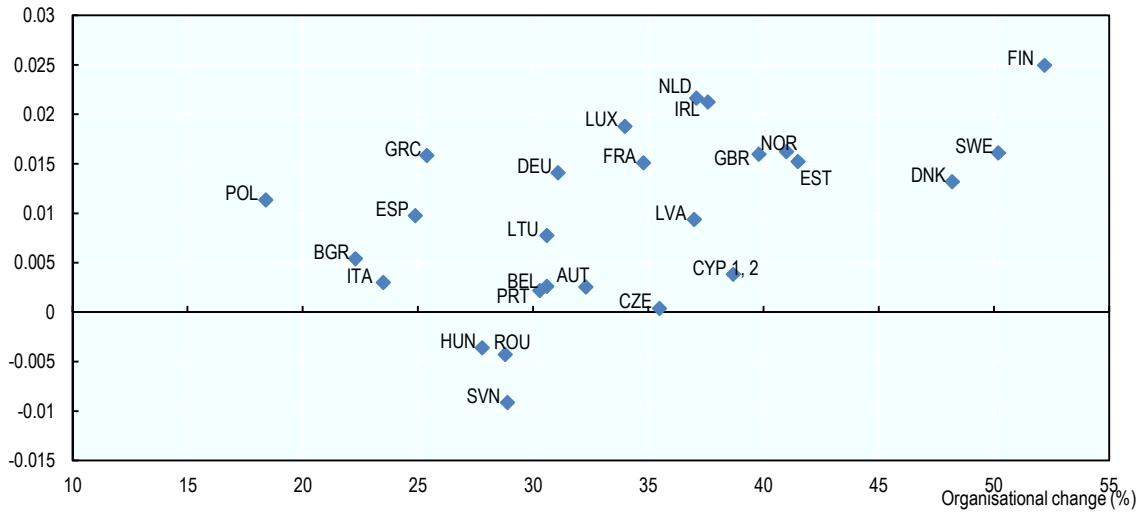
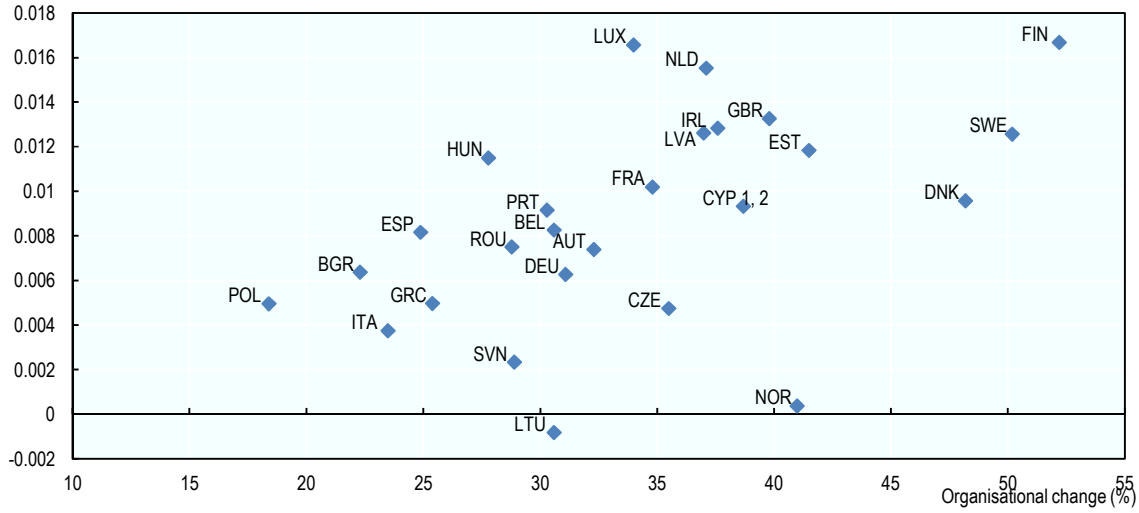
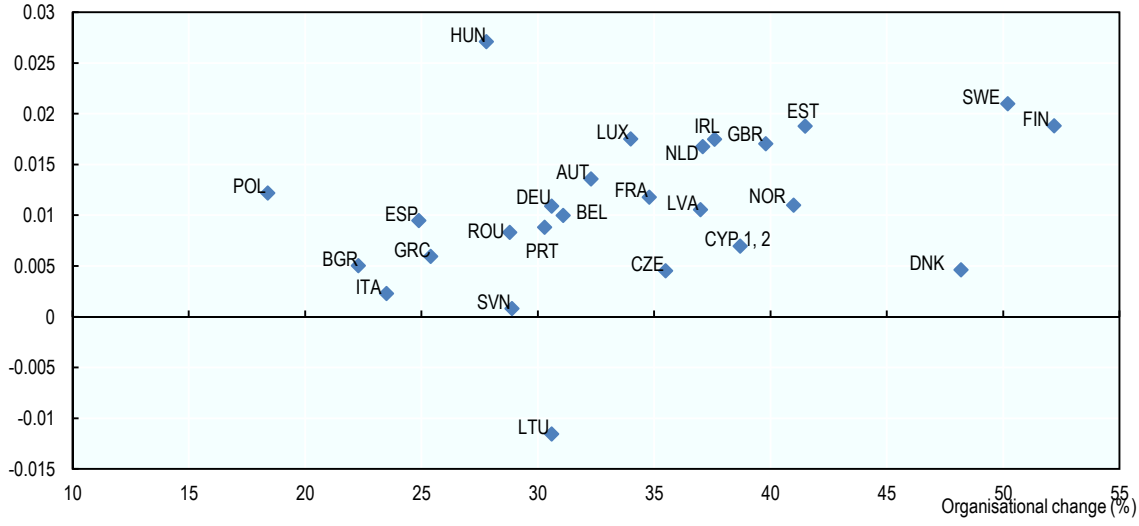


Figure 3.11. Link between organisational change and management-related skill needs (European countries) *(cont.)*

Panel B. Freedom to make decisions



Panel C. Co-ordinate or lead others



Note: Latest available year for skill needs indicator.

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Source: *OECD Skills for Jobs Database* and European Working Conditions Survey (2010).

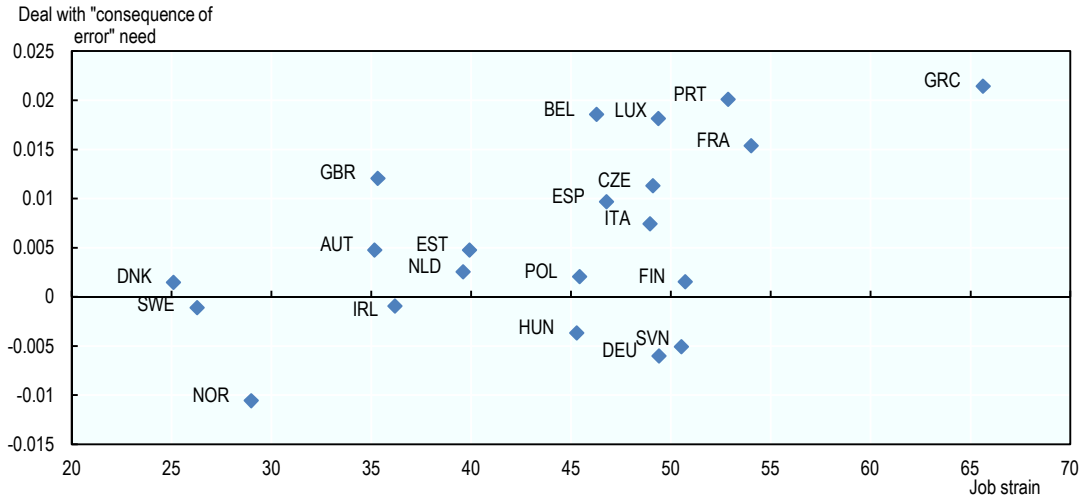
The importance of adapting the organisation of work to address the new challenges stemming from technological change is of paramount importance. Countries and firms unable to adjust their productive processes and work organisation to cope with the increasingly competitive pressure coming from technological progress are likely to suffer from lower job quality (OECD, 2016) and especially higher levels of *job strain.*[24] Organisational change is, for instance, important to re-design tasks and jobs so that workers are in an optimal position to adopt and use new technologies effectively. Results show, for instance, that administration and management knowledge is fundamental to reap the benefits of organizational change and that countries moving towards a substantial reorganisation in the workplace will also need to develop these skills more broadly. While the question on how to develop and strengthen this *knowledge* is beyond the scope of this report, evidence from O*NET shows that managerial occupations (e.g. chief executives, industrial production managers, education administrators) apply the knowledge of administration and management in areas such as project management, enterprise resource planning or human resources management.[25]

Failure to adapt the production and the organisation of work to the new standards imposed by rapid technological change is likely to increase the level of job demands as well as time pressure. Workers in "inefficient" workplaces will be less effective than their competitors facing, as a result, an increasing level of job strain to which they will be exposed daily.

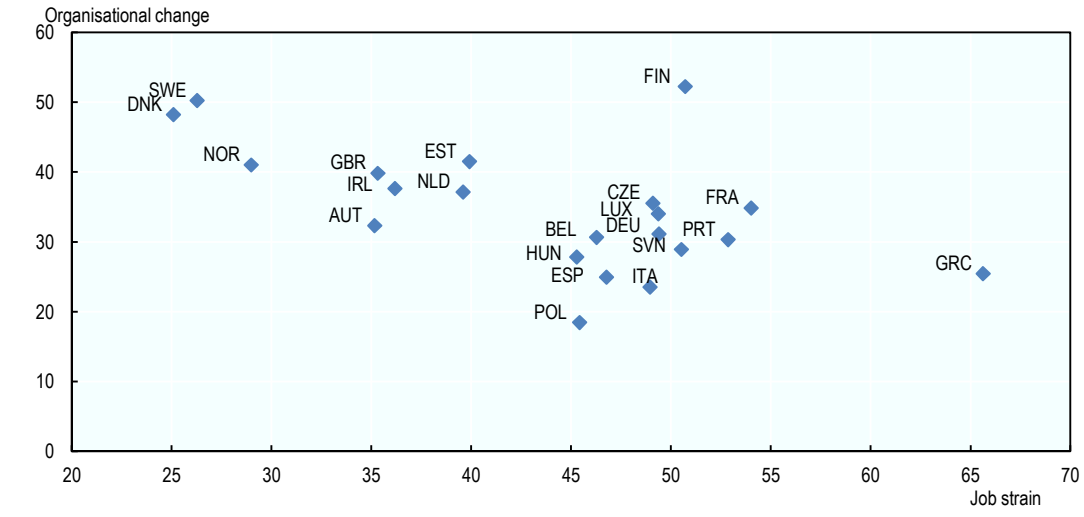
Evidence that combines data from the *OECD Skills for Jobs Database* with information coming from the *OECD Job Quality Database* shows a positive association between the degree of job strain suffered by workers and the shortages of several skills needed to cope with such strain across countries. Results in Figure 3.12 show, for instance, the strong positive association between shortages of workers able to cope with difficult and stressful decisions[26] and the extent of job strain across countries. Moreover, results in Panel B show a negative correlation between the extent of organisational change and job strain, highlighting how countries that have been able to effectively reorganise work and tasks to adapt and exploit technological change are both experiencing smaller shortages of critical problem solving and adaptability skills as well as lower degrees of job strain overall.

Figure 3.12. Job strain, skill shortages and organisational changes in the workplace (European countries)

Panel A. Ability to deal with "consequence of error" and job strain



Panel B. Organisational change and job strain



1. Latest available year for skill needs indicator.

Source: *OECD Skills for Jobs Database, OECD Job Quality Database* and European Company Survey (2010).

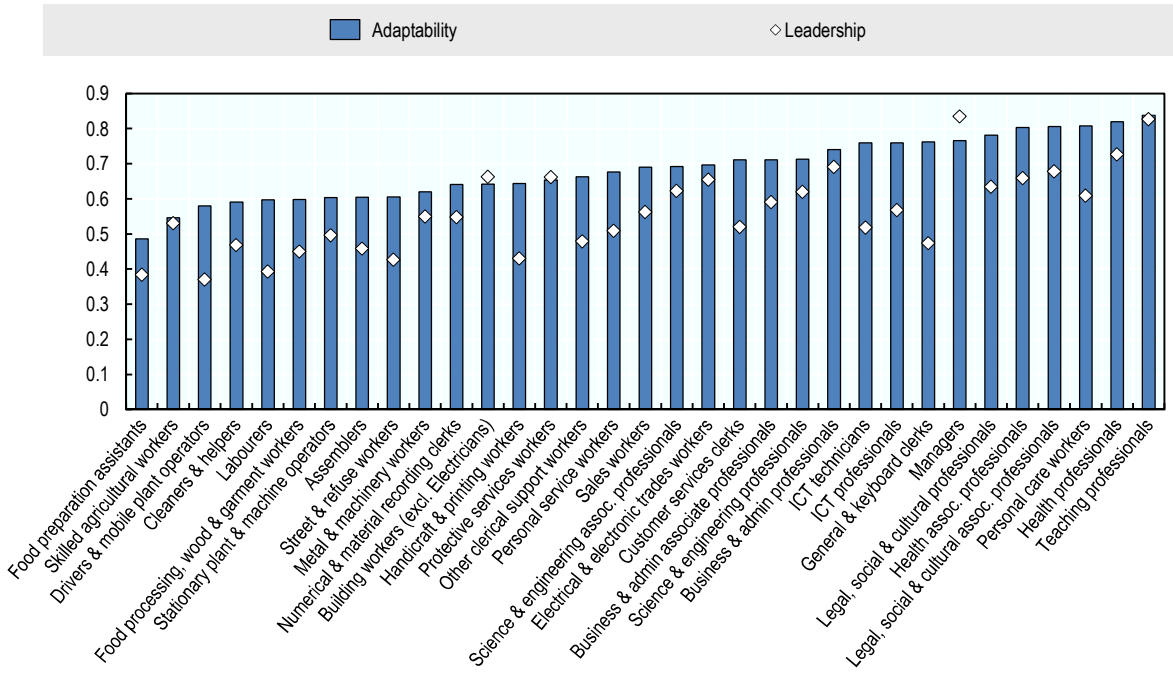
Soft skills

In addition to technical and cognitive skills, individuals also need a set of "soft" or social skills to be successful in their jobs. While a commonly agreed definition of soft skills does not exist, they generally encompass skills or character qualities such as leadership, initiative, adaptability and persistence. The growing importance of social skills in the labour market has already been documented in the literature. Deming (2015), for instance, shows that in the United States employment growth in jobs with high social skill requirements has been substantial in the last decades. Growth has been particularly strong in jobs that combine high levels of both cognitive and social skills.

It is argued by many that technological progress could be a potential explanation for the growing importance of social skills, as social skills cannot (easily) be automated.

All jobs require a certain level of soft skills, but the intensity with which occupations make use of soft skills can differ significantly between occupations. As an example, Figure 3.13 shows the intensity of adaptability and leadership soft skills for each occupation grouped at the 2-digit level as derived from the O*NET database. Adaptability, defined as being open to change (positive or negative) and to considerable variety in the workplace, is required in all occupations, but all the more so in occupations related to the social sector, like teaching professionals, health professionals and personal care workers. The level of adaptability is lower, instead, among elementary occupations like food preparation assistants and cleaners, but also for drivers and agricultural workers. Similarly, some degree of leadership skill (i.e. willingness to lead, take charge, and offer opinions and direction) is required in all occupations, but it is much more important for managers and teachers than for workers in elementary occupations.

Figure 3.13. Adaptability and leadership requirements per occupation (2-digit ISCO-08)



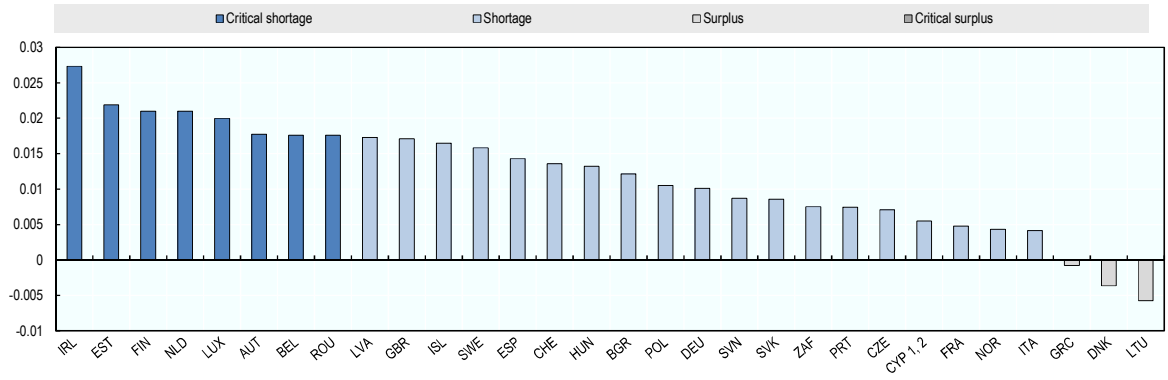
Source: O*NET; authors' calculations.

Evidence on imbalances in adaptability and leadership, as well as attention to detail and persistence is presented in the Figure 3.14. The ranking of countries is relatively similar across soft skills. The exception is leadership skills and attention to detail, defined as being careful about detail and thorough in completing work tasks, for which there is no significant correlation between country rankings. The strongest correlation is found between leadership skills and persistence, defined as requiring persistence in the face of obstacles. The four soft skills from Figure 3.14 are in shortage in almost all countries. Some small surpluses are observed in Lithuania, Denmark, Greece and Slovenia. The finding of deep soft skill shortages is in line with more subjective survey

evidence, like the recent PayScale management survey which showed that over 40% of respondents felt like graduates lack critical thinking, attention to detail, communication, ownership and leadership skills (PayScale, 2016).

Figure 3.14. Soft skill imbalances (Europe and South Africa)

Panel A. Adaptability



Panel B. Attention to details

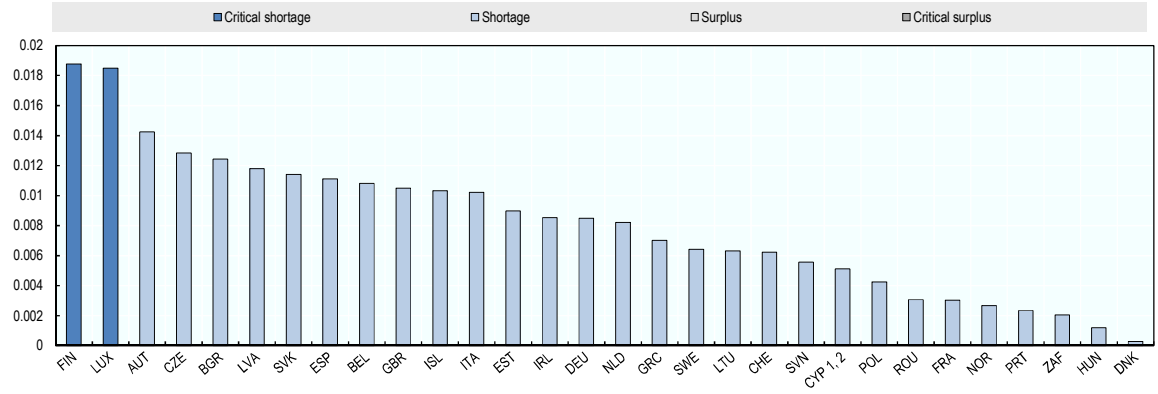
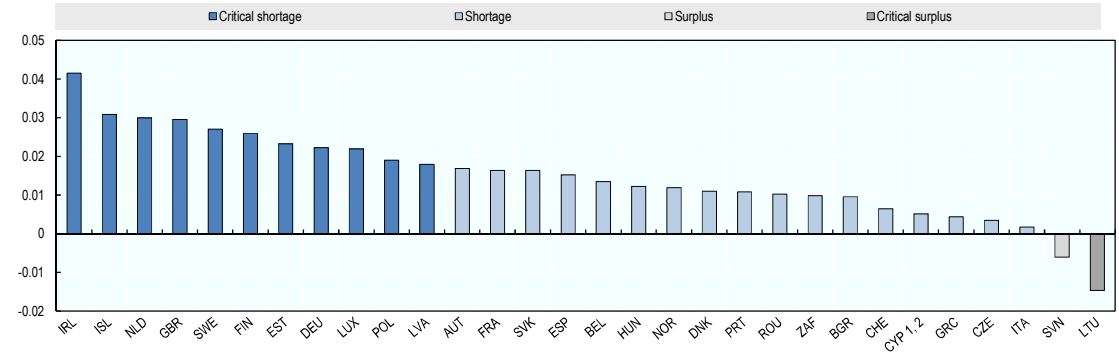
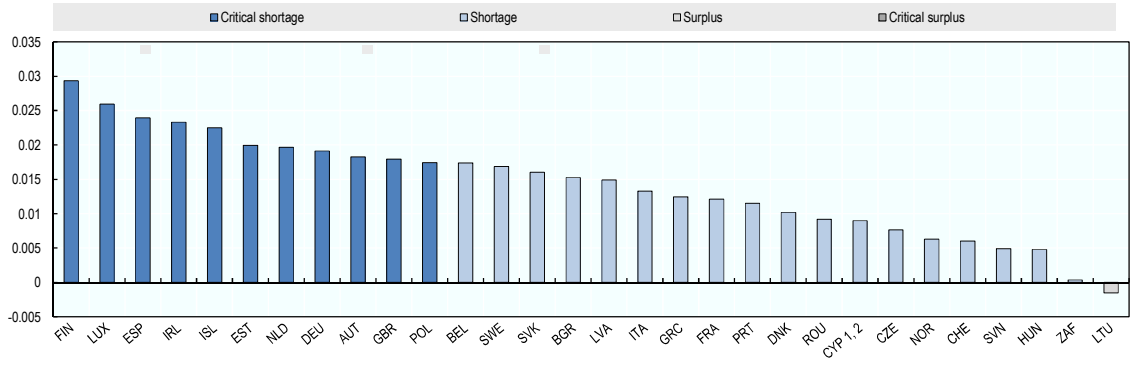


Figure 3.14. Soft skill imbalances (Europe and South Africa) *(cont.)*

Panel C. Leadership



Panel D. Persistency



Note: Latest available year.

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. Values for the work styles dimension vary between -0.019 and 0.053 across countries.

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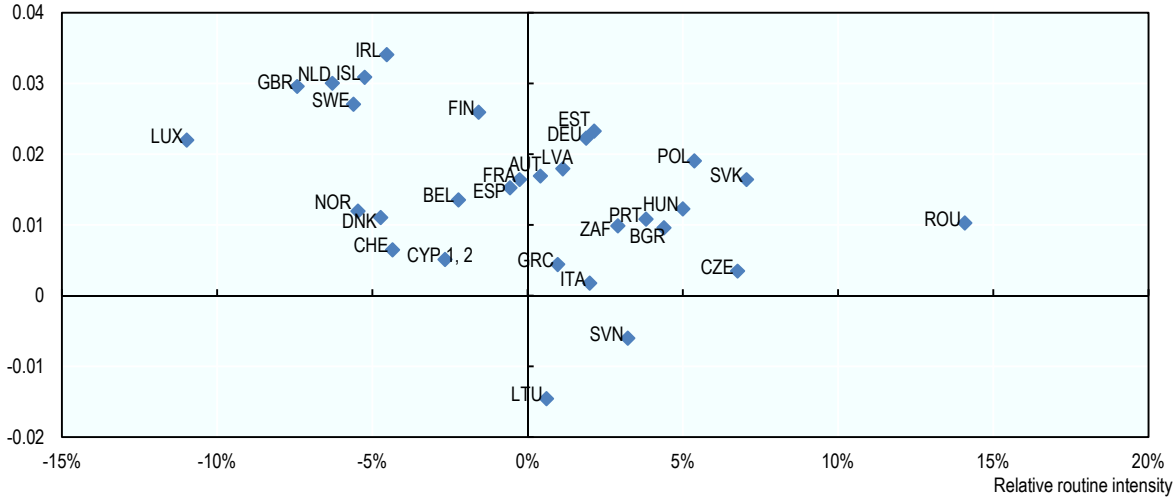
Source: *OECD Skills for Jobs Database*.

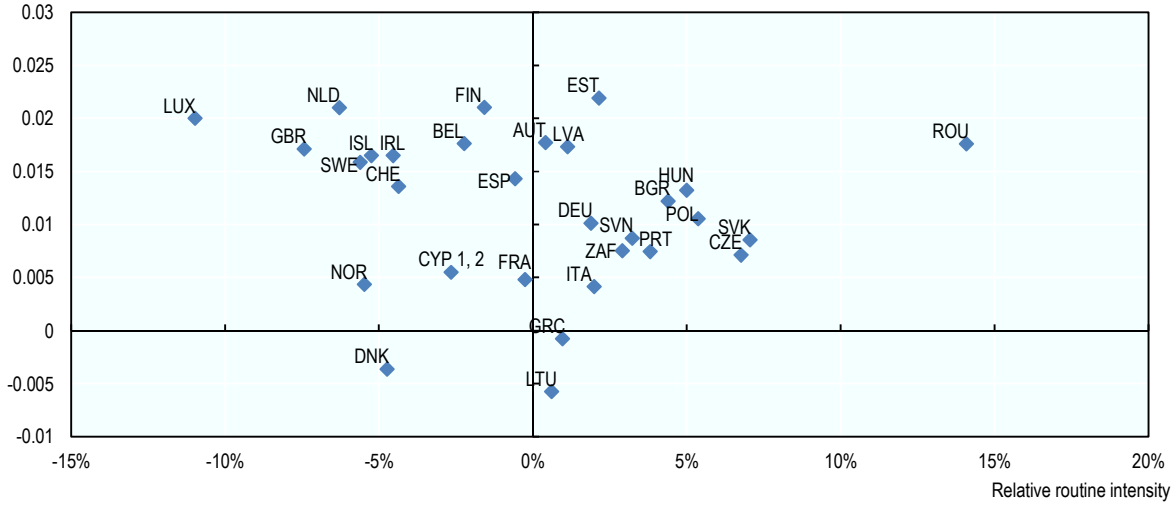
As mentioned above, the growing importance of soft skills could potentially be linked to technological progress. With technology replacing routine cognitive and routine manual tasks, the employment share of these routine occupations has been falling. Employment in occupations consisting of tasks that are complementary to automation, and often require non-automatable soft skills, has been on the rise. Figure 3.15 explores this relationship by comparing the routine intensity of each country's economy to the imbalance in leadership and adaptability skill need. Routine intensity is measured as the employment intensity in occupations requiring routine cognitive and manual skills, following the definition of Autor and Acemoglu (2011). As expected, countries with relatively low routine intensity generally have stronger shortages of leadership and adaptability skills.

Figure 3.15. Routine intensity and soft skill need (Europe and South Africa)

Panel A. Leadership skill need



Panel B. Adaptability



Note: Latest available year.

Routine intensity is measured as the employment weighted average value of O*NET variables "Importance of repeating the same tasks", "Importance of being exact or accurate", "Structured v. unstructured work", "Pace determined by speed of equipment", "Controlling machines and processes" and "Spend time making repetitive motions". These employment weighted averages are transformed into relative values by calculating the distance from the country mean. The final values are averages of these relative values of the five O*NET variables.

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Source: *OECD Skills for Jobs Database.*

Using the *OECD Skills for Jobs Database* at the micro level, it is possible to analyse whether there is a relationship between soft and cognitive skill requirements of occupations and their degree of imbalance. The OLS regression of the occupational shortage indicator on the O*NET values of cognitive abilities and soft skills (i.e. adaptability, attention to detail, leadership and persistence) shows that both skill types have a significant positive relationship with the degree of shortage (Table 3.4). This result suggests, in turn, that occupations with similar cognitive skill requirements are more likely to be in shortage when they also have high soft skill requirements. Adding an interaction term of the two skill types also shows that the impact of soft skill requirements on occupational shortages is bigger at higher cognitive skill requirement levels, which is consistent with Deming's (2015) finding of particularly strong growth in jobs combining cognitive and soft skills.

Table 3.4. The link between soft and cognitive skill requirements and occupational imbalances

	Final year only		All years	
Cognitive abilities	2.389***	-2.946	2.031***	-1.807*
Soft skills	0.664*	-1.111	1.321***	0.045
Interaction between cognitive and soft skills	..	7.749	..	5.575***
Number of observations	*981*	*981*	*11 028*	*11 028*

Note: Regressions include country-year dummies. The dependent variable is the occupational shortage indicator. Soft skills are a combination of adaptability, attention to detail, leadership and persistence. ***Significant at the 1% level, * significant at the 10% level (robust standard errors).

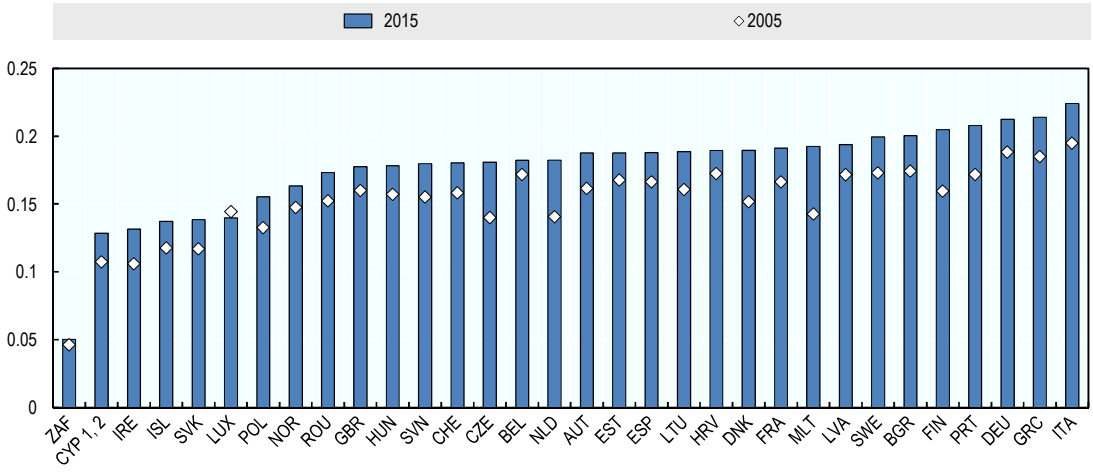
Population ageing

Rising life expectancy and declining fertility rates in developed countries have led to significant changes in the age structure of populations over the last decades. The share of the population aged 65 or above in the total population has been on the rise, and is now close to 20% in most European countries (Figure 3.16). The South African population structure differs significantly from that of European countries, with the elderly population only representing 5% of the total population. Nonetheless, this share has increased significantly in the last decades also in South Africa. Projections suggest that the share of the elderly population will increase significantly in the coming years, reaching around 25% to 30% in European countries and 10% in South Africa by 2050.[27]

As older people have different needs in terms of products and services than younger people, population ageing will have an impact on the type of skills that are needed in the labour market. An ageing population will likely require more healthcare and social services, and it will therefore be increasingly necessary to develop adequate healthcare knowledge and social skills. If the development of these skills and knowledge does not match the speed of the demand, shortages might arise.

Figure 3.17 explores whether countries that experienced stronger growth in the share of the older population also have bigger shortages of healthcare professionals.[28] The results seem to confirm this hypothesis. In general, countries with stronger population ageing show larger shortages of healthcare professionals. The main exception is Luxembourg, which has a strong shortage of health professionals but its older population remained almost constant in the period 2005-15. Without this outlier, the positive correlation in Figure 3.17 is found to be statistically significant.

Figure 3.16. Size of the older population (65+), Europe and South Africa (2005, 2015)



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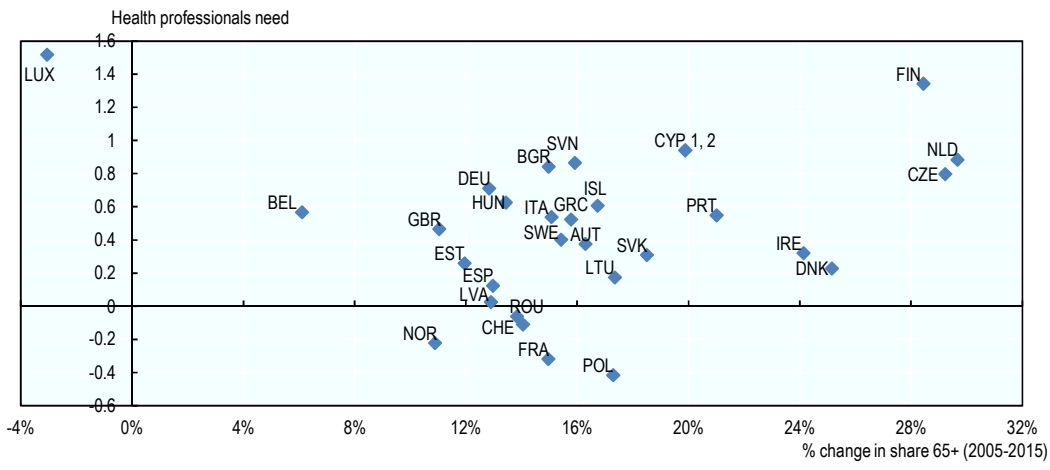
Source: United Nations World Population Prospects: The 2015 Revision.

Figure 3.17. The link between population ageing and health professionals need



Note: Does not include South Africa. Health professionals need refers to the latest available year.

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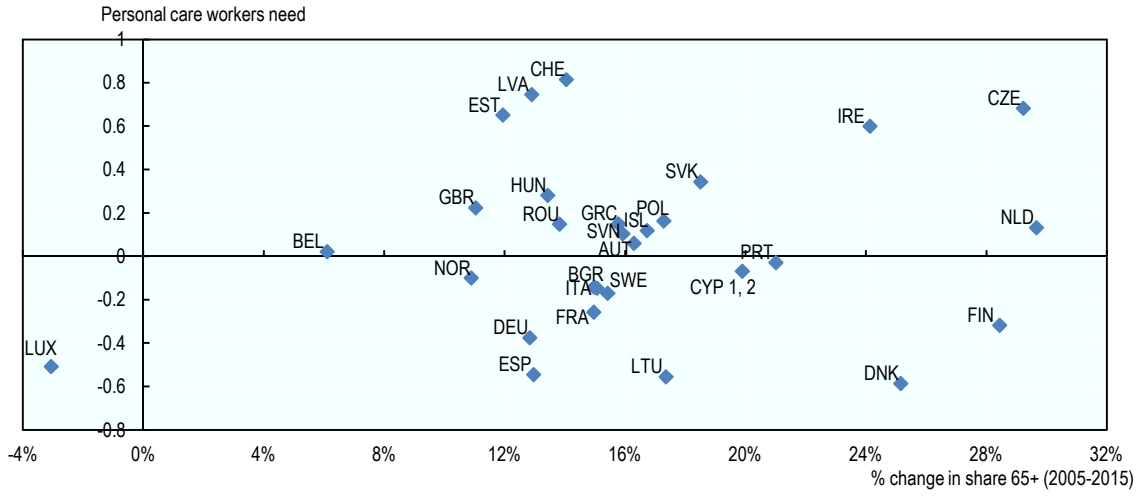
Source: *OECD Skills for Jobs Database*; United Nations World Population Prospects: The 2015 Revision.

Similarly, countries with older populations might experience stronger needs for personal care workers. Figure 3.18 shows that there is no significant relationship between ageing population and personal care need. However, this is likely to be related to the fact that personal care workers include both: i) Child care workers and teachers' aides; and ii) Personal care workers in health services. The need for childcare workers and teachers' aides is not expected to be positively correlated with population ageing.

Figure 3.18. The link between population ageing and personal care workers need



Note: Does not include South Africa. Personal care workers need refers to the latest available year.

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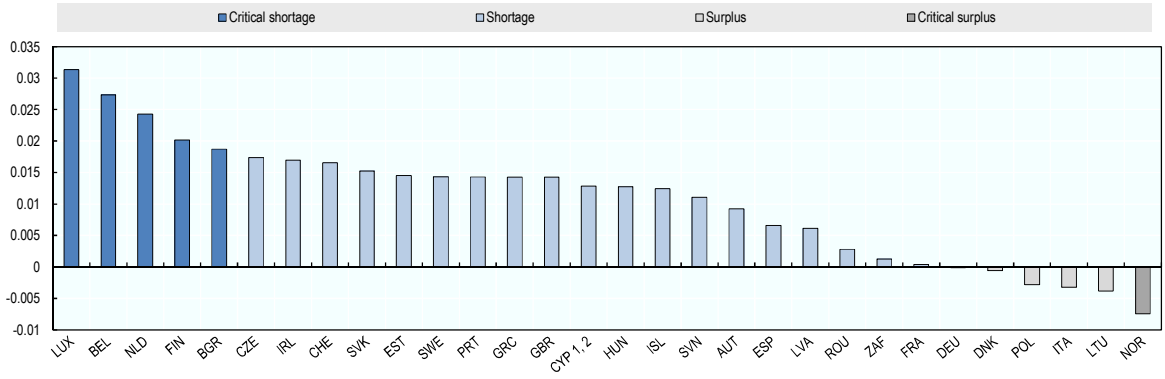
Source: *OECD Skills for Jobs Database*; United Nations World Population Prospects: The 2015 Revision.

Imbalances in healthcare and personal care occupations are of course not only the result of an increased demand for those services as a result of population ageing. In many countries the supply of healthcare and personal care workers is weak due to the perceived unattractiveness of some of the associated jobs. In some countries, like for example South Africa, the availability of healthcare professions is limited because of substantial emigration of healthcare graduates (OECD, 2004). Many OECD countries use quotas on the number of students admitted to certain programmes in healthcare-related education (*numerus clausus*) as a way to balance supply and demand. In view of the existing and anticipated shortages, a range of countries have increased these quotas in the last years (OECD, 2016).

To satisfy the needs for care of an ageing population, adequate knowledge of medicine should also be available in the working-age population. Figure 3.19 gives an overview of the imbalances in medicine and dentistry knowledge across European countries and South Africa. Most countries are currently experiencing shortages in medicine and dentistry knowledge, with the biggest shortages found in Bulgaria, Finland, the Netherlands, Belgium and Luxembourg.

Figure 3.19. Medicine and dentistry knowledge imbalances



Note: Latest available year. 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. Values for the knowledge dimension vary between -0.040 and 0.056 across countries.

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Source: *OECD Skills for Jobs Database.*

Individuals working in the healthcare or personal care sector also require specific social skills to be successful in their jobs. Figure 3.20 shows that "Concern for others" and "Social orientation" are in shortage in most European countries and South Africa. The biggest shortages of "concern for others" can be found in the Netherlands, Estonia, Belgium, Switzerland, Hungary and Ireland, whereas "Social orientation" is also strongly in shortage in Romania.

Figure 3.20. Imbalances in social skills related to care professions

Panel A. Concern for others

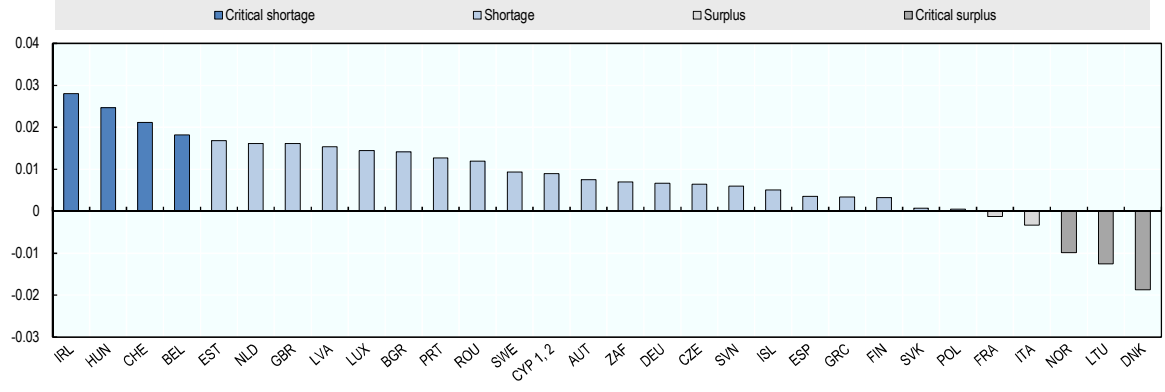
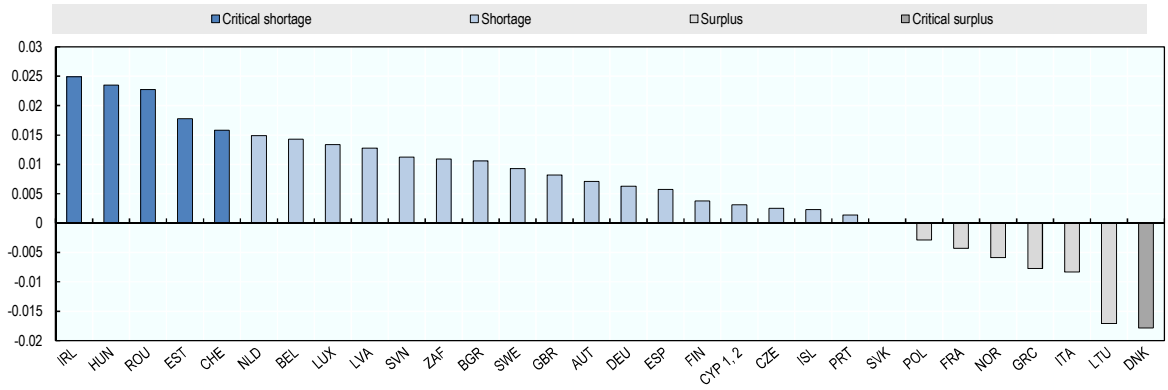


Figure 3.20. Imbalances in social skills related to care professions *(cont.)*

Panel B. Social orientation



Note: Latest available year.

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. Values for the work styles dimension vary between -0.019 and 0.053 across countries.

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Source: *OECD Skills for Jobs Database.*

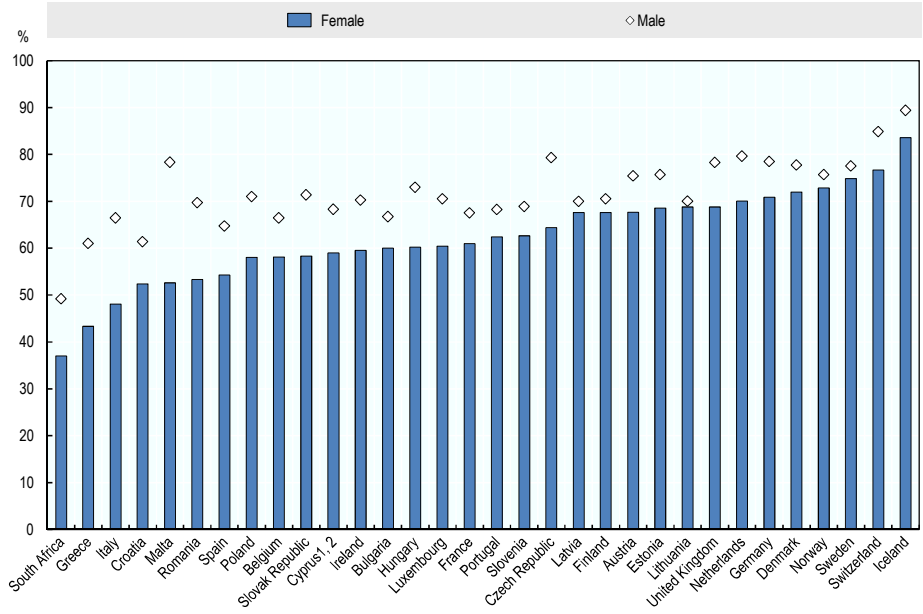
Changing labour force composition: Women and older workers

Gender: Increased female labour market participation

Over recent decades, the participation of women in the labour market has increased considerably. Across OECD countries, the female prime-age (25 to 54) employment rate rose from an average of 54% in 1980 to 71% in 2010 (Thévenon, 2013). Despite this strong increase, the employment rate of women remains below the male employment rate in European countries and South Africa (Figure 3.21). The gap between male and female employment rates is smallest in Lithuania, Sweden, Norway and Finland at less than 3 percentage points. The biggest gaps are observed in Malta (25.7 percentage points), Italy (18.4 percentage points), Greece (17.7 percentage points) and Romania (16.4 percentage points), but also in the Czech Republic, Hungary, Ireland, Luxembourg, Poland, Slovak Republic, Spain and South Africa the gap exceeds 10 percentage points.

Figure 3.21. Female and male employment rates (2016, Europe and South Africa)

Aged 15-64



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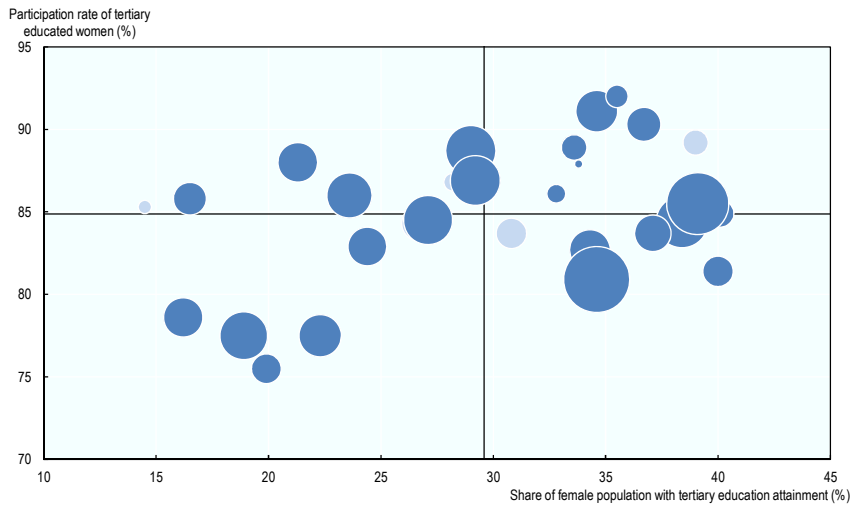
Source: *OECD Employment Database*, Eurostat.

There are big differences in the occupational structure of male and female employment. Despite efforts to reduce occupational gender segregation, female employment remains strongly concentrated in specific occupations. Across European countries and South Africa, the share of women is biggest in care-related occupations (healthcare, personal care), teaching-related occupations, administrative occupations (clerks) and certain manual occupations (cleaners and helpers, food preparation assistants). If the occupations in which women tend to specialise are mainly in surplus, this signals that there is a need for women to move away from their traditional occupational choices. If, on the contrary, female-dominated occupations are mainly in shortage, this implies that more labour should move into these occupations, both male and female. The correlation between the share of female workers and the occupational shortage indicator is only statistically significant for four countries: In the Netherlands, Estonia and Ireland, female-dominated occupations are more often in shortage (positive correlation), while in France, female-dominated occupations are more often in surplus (negative correlation). Overall, the lack of significant relationship in most countries suggests that female-dominated occupations do not differ from other occupations in terms of their likelihood of being in shortage or surplus.

A higher participation of women in the labour market implies a larger supply of skills. Therefore, countries with higher female labour participation might experience

fewer shortages, especially in female-dominated occupations. Figure 3.22 explores this relationship for health professionals, as healthcare occupations have an above average share of female workers in the majority of countries. Overall, the countries with the smallest healthcare shortages are those that have a large share of tertiary educated women and a high participation rate of tertiary educated women. The relationship is, however, not very strong, and there are countries with large shares of tertiary-educated women and average participation rates that have big shortages, and one country (Romania) that has a small healthcare surplus while having few tertiary-educated women and average participation. This suggests that there may be many other factors that have an impact on shortages in addition to female labour supply. In other female-dominated occupations, such as teachers and clerks, there is no clear relationship between participation and shortages, confirming that there are a host of factors contributing to imbalances.

Figure 3.22. The link between tertiary-educated female labour supply and health professionals needs (Europe)

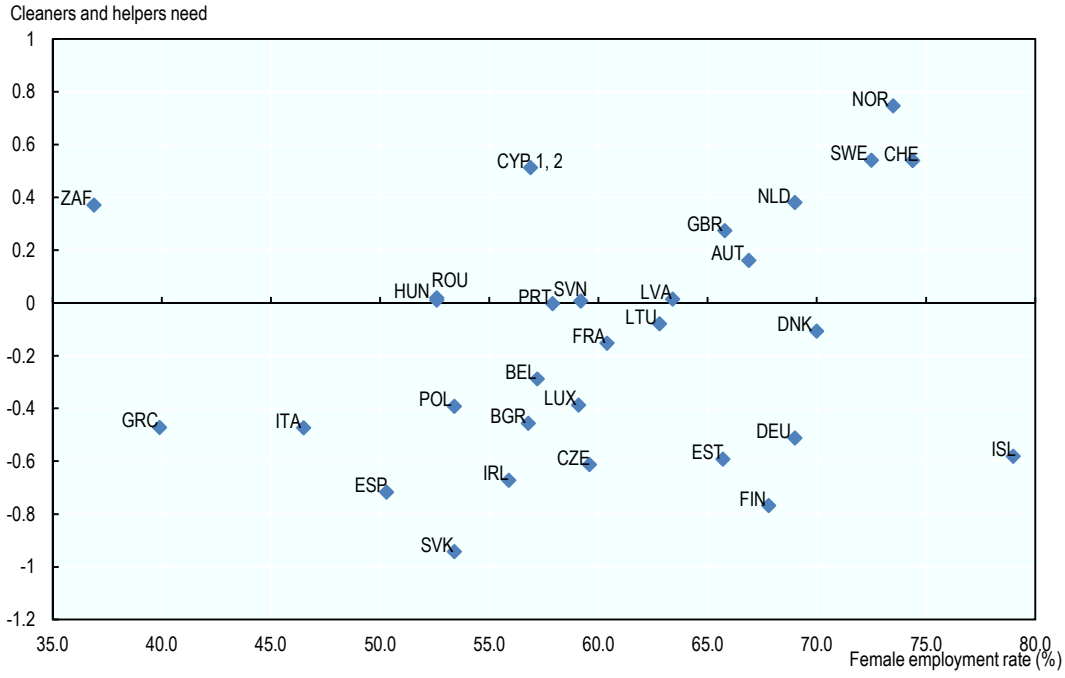


Note: The size of the bubbles refers to the degree of Health Professionals occupational imbalance. Lighter blue bubbles represent surpluses.

Source: *OECD Skills for Jobs Database*, Eurostat.

Higher female labour market participation does not only lead to a larger supply of certain skills, but also to a stronger demand for some. Employed women are likely to outsource some of their unpaid work, such as childcare and household tasks (e.g. cleaning). Figure 3.23 shows that countries with higher female employment rates have also stronger shortages in the "cleaners and helpers" occupation. While the correlation in the case of "cleaners and helpers" is clearly positive, this is not the case for other occupations, such as personal care workers. This is not surprising, as in many occupations the increased demand can be (partially) compensated by the bigger supply of female labour.

Figure 3.23. Female employment rate and "cleaners and helpers" need (Europe and South Africa)



Note: Latest available year for skill need indicator, 2013 for employment rate. Employment rate refers to female population aged 15-64.

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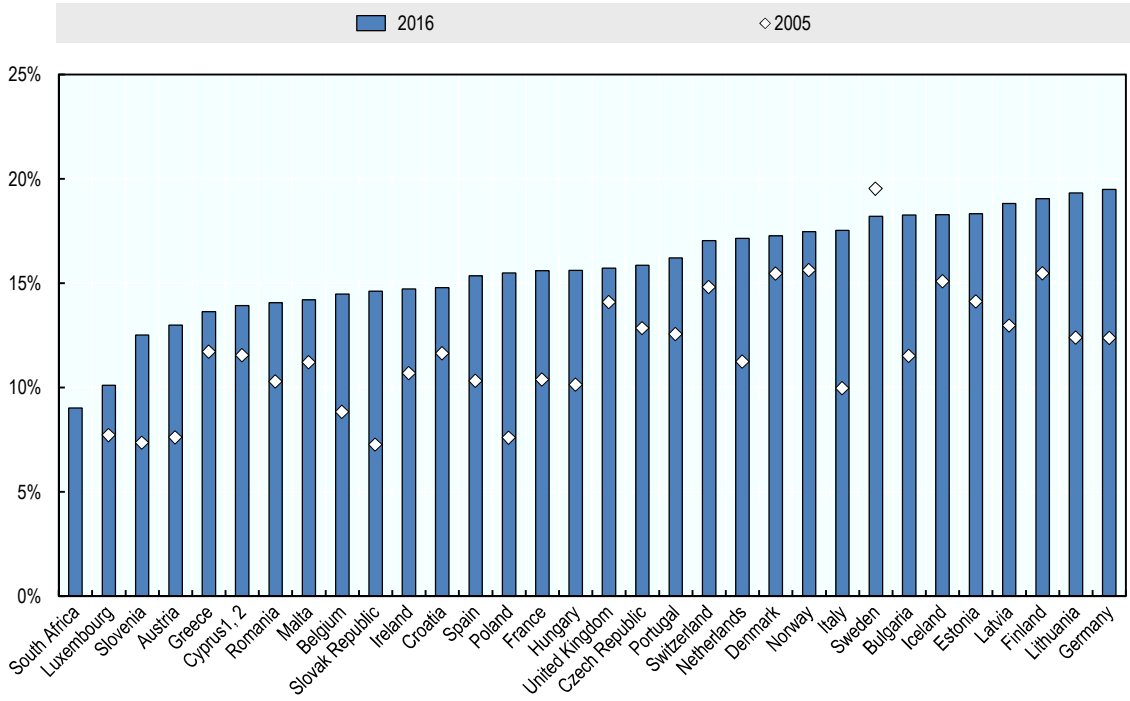
Source: *OECD Employment Database,* Eurostat, *OECD Skills for Jobs Database.*

Older workers and skills obsolescence

As the population of developed countries is ageing, the age structure of the active population has changed. In combination with changes in retirement regulations, this has resulted in a larger share of workers aged 55-64 in total employment (15 to 64) in most countries (Figure 3.24). The Adult Skills Survey (PIAAC) showed that older individuals (55-64) have significantly lower proficiency in literacy and numeracy then their younger counterparts (25-32). This can be explained both by differences in quantity and quality of education across generations (i.e. cohort effect) and the deterioration of skills with age (i.e. age effect). Better skill use and on-the-job training could reduce skill gaps between younger and older workers (Paccagnella, 2016).

Figure 3.24. Share of 55-64 year-olds in total employment (Europe and South Africa)



Note: Total employment refers to employment of 15-64 year-olds.

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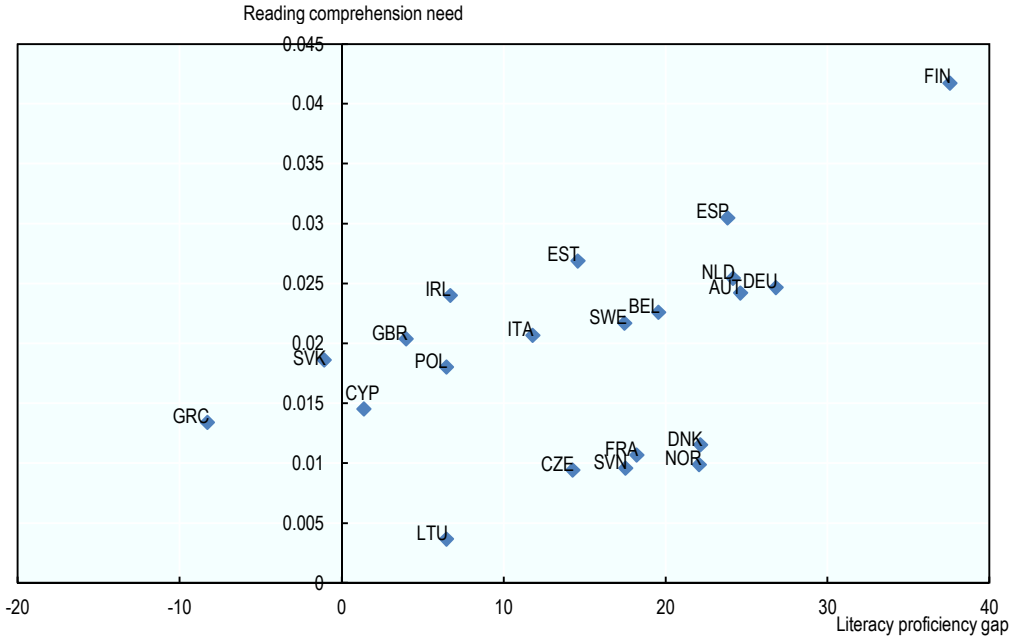
Source: *OECD Employment Database*, Eurostat.

In countries where the cognitive skill gap between older and younger workers is bigger, shortages in key information processing skills could be expected to be bigger. Figure 3.25 confirms this relationship for reading comprehension, written expression and mathematical reasoning: the bigger the gap in literacy proficiency, the larger the shortages in reading comprehension and written expression; and the bigger the numeracy proficiency gap, the larger the mathematical reasoning shortage.

Figure 3.25. Link between age-related skill gaps and information processing skill shortages

25-34 year-olds minus 55-64 year-olds

Panel A. Reading comprehension



Panel B. Written expression

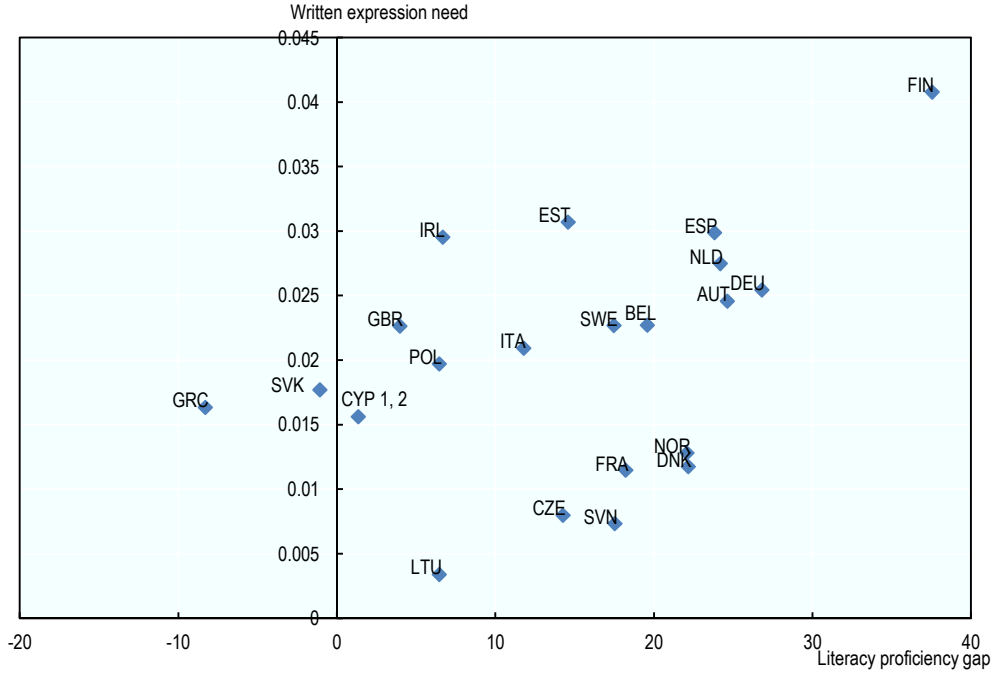
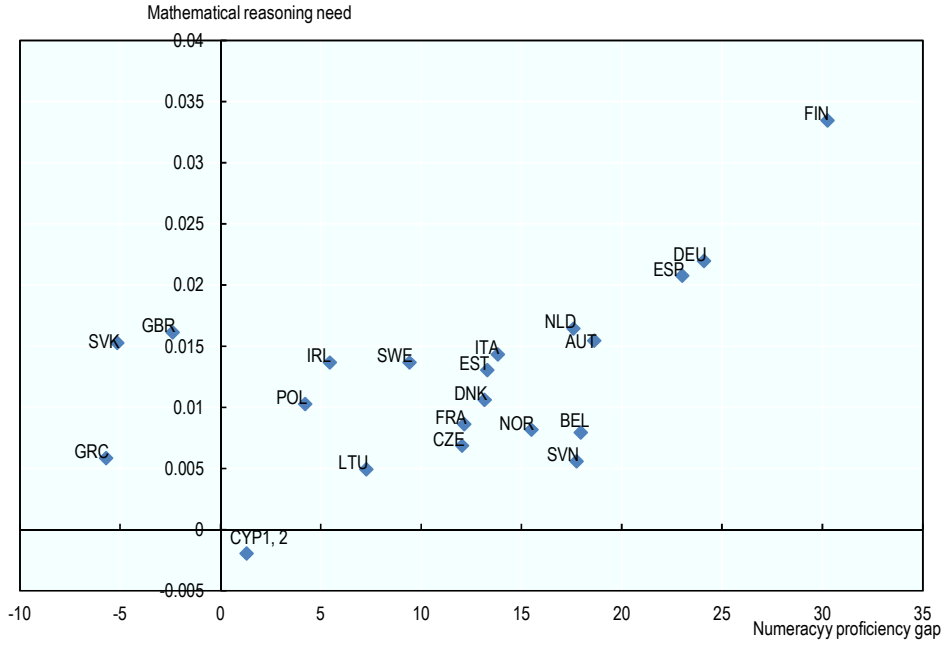


Figure 3.25. Link between age-related skill gaps and information processing skill shortages *(cont.)*

25-34 year-olds minus 55-64 year-olds

Panel C. Mathematical reasoning



Note: For literacy and numeracy proficiency United Kingdom only includes England, Belgium only includes Flanders.

Skill proficiency gaps are corrected for gender, education, immigrant and language background and parents' educational attainment.

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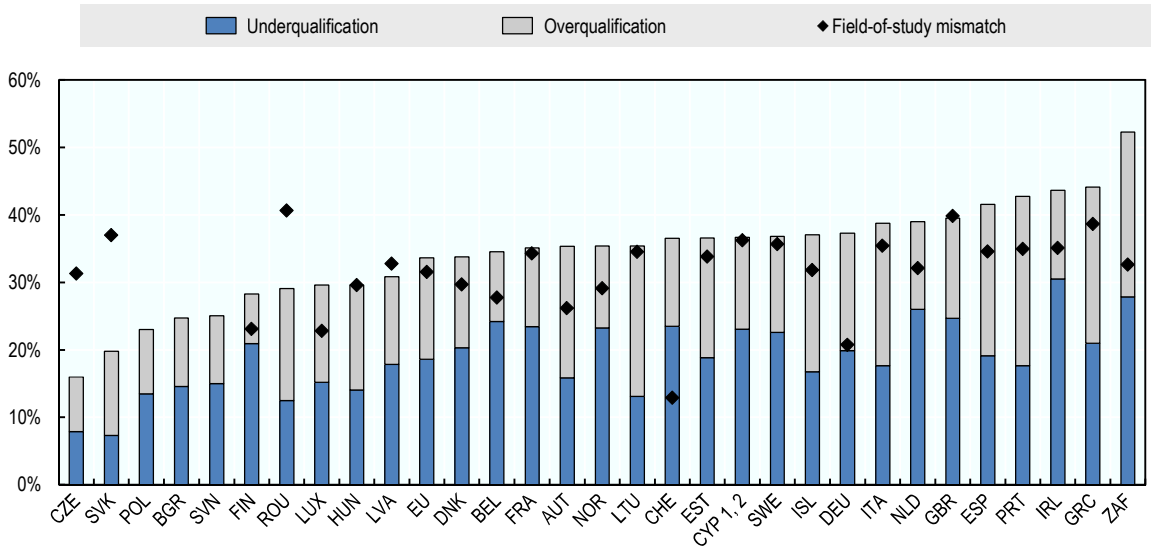
Source: *OECD Skills for Jobs Database*, PIAAC.

Mismatch indicators: Results and analysis

Individuals can be mismatched to their job in terms of qualification level and field of study. Figure 3.26 shows that countries differ widely in the degree of qualification and field-of-study mismatch. In the Czech Republic only 16% of workers are employed in a job that generally requires a different qualification, compared to 52% in South Africa. Overall, under-qualification is more common than over-qualification (in 19 out of 30 countries). The largest share of under-qualified workers is found in Ireland (30%), and the smallest in the Slovak Republic (7%). Over-qualification is most common in Portugal (25%), and least common in Finland (7%). The share of individuals mismatched in terms of field of study ranges from 13% in Switzerland to 41% in Romania. Mismatch is more common in some occupations than in others, as some occupations require specific skills or qualifications and others are more general. Across European countries, for example, qualification and field-of-study mismatch are almost zero for health professionals, but very high among elementary workers.

Figure 3.26. Incidence of qualification and field-of-study mismatch by country, Europe and South Africa (2015)

Share of employed aged 15-64



Note: Germany 2013 data. The European average (EU) is the unweighted average of available European countries.

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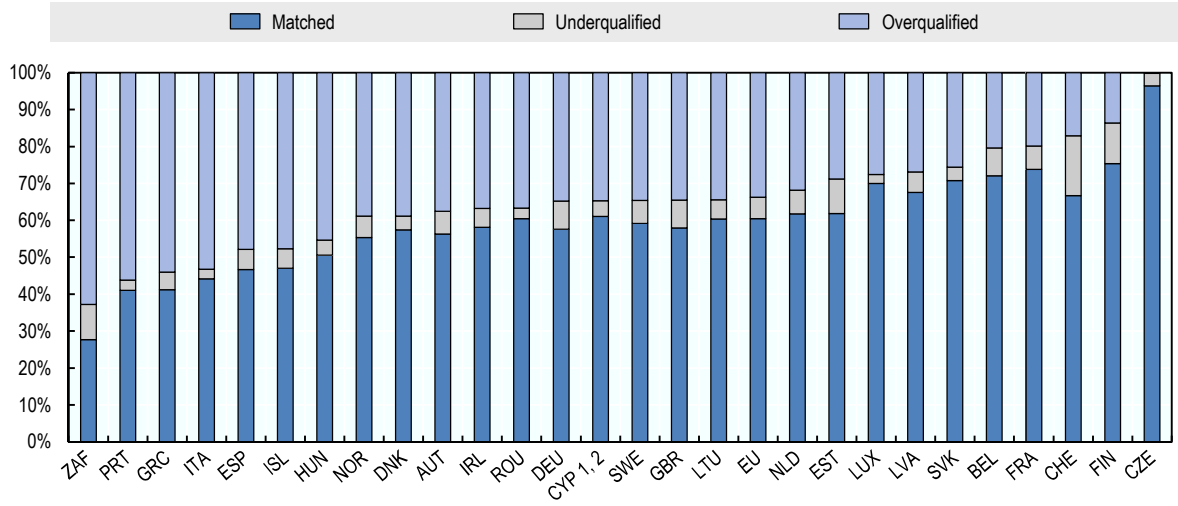
Source: *OECD Skills for Jobs Database.*

As Figure 3.26 shows, there is no clear relationship between the degree of qualification mismatch and field-of-study mismatch. The correlation between both types of mismatch is positive but insignificant. OECD (2011) shows that field-of-study mismatch in itself does not necessarily have a negative impact on an individuals' skill use or wage. In contract, over-qualification does lead to a significant wage penalty and a lower level of skill use. As such, it is important to understand the overlap between field-of-study and qualification mismatch. Across European countries, the majority of individuals mismatched by field-of-study are not mismatched in terms of qualification level (61%) (Figure 3.27). The majority of individuals who are field-of-study and qualification mismatched are over-qualified (34%). In the Czech Republic almost all field-of-study mismatched workers have the correct qualification level for their job (96%), while this is only true for 28% of South Africans who are mismatched by field-of-study. Therefore, field-of-study mismatch can have worse implications in South Africa then in the Czech Republic, even while these countries have a similar overall incidence of field-of-study mismatch.

Figure 3.27. Overlap between field-of-study and qualification mismatch

Percentage of field-of-study mismatched workers, 2015



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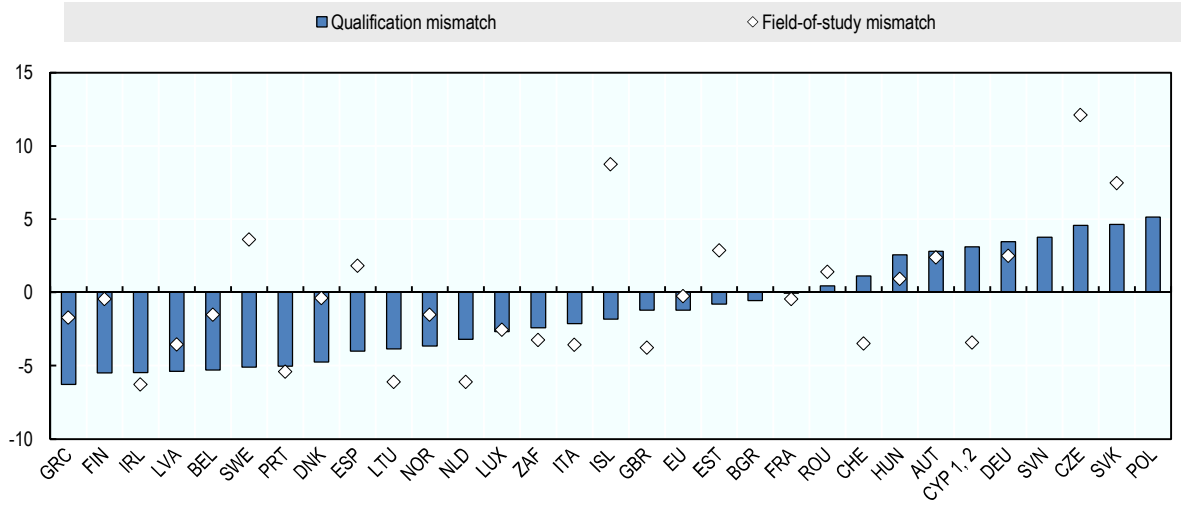
Source: *OECD Skills for Jobs Database.*

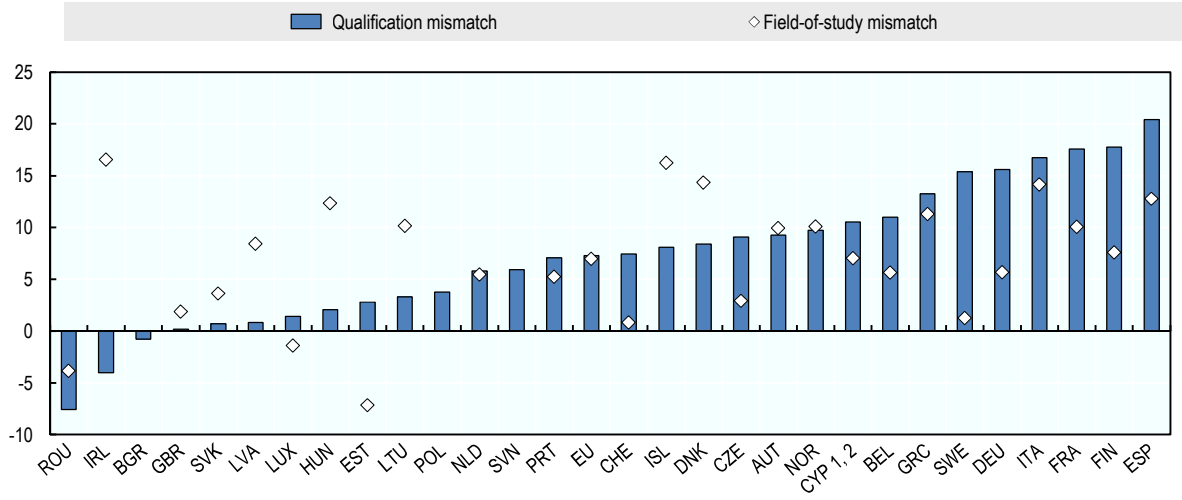
The degree of mismatch can vary between different socio-economic groups. Panel A of Figure 3.28 shows that in the majority of countries women have a lower probability of being mismatched than men. Differences in qualification mismatch are small in all countries, with women having at most a 6 percentage points lower mismatch incidence (Greece). Similarly, gender difference in field-of-study mismatch are generally small, with the exception of Iceland and the Czech Republic where women have an incidence of field-of-study mismatch that is about 10 percentage points higher than for men. Migrant status has a much bigger impact on the degree of mismatch (Panel B), with foreign-born workers having a more than 15 percentage point higher incidence of qualification mismatch in Sweden, Germany, Italy, France, Finland and Spain. Only in Romania, Ireland and Bulgaria are native-born more likely to be mismatched in terms of qualifications than foreign-born. The difference in qualification mismatch is mainly driven by a higher incidence of over-qualification among foreign-born individuals. Similarly, sizeable gaps can be observed in many countries for field-of-study mismatch. A comparison by country of origin shows that non-EU migrants have a higher incidence of mismatch than EU migrants in most European counties. Immigrants could be at higher risk of mismatch for a number of reasons including poor language proficiency, the fact that they often hold qualifications acquired in their home country or discrimination (OECD, 2011).

Figure 3.28. Difference in mismatch between socio-economic groups (Europe and South Africa, 2015)

Panel A. Gender: Percentage point difference between women and men



Panel B. Migrant status: Percentage point difference between foreign-born and native-born workers



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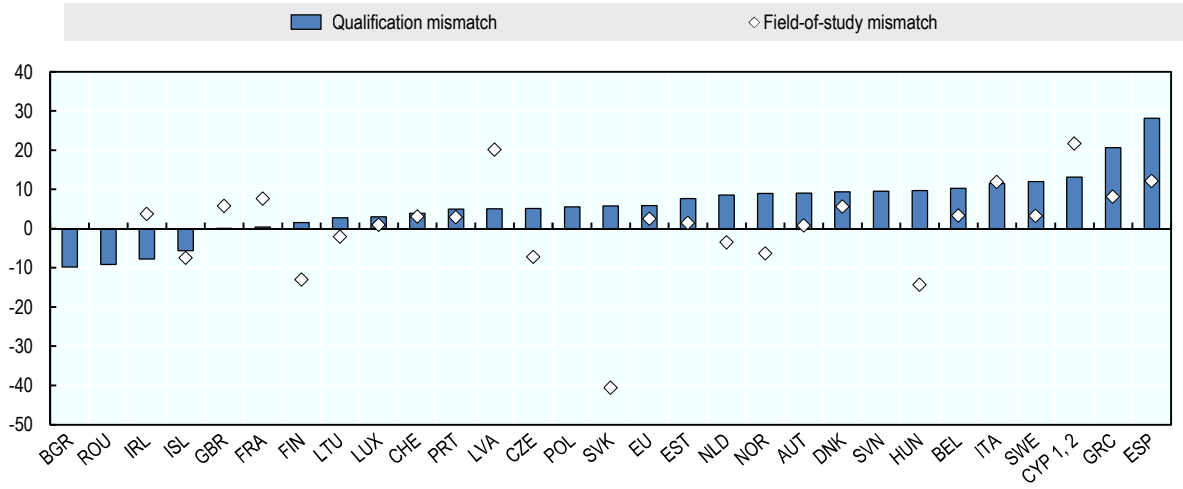
Source: *OECD Skills for Jobs Database.*

The degree of mismatch also varies by job. Panel A of Figure 3.29 shows that temporary workers have a higher mismatch incidence in all countries except the United Kingdom for qualification mismatch and Estonia, Latvia and Switzerland for field-of-study mismatch. Similarly, mismatch is higher among part-time workers than among

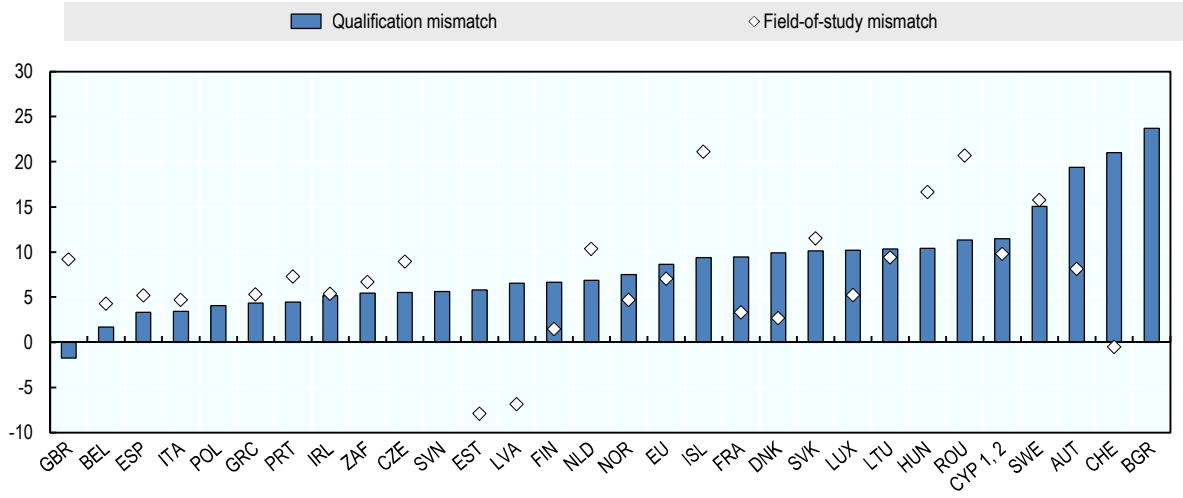
full-time workers in all countries except Portugal and Switzerland. Interestingly, in the majority of countries, the difference in the degree of field-of-study mismatch is higher than the difference in qualification mismatch. The higher incidence of mismatch could be linked to the low availability of part-time jobs in specific fields, and especially in high-skilled jobs.

Figure 3.29. Difference in mismatch between job characteristics (Europe and South Africa, 2015)

Panel A. Contract type: Percentage point difference between temporary and permanent workers



Panel B. Working time: Percentage point difference between part-time and full-time workers



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Source: *OECD Skills for Jobs Database.*

While interesting, it is difficult to infer the drivers behind mismatch from simple between-group comparisons. Differences between genders, for example, might be related to the fact that women have a higher probability of being employed in part-time jobs, and by differences in occupational specialisation. Accounting simultaneously for multiple relevant factors, it is found that migrant status has a substantially bigger impact on the probability of being mismatched by qualification than gender, contract type and working hours (see Table 3.5). Moreover, gender and working hours only have a small impact on qualification mismatch probabilities. Working hours, however, has a much bigger impact on the probability of being field-of-study mismatched. Age is also an important driver of mismatch, with both qualification mismatch and field-of-study mismatch increasing with age. This is not surprising, as the importance of educational level and field generally decreases with work experience.

Table 3.5. Determinants of qualification and field-of-study mismatch (Europe, 2015)

Probit regressions, marginal effects

		Qualification mismatch	Under-qualification	Over-qualification	Field-of-study mismatch
Migrant status	Foreign-born	0.087***	0.038***	0.088***	0.041***
Household characteristics	Children	-0.005**	0.004*	-0.008***	-0.019***
Age groups	20-24	0.005	-0.100***	0.167***	0.055***
	25-29	0.021**	-0.125***	0.206***	0.065***
	30-34	0.016*	-0.117***	0.198***	0.084***
	35-39	0.012	-0.100***	0.178***	
	40*44	0.013	-0.074***	0.157***	
	45-49	0.025***	-0.033***	0.126***	
	50-54	0.037***	-0.005	0.106***	
	55-59	0.064***	0.027***	0.098***	
	60-65	0.084***	0.046***	0.105***	
Gender	Female	-0.005**	-0.015***	0.008***	-0.022***
Working hours	Part-time	0.010***	0.008***	0.004*	0.060***
Contract type	Temporary	0.041***	0.035***	0.018***	0.037***
N		*925069*	*787048*	*755397*	*147577*

*Significant at the 10% level, ** 5% level, *** 1% level.

The sample includes: Austria, Belgium, Bulgaria (not for field-of-study), Cyprus[1,2], the Czech Republic, Denmark, Greece, Estonia, Finland, France, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland (not for field-of-study), Portugal, Romania, the Slovak Republic, Slovenia (not for field-of-study), Spain, Sweden, Switzerland, and the United Kingdom.

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The dependent variables are defined as follows: the probability of being mismatched as opposed to well-matched by qualifications; the probability of being underqualified as opposed to well-matched by qualifications; the probability of being overqualified as opposed to well-matched by qualifications; the probability of being mismatched as opposed to well-matched by field-of-study. Control variables not reported in the table include: country dummies, occupation dummies, industry dummies. The reference age group is 15-19.

Notes

1. Throughout this report, whenever referring to each specific dimension of *skills*, *knowledge* and *abilities* (see Chapter 1) these are displayed in italics while when generically referring to all three dimensions altogether, the term "skills" is used.
2. While the values computed for shortages and surpluses are unbounded, they range in between -0.019 and 0.042 for *skills*, -0.040 and 0.056 for *knowledge* and -0.025 and 0.035 for *abilities*. Shortages of stronger intensity are, therefore, found in certain *knowledge* (i.e. computer and electronics) and *skills* (i.e. reading comprehension) and less so in *abilities*. Surpluses are more intense, instead, in *knowledge* (i.e. mechanical) and *abilities* (i.e. flexibility, balance and coordination) and less so in *skills*.
3. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".
4. Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.
5. O*NET provides categorical information about the level and importance of a large and predefined set of skills for all occupations regardless of occupations' characteristics, sectors or education level. Information on the full spectrum of skills is, therefore, provided for all occupations and so, also for those that make only a marginal use of some of these skills.
6. Skill concentration is measured through the Herfindahl index, which in its original application used the sum of squared market shares to estimate industry concentration. To calculate the Herfindahl index on skill requirements, first the total skill requirement per occupation is calculated as the sum of all skills weighted by their required level. Then, the share of each skill is calculated as their required level divided by the total skill requirement and the squared sum of those share of skills equates the skill concentration. Hence, occupations with higher skill requirement in only certain skills will be given a higher score of skill concentration and specialisation.
7. The concentration and intensity data from the charts are provided in the Annex Table A.4.
8. Abilities are enduring attributes of the individual that influence performance.
9. Average linked clustering is used to cluster the occupation groups, as it combines lesser sensitivity to outliers with greater conciseness. Clustering is done for the most aggregate level of skills (7 types), abilities (15 types) and knowledge (9 types).

10. The European average is calculated as the unweighted average of imbalances and employment shares across European countries in the latest available year.

11. The optimal number of clusters was chosen based on the Duda-Hart index.

12. See Table 2.2 for details on the ISCO occupations.

13. The top quartile of shortage occupations are labelled "critical shortage", and the bottom quartile of surplus occupations "critical surplus". Critical imbalances at the occupation level are therefore defined within countries, which is different from the methodology used to identify critical imbalances of *skills*.

14. The analysis shows that there are no groups that combine occupations in *critical* shortage and occupations in *critical* surplus for the average of countries analysed in Figure 3.2

15. The country profiles show the cluster graphs for *skills*. Graphs for *abilities* and *knowledge* are available upon request.

16. As pointed out by Kutsekoda (2016), for instance, the quality of the training received by students coming out from managerial and business tracks is not sufficient for them to enter management positions. Shortages arise, then, in those occupations that are less exposed to the use of engineering and technology skills.

17. http://skillspanorama.cedefop.europa.eu/en/analytical_highligths/estonia-mismatch-priority-occupations.

18. Examples of key technologies are Apache Hadoop or Pig technologies, MongoDB, Talend Big Data Integration.

19. Examples are AJAX, Google AngularJS, jQuery or LAMP Stack.

20. Also, according to Acemoglu and Restrepo (2016) for the United States, one more robot per thousand workers reduces the employment rate by about 0.18-0.34 percentage points and wages by 0.25-0.5%.

21. https://techcrunch.com/2015/06/09/software-is-eating-the-job-market/.

22. The skills analysed span from cognitive ones such as written expression and comprehension, oral expression, deductive and inductive reasoning or fluency of ideas to skills that can be categorised as manual, routine and physical such as static strength, extent of flexibility or trunk strength. Results are for the average of countries examined in the database.

23. The change is intended to have affected workers' immediate working environment during the previous three years.

24. In the OECD Job Quality framework, the quality of the working environment is measured by the incidence of job strain, which is a combination of high job demands and limited job resources. Jobs that are characterised by a high level of job demands such as time pressure or physical health risk factors, combined with insufficient job resources to accomplish the required job duties, such as work autonomy and social support at work, constitute a major health risk factor for workers.

25. Several different technologies and software are the core tools used in these occupations (i.e. HCSS HeavyBid; HCSS HeavyJob; Microsoft Project; Microsoft SharePoint or SAP), and upscaling the provision of training in these, as well as similar, technologies could help reduce shortages in the labour market.

26. The underlying skill category is "Consequence of Error" defined as the ability to cope with situations where mistakes are not readily correctable. Occupations related to this ability are midwives, acute and critical care nurses as well as hospitalists.

27. These data are based on the medium-fertility scenario of the 2015 United Nations population projections.

28. South Africa is excluded from this analysis, as the health care shortages experienced in South Africa have very different underlying sources than in European countries. Adding South Africa to the analysis does not significantly alter the observed correlation.

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Annex A

Methodology and data details

Latest year available per country used across tables

Skill needs data in most tables is constructed comparing countries using the latest year for which data is available for all five sub-indices. Table A.1 shows for each country the year used across the report.

Table A.1. Latest available year per country

Country	Year	Country	Year	Country	Year
Austria	2014	Greece	2014	Poland	2013
Belgium	2013	Hungary	2014	Portugal	2013
Bulgaria	2014	Iceland	2012	Romania	2013
Cyprus[1, 2]	2013	Ireland	2013	Slovak Republic	2013
Czech Republic	2013	Italy	2013	Slovenia	2012
Denmark	2014	Latvia	2014	South Africa	2014
Estonia	2013	Lithuania	2013	Spain	2014
Finland	2014	Luxembourg	2013	Sweden	2013
France	2013	Netherlands	2014	Switzerland	2013
Germany	2011	Norway	2014	United Kingdom	2013

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Missing sub-index per country per year

Some sub-indices could not be calculated due to missing components in the data sources in some countries and years. Table A.2 presents the years between 2004 and 2015 for which data is unavailable for some countries.

Table A.2. Missing sub-indices per country and year

	Years	Countries
Employment	2004	Austria, Germany, Hungary, Italy, Poland, Romania, South Africa
	2005, 2006	Hungary, Poland, Romania, South Africa
	2007, 2008, 2015	South Africa
Hours worked	2004	Austria, Hungary, Italy, Poland, Romania, South Africa
	2005, 2006	Hungary, Poland, Romania, South Africa
	2007, 2008	South Africa
	2014	Germany
	2015	Germany and South Africa
Under-qualification	2004	Austria, Denmark, Hungary, Italy, Norway, Poland, Romania, South Africa, United Kingdom
	2005, 2006	Denmark, Hungary, Norway, Poland, Romania, South Africa, United Kingdom
	2007	Denmark, South Africa, United Kingdom
	2013, 2014	Germany
	2015	Germany and South Africa
Unemployment	2004, 2005	France, Hungary, Netherlands, Norway, Poland, Romania, South Africa
	2006, 2007	France, Netherlands, Norway, South Africa
	2008	France, Netherlands, Norway
	2009, 2010, 2011	France, Norway
	2012, 2013	Norway
	2014	Germany, Norway
	2015	Germany, Norway, South Africa
Wages	2004	Austria, Bulgaria, Cyprus[1, 2], Czech Republic, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, South Africa, Spain, Switzerland, United Kingdom
	2005	Bulgaria, Greece, Hungary, Italy, Latvia, Poland, Portugal, Romania, Spain, South Africa, Switzerland
	2006	Bulgaria, Greece, Hungary, Italy, Latvia, Poland, Portugal, Romania, South Africa, Switzerland,
	2007	South Africa, Switzerland
	2008, 2009, 2010	South Africa
	2012	Germany
	2013	Germany, Iceland, Slovenia
	2014	Belgium, Cyprus, Czech Republic, Estonia, France, Germany, Iceland, Ireland, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovenia, South Africa, Sweden, Switzerland, United Kingdom
	2015	All countries

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List of country-specific reclassification of educational levels

Between 2004 and 2015, some countries reviewed how their education programmes fit into the ISCED framework. Programme reclassifications result in a large number of people with a certain level of education in one year inexplicably moving to another level in the following year. In order to address this issue, the two educational levels where the reclassification takes place are aggregated into one single level. This minimises fluctuation across time preventing jumps in the calculation of the under-qualification sub-index of the skill needs indicators.

Table A.3. Education levels reclassifications

Country	Combined ISCED levels
Austria	1 and 2
Austria	4 and 5
Hungary	3 and 4
Netherlands	4 and 5
Norway	4 and 5
Slovak Rep.	3 and 4
Switzerland	3 and 4

Intensity and concentration of knowledge, skills and abilities

The table below shows the average values for concentration and intensity of abilities, knowledge and skills for each occupation for the (unweighted) average of all European countries and South Africa. Skill concentration is measured through the Herfindahl index, which in its original application used the sum of squared market shares to estimate industry concentration. To calculate the Herfindahl index on skill requirements, first the total skill requirement per occupation is calculated as the sum of all skills weighted by their required level. Then, the share of each skill is calculated as their required level divided by the total skill requirement and the squared sum of those share of skills equates the skill concentration. Hence, occupations with higher skill requirement in only certain skills will be given a higher score of skill concentration and specialisation. Average intensity is calculated as average level multiplied by the average importance of each skill, knowledge and ability per occupation.

Table A.4. Skill concentration and intensity per occupation (cross-country average)

Occupation	Average concentration			Average intensity		
	Abilities	Knowledge	Skills	Abilities	Knowledge	Skills
10	0.18	0.21	0.19	0.18	0.22	0.27
21	0.18	0.21	0.19	0.2	0.24	0.28
22	0.17	0.22	0.2	0.22	0.24	0.27
23	0.19	0.22	0.21	0.17	0.2	0.23
24	0.2	0.23	0.2	0.17	0.19	0.23
25	0.19	0.26	0.19	0.17	0.16	0.26
26	0.19	0.22	0.21	0.17	0.19	0.23
31	0.16	0.21	0.18	0.21	0.19	0.24
32	0.16	0.22	0.2	0.21	0.19	0.21
33	0.19	0.24	0.21	0.16	0.15	0.2
34	0.17	0.22	0.2	0.18	0.17	0.2
35	0.17	0.25	0.18	0.18	0.16	0.23
41	0.19	0.3	0.22	0.13	0.12	0.15
42	0.18	0.26	0.22	0.14	0.13	0.15
43	0.18	0.25	0.21	0.14	0.11	0.15
44	0.17	0.24	0.21	0.15	0.12	0.13
51	0.16	0.23	0.2	0.16	0.1	0.14
52	0.17	0.24	0.21	0.15	0.14	0.17
53	0.16	0.23	0.21	0.17	0.12	0.16
54	0.15	0.23	0.2	0.22	0.16	0.17
61	0.15	0.21	0.19	0.22	0.16	0.19
71	0.15	0.22	0.18	0.21	0.17	0.17
72	0.15	0.23	0.18	0.22	0.14	0.19
73	0.16	0.22	0.18	0.19	0.12	0.18
74	0.15	0.22	0.18	0.24	0.18	0.24
75	0.16	0.22	0.19	0.18	0.1	0.15
81	0.15	0.23	0.19	0.19	0.1	0.16
82	0.16	0.24	0.19	0.18	0.09	0.16
83	0.15	0.23	0.19	0.22	0.11	0.16
91	0.16	0.24	0.2	0.12	0.07	0.09
92-93	0.15	0.21	0.19	0.18	0.1	0.12
94	0.16	0.21	0.2	0.13	0.08	0.09
95-96	0.15	0.23	0.19	0.17	0.11	0.14

O*NET data reclassified into ISCO levels

The occupations used in the O*NET database are not the occupations reported in the surveys used in this report (e.g. EU-LFS, EU-SILC). O*NET occupations are constructed based on the United States' Standard Occupational Classification (SOC), but some SOC occupations are further disaggregated into more detailed occupations. A first step in the recoding of these O*NET occupations into the more commonly used occupational classifications, is to move from the more detailed O*NET codes to the overarching 6-digit SOC code. This is done by taking the average of the values of all O*NET occupations within one SOC occupation. While weighted averages based on the size of the occupation would be preferred, this information is not available.

However, most of the O*NET occupations within the same SOC occupation are very similar in terms of their skills characteristics.

While these 6-digit SOC codes are often used in US data, European data generally use the International Standard Classification of Occupations (ISCO). Official crosswalks between the two classifications have been developed. The problem when recoding 6-digit SOC into 4-digit ISCO is that many SOC occupations are split over different ISCO occupations. Ideally one would know which share of a SOC occupation is attributed to an ISCO occupation. However, this information is not (readily) available. As an approximation, it is assumed that employment from one SOC occupation is spread equally over the related ISCO occupations. Employment per SOC occupation is taken from the US Bureau of Labor Statistics Occupational Employment data (2015). Other strategies can be used, such as taking unweighted averages or mapping each SOC occupation to only one ISCO occupation based on a subjective comparison of the occupations (i.e. matching the titles that are most closely related). However, as the O*NET characteristics are generally similar for SOC occupations within ISCO occupations, the different methodologies are unlikely to generate widely different results. The same strategy can be followed for other occupational classifications, such as the Canadian National Occupational Classification (NOC).

The O*NET information is further aggregated the 2-digit ISCO level by taking employment weighted averages. While it is preferred to do this aggregation with country-specific weights to take differences in occupational structure into account, 4-digit ISCO employment levels are not available for all European countries. For countries without this detailed information (i.e. Bulgaria, Cyprus[1,2], Denmark, Iceland, Italy, Greece, Latvia, Portugal and Spain) the average cross-country weights are used.

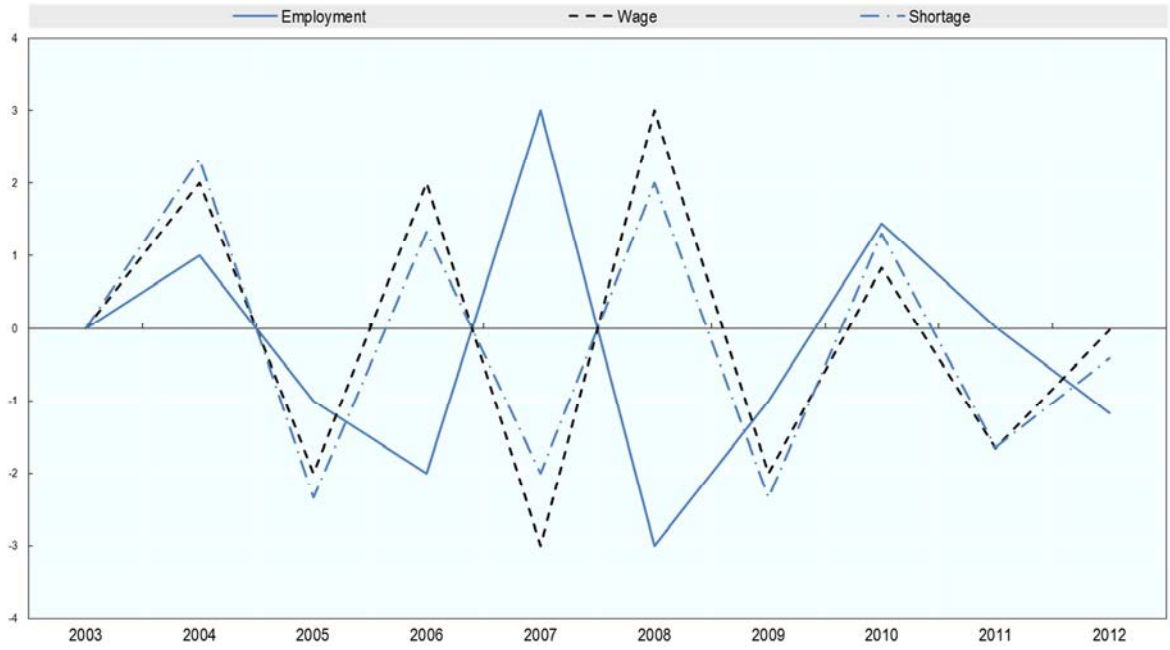
Interaction between supply and demand for occupation and skills in the labour market

A simplified interpretation of the shortage indicator combines two sub-indexes: wages, measuring the prices in the labour market, and employment, measuring the quantities. The indicator needs to return higher values whenever wage and employment trends are both growing positively and lower values when they are both decreasing.

However, conflicting evidence in the growth of prices and quantities are harder to interpret. Growing wages and stagnant or declining employment should signal a shortage (as employers are willing to pay more for a lower number of employed workers), whereas lowering wages with increasingly high employment rates should indicate a surplus (as employers are able to employ more workers paying a lower wage). The weighting system that gives employment half the weight given to wages was created in order to accommodate the predicted results for conflicting evidence and interpret the potentially conflicting evidence coming from wage and employment pressure analyses.

The figure below illustrates how, given an hypothetical shock of the same magnitude to both wages and employment, a the chosen weighting structure returns a shortage indicator that falls between employment and wages, although closer to wages and following the same sign as the wage variation.

Figure A.1. Simulated shocks to employment and wage and effect on occupational shortage indicator



Source: OECD calculations.

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(81 2017 11 1 P) ISBN 978-92-64-27786-1 – 2017

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ISBN 978-92-64-27786-1
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