II. Structural change in labour demand and skills mismatches in the euro area

By Daniel Alonso and Alkistis Zavakou

Skills mismatches, i.e. discrepancies between the skills that employers are looking for and the skills that the workforce have, remain high in many Member States. This may be temporary, due to labour market friction and the business cycle, or more persistent, due to structural imbalances between the supply and demand of skills.

At the same time, technological change (along with globalisation and demographic change) is having a structural impact on the demand (and on the supply) of skills, which may exacerbate the skills-to-job mismatch. In terms of demand, the structure of employment is largely shifting from routine to non-routine occupations in the euro area as a whole.

Only a few studies have so far tried to assess the link between the change in the task content of jobs and skills mismatches. This section investigates this link. The analysis suggests that new technologies that reduce the demand for workers performing routine tasks have increased skills mismatches. This is consistent with the phenomenon of technological change driving permanent shifts in the demand for labour, which lead to imbalances between supply and demand.

The increasing demand for highly skilled tasks along with the decline in demand for routine tasks have increased skill mismatches in the euro area. Although this may be partly offset by improvements in economic conditions, unless there is a suitable policy response, the labour market trends are set to result in higher skill mismatches, in particular during a downturn in the economy. In this regard, the Recovery and Resilience Facility as well as the revised Skills Agenda provide Member States key tools to facilitate the adaptation of education and training systems to support digital skills as well as to foster educational and vocational training for all ages. ([86]*)*

II.1. Introduction

While the structural change in employment is well documented, little is known about its impact on skills mismatches. Recent research highlights a progressive shift of employment from middle-skilled jobs towards low- and high-skilled jobs in many countries around the world, a phenomenon known as job polarisation. ([87]) A large strand of literature has focused on the causes of this phenomenon, identifying technology and globalisation as the main drivers of the decline in the share of middle-wage (mid-skill) jobs. Less is known, however, about its consequences and more precisely its impact on skills and skills mismatches. Technology can replace workers in routine tasks that are easy to automate and it can complement workers in tasks that require creativity, problem solving and cognitive skills. As machine learning and artificial intelligence advance in many sectors, a growing number of workers may need to move from occupations in decline (concentrated in routine tasks) to growth sectors (which require non-routine cognitive skills).

All EU Member States have experienced a sharp decline in the relative share of mid-skill jobs compared to low- and high-skill ones over the past two decades, though unevenly. Compared to the pre-financial crisis period, the proportion of workers in middle-paid and mid-skill jobs is shrinking in all EU Member States, albeit to different degrees. In countries that experienced a late shift of employment from agriculture and manufacturing to service sectors, such as southern and central European countries, the decline in mid-skill occupations seen at national level may have occurred due to employment reallocations, both

([86]) This section was prepared by Daniel Alonso and Alkistis Zavakou (DG Employment and Social Affairs and Inclusion). It draws on earlier work, see: *The relationship between polarisation and skills mismatches: evidence for the EU*, Labour Market and Wage Developments in Europe, 2019. The authors wish to thank an anonymous reviewer for useful comments.

([87]) See, for instance, Acemoglu, D. and D. Autor (2011), "Skills, Tasks and Technologies: Implications for Employment and Earnings", in Handbook of Labor Economics; Autor, D. (2014). Skills, education, and the rise of earnings inequality among the "other 99 percent". Science (New York, N.Y.). 344. 843-51; Michaels, Guy, Natraj, Ashwini and Van Reenen, John (2014) Has ICT polarized skill demand? Evidence from eleven countries over 25 years. Review of Economics and Statistics, 96 (1). pp. 60-77.

between and within sectors. This shift is expected to affect both the demand and the supply of skills: the type of tasks carried out in jobs as well as the type of professions and occupations required in the labour market.

Skills mismatches remain high. Today, over 60 million adults in the EU lack necessary literacy, numeracy and digital skills. Digital technologies are increasingly used in workplaces across Europe and nowadays most jobs require basic digital skills. In 2017, almost half of the EU population (43%) had basic or below basic digital skills, with the share rising only slightly since 2015. 38% of employers reported that the lack of digital skills had an impact on their performance, notably through productivity losses.

In this context, it is relevant to examine whether structural changes in demand for labour have affected skills mismatches and, if so, to what extent. Both topics have received increasing policy attention. On the one hand, technological progress and automation are offered as explanations for structural change in labour demand. On the other hand, there is substantial evidence that skills mismatches are having negative effects on wages and job satisfaction, but also on productivity and output. [88] By contrast, the effect of recent changes to the structure and content of employment on skills mismatches has been much less analysed, although the literature on job polarisation suggests there is such a link. [89]

From a theoretical point of view, the effect of structural change in the demand for skills mismatches is ambiguous. Starting from a hypothetical situation in the labour market, in which the supply of skills perfectly matches demand and adequately trained workers fill all jobs, a structural change in employment could increase different aspects of the skills mismatch. In the absence of a supply response, it could increase macroeconomic skills mismatches, as it would result in a fall in demand for middle-skilled workers and a rise in demand for high- and low-skilled workers. It could also increase labour shortages for those two groups. Furthermore, under-qualification could rise among workers moving to the growing share of high-skill jobs, while over-qualification would rise for those in low-skill jobs, if workers previously employed in middle-skill jobs take up these jobs. Whether these effects will materialise is uncertain for at least three reasons. First, the supply of skilled workers is increasing in many EU countries, though this may or may not be in step with the increasing share of high-skill jobs. Secondly, labour markets tend to have a degree of skills mismatches and the different starting positions in terms of the level and type of mismatches will clearly change how polarisation shapes them. In a country with a high rate of under-skilling, for example, job polarisation could even reduce under-skilling, if it results in medium-skilled workers shifting from medium- to low-skilled jobs. Lastly, job polarisation may interact with unemployment (i.e. the workers previously employed in middle-skill occupations might become unemployed instead of moving immediately to low-skill and/or high-skill occupations). If so, it may not affect skills mismatches at all. In sum, this illustrates that the relationship between job polarisation and skills mismatches is not straightforward, but rather ambiguous.

This section examines the relationship between structural changes in employment and skills mismatches and the main causes of skills mismatches across the Member States. It is structured as follows: first, we review the literature on the determinants of skills mismatches. Then we give an overview of the main concepts and aspects of skills mismatches and structural changes in employment described in the literature and the indicators used to track these phenomena in operational terms, their pros and cons, how it has changed over time in the Member States and some illustrative statistics. We then estimate the effect of structural change in labour demand on skills mismatches across euro-area countries between 2002 and 2018, presenting empirical findings. The section concludes by setting out some policy recommendations.

(88) See, for instance, Mavromaras, K., S. McGuinness and Y.K. Fok (2009), "Assessing the incidence and wage effects of overskilling in the Australian labour market", *Economic Record*, Vol. 85, No 268, pp. 60-72; European Commission (2015), "Employment and Social Developments in Europe – Annual review 2015", Directorate-General for Employment, Social Affairs and Inclusion; Bennett, J. and S. McGuinness (2009), "Assessing the impact of skill shortages on the productivity performance of high-tech firms in Northern Ireland", *Applied Economics*, Vol. 41, No 6, pp. 727-37.

(89) Goos, M., A. Manning (2007), Lousy and Lovely Jobs: The Rising Polarization of Work in Britain, *The Review of Economics and Statistics*, 89, issue 1, p. 118-133.

II.2. The skills mismatch: measurements and causes

Skills mismatches are discrepancies between the demand and the supply of skills in the labour market, where the skills that employers are looking for are different from the skills offered by workers. Although skills mismatch is a broad, umbrella term, this section focuses on the macroeconomic skills mismatch, which captures the gap between the skills of the working-age population and the skills needed in the economy.

The macroeconomic skills mismatch shows a relative dispersion of employment rates across population groups with different educational attainment. Although the term "macroeconomic skills mismatch" is widely used in literature, the term "macroeconomic qualifications mismatch" would arguably be more accurate as the indicator used to track this phenomenal in operational terms is qualifications. If data are available, it is possible to directly compare the profile of job vacancies (in terms of qualification levels) with the profile of (un)employment. ([90]) Nevertheless, as reliable data on vacancies at EU level are hard to obtain, simplified measures can be used to compare the composition of employment in terms of qualifications (as a proxy for labour demand) with that of the working-age population (as a proxy for supply). Alternatively, it is possible to compare the profile of unemployment (as a proxy for the lack of demand) with the qualifications profile of the labour force (as a proxy for supply). Thus, in the absence of reliable data on job vacancies, the macroeconomic skills mismatches indicator is defined as the relative dispersion of employment rates across three population groups with different levels of educational attainment: the low, middle and high skilled. ([91]) In general, macroeconomic skills mismatches are high if the employment rates of low- and/or middle-skilled workers are lower than those of high-skilled workers and when the former make up a substantial share of the working-age population. ([92])

The causes of macroeconomic skills mismatches can be both cyclical and structural. On the one hand, as low-skilled employment tends to be more cyclical than high-skilled employment, the difference in employment rates between qualification groups typically increases in economic downturns. As a result, macroeconomic skills mismatches typically increase during an economic downturn and fall again during the recovery. Nevertheless, changes in the index could also be due to structural factors, such as technological, occupational or demographic changes or differences in the impact of changing institutional settings and of demographics across education groups (e.g. if the increasing generosity of benefit systems affects low-qualified workers more than highly-qualified ones). Some skills mismatches are inevitable in dynamic, continuously changing economies, as there are always some unfilled positions, despite a degree of unemployment. Moreover, some people are in jobs that do not fully match their skills profile. Even when an economy is "in equilibrium", less-skilled workers are likely to experience higher unemployment rates than the highly skilled. ([93]) Nevertheless, high and persistent macroeconomic skills mismatches are costly for firms, workers, the society and the economy as a whole. ([94])

Over the last decade, the macroeconomic skills mismatch has tended to follow a countercyclical pattern in the euro area. It increased during the financial crisis and recession and fell again during

([90]) See Şahin, A., J. Song, G. Topa and G.L. Violante (2014), "Mismatch unemployment", *The American Economic Review*, Vol. 104, No 11, pp. 3529-64

([91])
$$SMI = \sum_{i=L,M,H} \left|\frac{E_i}{E_t} - \frac{P_i}{P_t}\right| = \frac{1}{e_t} \sum_{i=L,M,H} \left|\frac{P_i}{P_t}(e_i - e_t)\right|$$
where i equals the three different qualification groups *(low-skilled, middle-skilled* and *high-skilled),* E_i, P_i and e_i equal the total employment, the working age population and the employment rate of group *i* respectively; and E_t, P_t and e_t equal the aggregate employment, the aggregate population and the aggregate employment rate respectively. This indicator have been calculated by Estevao and Tsounta (2011) for US states, by the ECB (2012) for the euro area as a whole and by European Commission (2013b) and Arpaia et al. (2014) for all EU Member States. The use of dispersion indicators to measure mismatch in the labour market dates back to Lipsey (1960).

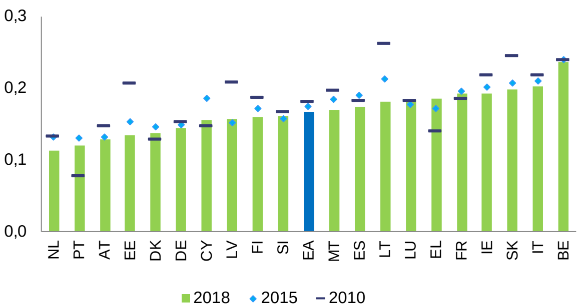
([92]) This measure ranges from 0 and 2. It equals 0 if the employment rates of all skill groups are equal to each other and hence to the aggregate employment rate. It equals 2 if the employment rate is extremely low (0%) in two out of three skill groups, and extremely high (100%) in the third group, and if the size of the former two is sufficiently high. For a detailed description of the indicator, see Kiss and Vandeplas (2015).

([93]) See Layard, R., S. Nickell and R. Jackman (2005), *Unemployment: Macroeconomic Performance and the Labour Market*, 2nd Edition, Oxford University Press, Oxford.

([94]) See, for example, Velciu M. (2017), "Job Mismatch – Effects On Work Productivity", *SEA - Practical Application of Science*, No 15, pp. 395-398, Fundaţia Română pentru Inteligenţa Afacerii, Iasi; LaRochelle-Côté, S. and D. Hango (2016), "Overqualification, skills and job satisfaction. Insights on Canadian Society", *Catalogue*, No 75-006-X, Statistics Canada.

the recovery (2011-2018), although there are considerable differences among Member States. Graph II.1 illustrates the changes in macroeconomic skills mismatches across euro area countries. In 2018, the highest rates were recorded in Belgium, Italy, and Slovakia with differences in employment rates among skill groups of above 18%. These countries generally combine substantial employment gaps (between low- and highly-qualified workers, and/or between medium- and highly-qualified workers) with substantial shares of low- and/or medium-qualified workers in their population. The lowest macroeconomic skills mismatches were in the Netherlands (11%) followed by Portugal (12%). In the recovery, most countries saw a reduction in the skills mismatch. The largest falls were in Lithuania, Cyprus, and Estonia. In these countries, the employment rate of medium- and high-qualified workers have been converging to the aggregate employment rate for decades, with the latter increasing as a share of the working-age population. The opposite applies to the employment rate of low-qualified workers, who, however, made up a shrinking part of the working-age population. By contrast, skills mismatches increased during the recovery in some of the countries hit particularly hard by the economic crisis (namely Greece and Portugal).

Graph II.1: **Relative dispersion of employment rates by education level (macroeconomic skills mismatch), 2010, 2015 and 2018**



Source: Own calculations based on Eurostat. Annual average based on the average of four quarters.

Although there is evidence that skills mismatches are at least partly cyclical, there are also significant structural causes. [95] One is technological change. [96] The rapid pace of technological change may require skills and qualifications higher than the skills the workforce can offer. It changes the demand for skills between sectors, occupations and firms. Technological change can lead to skill shortages by creating the need for new skills that are not immediately available on the labour market, until the broader education system (including employer training) is able to meet the demand for new skills. In addition, firms may wish to hire high-skilled workers as they can adapt at a lower cost relative to unskilled workers. [97] Demographic trends are another structural factor that can compound skill shortages by having an impact on the size, age and profile of the labour force. Demographic change also affects the demand for goods and services, and hence the demand for the skills required to provide them (e.g. medical services and personal care). A shift in the demand for labour towards more skilled jobs and an ageing workforce – a long-term feature of European economies – can result in skill shortages and mismatches, as older workers have skills that do not necessarily match closely the skills required by the process of digitalisation of modern economies.

II.3. Structural change in employment: measures and causes

II.3.1. Labour market polarisation in the euro area

Over the last few decades, the labour markets in most developed countries have undergone substantial change. Since the middle of the twentieth century, structural changes have occurred as labour has moved out of manufacturing and into the service sectors. One of the key explanations for structural transformation is differential productivity growth – or biased technological progress – across sectors, combined with complementarity between the goods and services produced by different sectors. [98] In terms of the effects on jobs, several papers have documented the polarisation of labour markets in the United States and in several European countries since the 1980s: employment

[95] Vandeplas, A, Thum-Thysen, A 2019, 'Skills mismatch and productivity in the EU', European economy discussion papers, no. 100, July 2019, Publications Office of the European Union, Luxembourg.

[96] See Di Pietro, G. 2002. 'Technological change, labor markets, and 'low-skill, low-technology traps'', Technological Forecasting and Social Change, Vol. 69, No. 9, pp. 885-895.

[97] See Desjardins, R. and K. Rubenson (2011), "An Analysis of Skill Mismatch Using Direct Measures of Skills", *OECD Education Working Papers*, No 63, OECD Publishing, Paris

[98] See Ngai, L., Rachel, and Christopher A. Pissarides. 2007. "Structural Change in a Multisector Model of Growth." American Economic Review, 97 (1): 429-443.

has shifted out of middle-earning routine jobs to either low-earning manual or to high-earning abstract jobs.

Although evidence of this job polarisation has been found for a number of countries ([99]), differences in methodology and/or data sources lead to different and sometimes contradictory results. ([100]) The key differences stem from three factors.

First, when defining jobs, some studies use only the two-digit ISCO occupational codes, while others take an occupation-industry matrix approach. Second, a key component of the jobs-based approach is that the jobs are ranked by median hourly wages (then used to construct job quality tiers). Some studies rank jobs based on each country's median hourly wage. ([101]) Others use country-specific wage levels to rank jobs by quality.

Third, although some studies classify jobs into three categories, which may have very uneven sizes in terms of number of occupations and in terms of share of employment, other studies classify jobs into equal-sized groups ranked by median hourly wage.

To establish the extent of job polarisation in European economies, this section follows the methodology suggested by Goos et al. (2014). ([102]) We grouped jobs according to mean wages in low, middle, and high-income occupations. ([103]) On average, over the period 2002-2018, the share of middle-paid jobs fell in the euro area ([104]) by about 13 pps, while the share of both low- and high-income jobs rose by 5 and 8 pps respectively (Graph II.2). However, this masks significant differences across Member States. While there is a clear hollowing-out of middle-paid jobs across the EU, the pace of this process differs by country.

([99]) These include the United States (Acemoglu and Autor, 2011; Autor and Dorn, 2013; Autor, 2014), the UK (Goos and Manning, 2007; Salvatori, 2018), Germany (Spitz-Oener, 2006; Dustmann et al., 2009; Kampelmann and Rycx, 2011), Sweden (Adermon and Gustavsson, 2015) and France (Harrigan, Reshef and Touba, 2016).

([100]) Some authors find different results and conclude that there is no clear pattern of pervasive polarisation. See Oesch, D., R. J. Menes (2011). Upgrading or polarization? occupational change in Britain, Germany, Spain and Switzerland, 1990-2008. Socio-Economic Review, 9(3); Fernández-Macías, E. (2012). Job Polarization in Europe? Changes in the Employment Structure and Job Quality, 1995-2007. *Work and Occupations*, 39(2), 157–182; Eurofound (2017), *Employment transitions and occupational mobility in Europe: The impact of the Great Recession*, Publications Office of the European Union, Luxembourg.

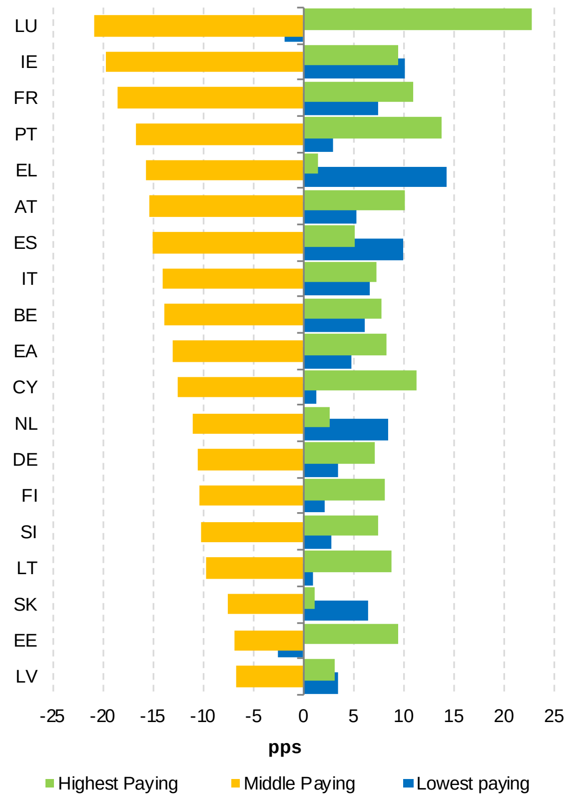
([101]) See, for example, Goos, M., A. Manning (2007), Lousy and Lovely Jobs: The Rising Polarization of Work in Britain, The Review of Economics and Statistics, 89, issue 1, p. 118-133.

([102]) Goos, M., A. Manning and A. Salomon (2014), "Explaining job polarization: routine-biased technological change and offshoring", American Economic Review, Vol. 104, No 8, pp. 2509–26. This methodology relies on the assumption that wages perfectly correlate with occupational skills requirements. This is common in the literature (e.g. Goos et al. 2009, Autor and Dorn 2013). However, an important caveat is that some jobs that require lower skill levels are paid better because of higher unionisation, collective agreements, social norms, etc.

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

([104]) Malta is not included due to data limitations.

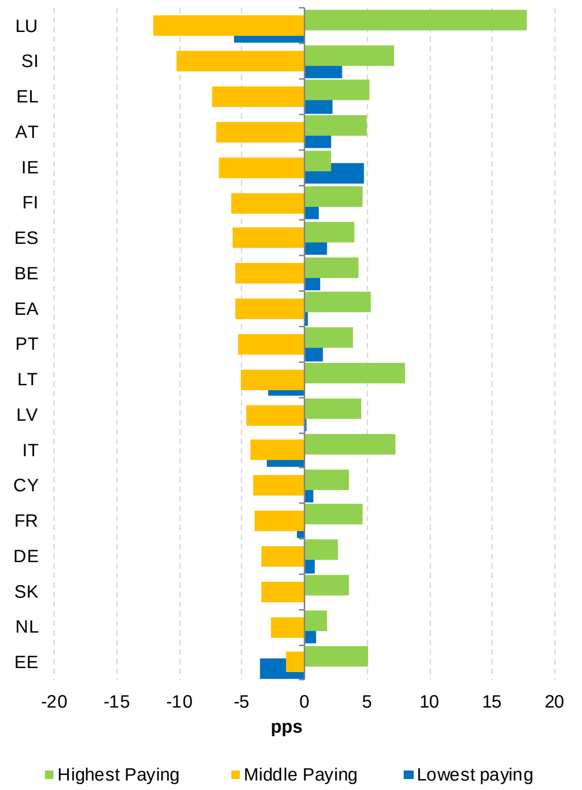
Graph II.2: **The proportion of middle-wage workers is shrinking**



High, middle and low-income jobs in the euro area change from 2002 to 2018 in pps.
Source: Own calculations based on Labour Force Survey (LFS).

The differences are not only between countries, but also over time. Splitting the period 2002-2018 into two halves (2002-2010 and 2011-2018) shows that, although the share of middle-income jobs fell in both periods in most countries, the fall sloped off significantly after the financial crisis of 2007-2008. More interestingly, since 2011 only Luxembourg, the Netherlands, Italy and Finland continue to show effects of polarisation (Graph II.4). Some countries (Slovenia, Greece and Latvia) even experienced an increase in middle-income jobs ("de-polarisation"). These countries may be benefiting from offshoring within the single market. Thus, less polarisation in these countries means job creation in routine occupations. Conversely, more polarisation in high-income countries may be the consequence of middle-income jobs shifting to certain middle-income countries.

Graph II.3: **Polarisation peaked at the height of the financial crisis**

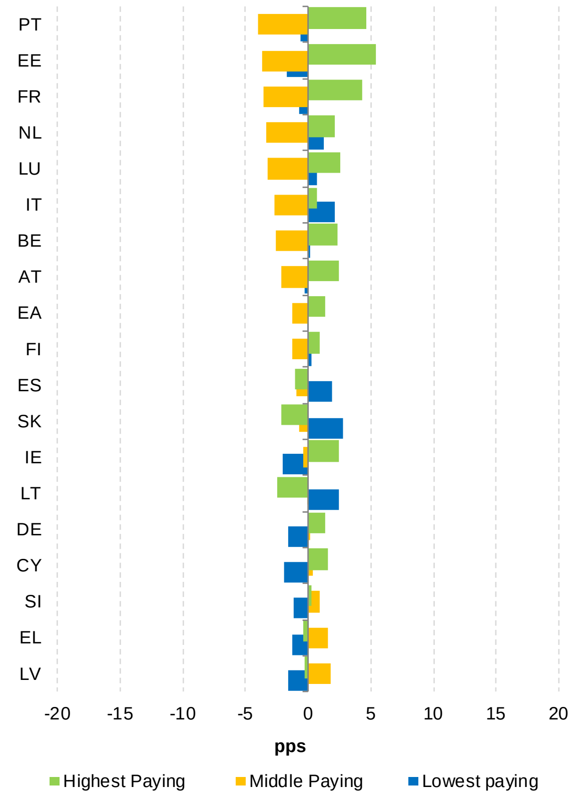


High, middle and low-income jobs in the euro area - change from 2002 to 2010 in pps.
Source: Own calculations based on LFS.

The shift in employment away from middle-skill jobs can occur in two ways. On the one hand, the factors underlying job polarisation may contribute to a shift of employment within an industry, as middle-skill jobs decline and the share of high- and low-skill jobs increases. Technological advances tend to be the main drivers of this aspect of job polarisation, as middle-skill jobs become obsolete. [105] On the other hand, employment may shift between industries when some industries experience rising demand for their products and respond by hiring workers, while other industries contract as demand for their products weakens. This reallocation of workers increases job polarisation if the industries in decline have a larger share of middle-skill jobs and the growth industries have a larger share of low- or high-skill jobs.

[105] OECD (2017), "OECD Employment Outlook 2017", OECD Publishing, Paris.

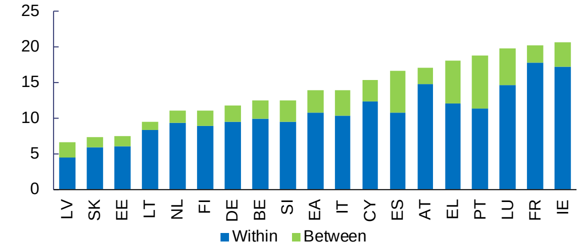
Graph II.4: **After the financial crisis, the rate of polarisation sloped off**



High, middle and low-income jobs in the euro area - change from 2011 to 2018 in pps.
Source: Own calculations based on LFS.

To understand the relative importance of cross-industry and intra-industry effects, it is useful to break down the change in overall polarisation over the period analysed by cross-industry and intra-industry components. [106] Graph II.5 shows that the prevalence of intra-industry polarisation is a pattern observed in all euro area countries. However, in some countries such as Spain, Portugal and Greece, the decline of specific sectors has also played a significant role, suggesting that jobs have shifted towards industries with higher degrees of polarisation, in particular from agriculture to services, reflecting structural changes in the labour market.

Graph II.5: **In all countries, polarisation has largely reflected intra-sector dynamics**



Percentage-point change in polarisation between 2000 and 2018.
Source: Own calculations based on LFS.

The main drivers behind job polarisation are still subject to some debate, but almost all explanations focus on the disappearance of "routine" occupations and are based on demand-side factors. Two factors emerge in particular: globalisation and technology.

Globalisation has an impact on the number of routine jobs via offshoring. Technology, however, affects job polarisation in two ways: i) by reducing employment in routine manual and cognitive tasks, moving displaced workers to less-routine jobs at the lower end of the skills spectrum; and ii) by increasing demand for workers in higher-skilled and (to a lesser extent) lower-skilled occupations, leading to growth at the upper and lower ends of the skills range. [107] This process, called Routine-Biased Technological Change explains the lower demand for middle-skill jobs relative to both high- and low-skill ones, giving rise to the polarisation of occupational structures documented in advanced countries. [108]

Although this section focuses on structural change in the profile of jobs on the demand side, there is also some evidence that changes in skills and task structures in employment may be driven by supply-

[106] See Goos, M., A. Manning and A. Salomon (2014), "Explaining job polarization: routine-biased technological change and offshoring", *American Economic Review,* Vol. 104, No 8, pp. 2509–26. Overall polarisation is the sum of high- and low-paid workers over total employment. Within-sector polarisation is the increase in the share of high- and low-income jobs within an industry; between-sector polarisation is the reallocation of employment towards more highly polarised industries. Within-industry polarisation is the change in polarisation by industry over the time period, multiplied by the average share of employment of that industry. Inter-industry polarisation is the change in the employment share of an industry over the time period, multiplied by the average level of polarisation in that industry.

[107] Blinder, Alan, (2009), How Many US Jobs Might be Offshorable?, *World Economics*, 10, issue 2, p. 41-78.

[108] RBTC was first formulated by David H. Autor & Frank Levy & Richard J. Murnane, 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration," The Quarterly Journal of Economics, Oxford University Press, vol. 118(4), pages 1279-1333. For a discussion of how technological transformations are shaping the European labour market see European Commission (2018), "Employment and Social Developments in Europe – Annual review 2018", Directorate-General for Employment, Social Affairs and Inclusion.

side changes. ([109]) Nevertheless, supply and demand changes are closely intertwined and it is difficult to disentangle their effects on polarisation. This issue merits further research.

The analysis was carried out at job level and looks at the task content of a specific occupation over time. It does not account for potential changes to the task content of specific occupations or jobs. As the literature suggests that the task content of jobs is also shifting towards less-routine tasks, the analysis may therefore underestimate the extent of the 'de-routinisation' shift.

II.3.2. The shift away from routine work in the euro area

This section follows the task-based approach to show the overall change to the task content of jobs in Member States. ([110]) Graph II.6 shows that the EU as a whole has experienced a significant growth in non-routine cognitive tasks (high-skilled tasks) and a steep decline in routine tasks (middle-skilled tasks), while non-routine manual tasks (low-skilled tasks) remain constant. Thus, if the assumed correspondence between routine and skill content of jobs is correct, the euro area seems to be undergoing a process of upskilling rather than a true polarisation phenomenon. ([111])

Although almost all countries have experienced a steep decline in routine tasks, few countries have experienced a simultaneous growth in high- and low-skilled tasks (true polarisation). Only Belgium, Estonia, Finland, Ireland and to a lesser extent Italy seem to be experiencing a true polarisation process, based on changes to the task content of jobs. However, several countries have experienced an increase in high-skilled tasks relative to middle- and low-skilled tasks (upskilling).

II.3.3. Offshoring in the euro area

In addition to the de-routinisation of the economy, another structural cause of job polarisation emphasised by the literature is offshoring, which results in routine activities moving to countries with lower labour costs. ([112])

Technological progress, particularly information and communication technologies, has made it easier to outsource tasks previously performed by middle-skilled workers. In particular, jobs that require little face-to-face interaction, or other on-site requirements, are more at risk of outsourcing. As a result, offshoring has been shifting domestic labour demand towards non-routine occupations (both low-skilled and high-skilled) for the last three decades. However, while offshoring has contributed to relative employment gains among high-skilled and relative losses in middle-skilled workers, it has not been the main factor contributing to polarisation. ([113])

Offshoring is conceptually distinct from, though related to, the degree of routine work in a job. ([114]) On the one hand, jobs that can be broken down into simple, routine tasks are likely to be easier to offshore than jobs requiring complex thinking, judgement, and human interaction. On the other hand, a wide range of complex tasks that involve high levels of skill and human judgement can also be offshored via telecommunication devices.

([109]) See Andrea Salvatori, 2018. "The anatomy of job polarisation in the UK," Journal for Labour Market Research, Springer Institute for Employment Research/ Institut für Arbeitsmarkt- und Berufsforschung (IAB), vol. 52(1), pages 1-15, December; Oesch, Daniel. (2013). Occupational Change in Europe: How Technology and Education Transform the Job Structure.

([110]) This section follows closely the methodology in Acemoglu, D. and D. Autor (2011), "Skills, Tasks and Technologies: Implications for Employment and Earnings", in *Handbook of Labor Economics*. See Box II.1 for more details on the methodology.

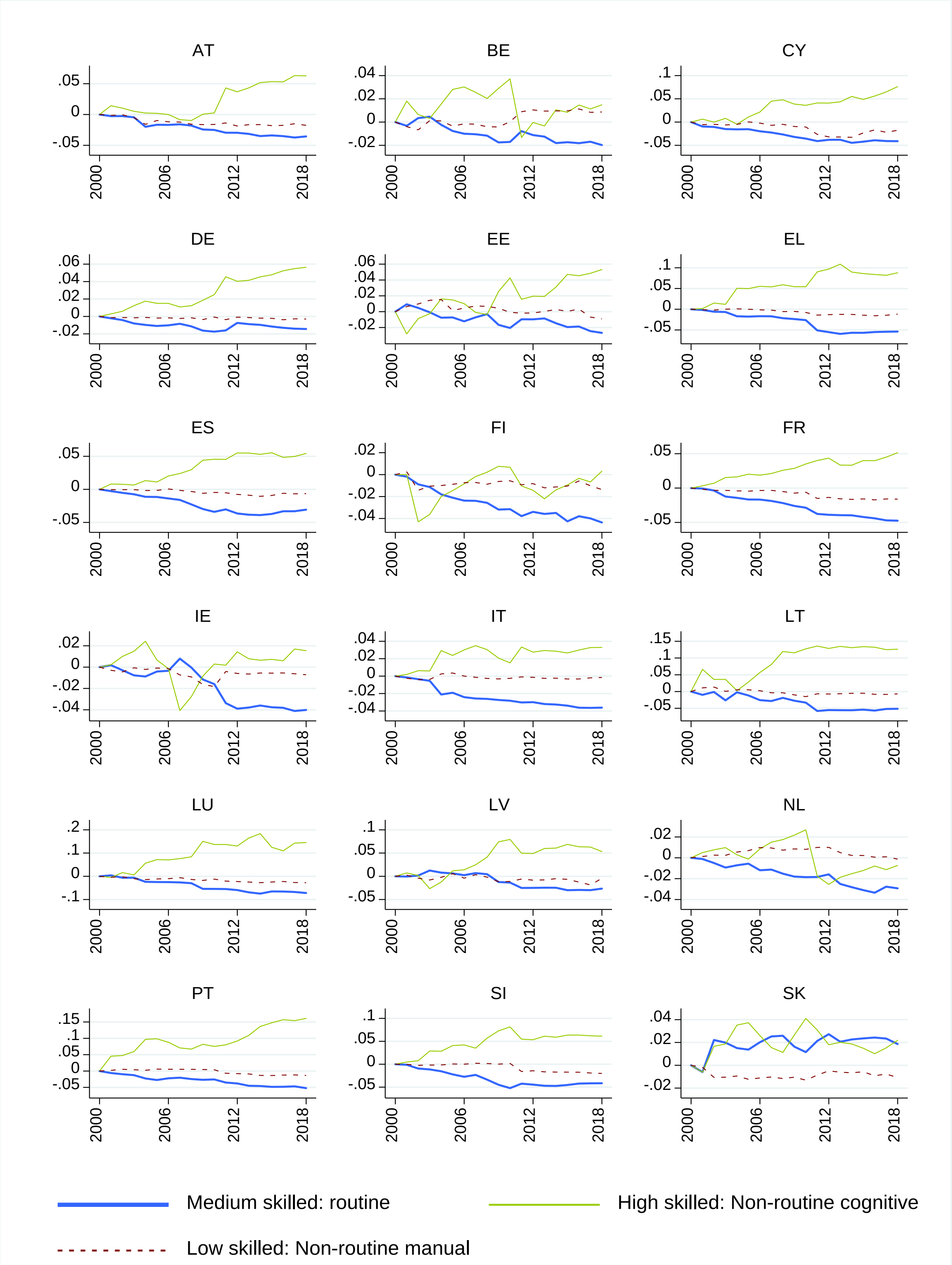
([111]) There is one caveat to add on the interpretation of routine tasks as medium-skilled: while this may be (to some extent) arguable when it comes to routine cognitive tasks; empirical evidence presented in Acemoglu and Autor (2011: p.1080) find that manual tasks are monotonically decreasing with skills levels, and that this applies both to routine and non-routine manual tasks (for more evidence on this, see Figure 11 in Górka et al. (2017))

([112]) See Autor, David H., and David Dorn (2013). "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market." *American Economic Review, 103 (5): 1553-97; Autor, D.H., D. Dorn and G.H. Hanson (2015), "Untangling trade and technology: evidence from local labour markets", The Economic Journal, Vol. 125, No 584, pp. 621–46.*

([113]) See Oldenski, L. (2014). Offshoring and the Polarization of the U.S. Labor Market. ILR Review, 67(3_suppl), 734–761; Goos, M., A. Manning and A. Salomon (2014), "Explaining job polarization: routine-biased technological change and offshoring", American Economic Review, Vol. 104, No 8, pp. 2509–26.

([114]) Blinder A.S., A. B. Krueger (2013) "Alternative Measures of Offshorability: A Survey Approach," Journal of Labor Economics, University of Chicago Press, vol. 31(S1), pages S97 - S128.

Graph II.6: **Almost all countries have experienced a decline in routine tasks**



(1) To make the results comparable the task indices were re-scaled to give an initial value of 0.
Source: Own calculations based on LFS and Ocupational Information Network (O*net) data.

Box II.1: The task-based approach and classifying task content

Studies following this approach are typically based on the job skill measurements created by Acemoglu and Autor (2011). They combine occupational databases or workers' surveys as a source of information on the task content of occupations with country-specific labour force survey data to analyse changes in task content of jobs over time. Although few studies use workers' surveys like the OECD Program for the International Assessment of Adult Competencies (PIAAC) or the European Working Conditions Survey (EWCS), many authors use an occupational database, in particular the Occupational Information Network dataset (ONET). Both alternatives, workers' surveys and occupational databases, have advantages and disadvantages in inferring the task content of jobs and occupations. On the one hand, using workers' surveys enables the study of variability in task content within each occupation or job type. However, collecting information on tasks from workers does introduce a potential bias in measurement, since their answers may be subjectively biased or indeed wrong (dissatisfied workers may exaggerate the level of routine work in their jobs, or new recruits may not be able to answer). Furthermore, there can be inconsistencies in the classification of workers across occupational levels and sectors. On the other hand, the Occupational Information Network dataset (ONET) is generally rather detailed in its measuring task content. However, it is only available for the US and although the task content of occupations should (in principle) be roughly the same across similarly developed economies, certain institutional and socioeconomic factors differ across countries, which could have an impact on the results, even at the level of task content.

This section follows the standard approach of combining the Occupational Information Network (O*NET) database as a source of information on the task content of occupations with the EU Labour Force Survey (EU-LFS) to analyse changes in the task content of jobs over time. Using the Acemoglu and Autor (2011) methodology, it creates six categories of task content: non-routine cognitive analytical, non-routine cognitive interpersonal, routine cognitive, routine manual, non-routine manual physical and non-routine manual personal. (1) Each of these categories was created by adding up the standardised task items (listed in Table 1). They can be further classified into three broad groups: non-routine cognitive, routine and non-routine manual, which approximate the top, middle and lower ends of the labour market respectively. Lastly, we standardised the task content measurements over time using the survey weights for each country separately so that the task indices give the overall intensity in the use of each task by country and year.

Table 1 displays the six task indices, paired by skill level, corresponding tasks and an example of occupation that requires high levels of each index.

Skill level	Task content measure	Tasks	Example
High skilled: non-routine cognitive tasks	Non-routine cognitive analytical	Analysing data/information Thinking creatively Interpreting information for others	Mathematicians, Actuaries and Statisticians
	Non-routine cognitive interpersonal	Establishing and maintaining personal relationships Guiding, directing and motivating subordinates Coaching/developing others	Managing Directors and Chief Executives
Medium skilled: routine tasks	Routine cognitive	The importance of repeating the same tasks The importance of being exact or accurate Structured vs. unstructured work	Cashiers and ticket clerks
	Routine manual	Pace determined by the speed of equipment Controlling machines and processes Spending time making repetitive motions	Rubber, plastics and paper products machine operators
Low skilled: non-routine manual tasks	Non-routine manual physical	Operating vehicles, mechanized devices, or equipment Spending time using hands to handle, control or feel objects, tools or controls Manual dexterity Spatial orientation	Heavy truck and bus drivers
	Non-routine manual personal	Social Perceptiveness Face-to-face discussions Assisting and Caring for Others	Hairdressers, beauticians, and related workers

Source: Own classification based on Acemoglu and Autor (2011).

(1) The category of non-routine manual personal is not part of Acemoglu and Autor's 2011 handbook paper, but it is available in their online data programmes used for the paper.

II.3.4. Individual measurements tracking labour market polarisation, the shift away from routine work and offshoring

Studies of this phenomenon do not typically provide a single measurement to track polarisation. An exception is the Job Polarisation Index (JPI). [115] The JPI tracks what it classes as "medium-level" jobs and measures what can be called imbalanced polarisation. The index tracks higher polarisation when and if the proportion of "medium-level" jobs, relative to its average in previous years, falls (and vice versa). The index also registers changes in the proportion of medium-level jobs that come about in a very imbalanced manner, e.g. if there is a major change to either low- or high-level jobs. Such imbalances would inflate the JPI.

This JPI comprises two measurements. The first tracks growth in the share of "low-level" and "high-level" jobs (the outflow from medium-level jobs). The second tracks the degree of imbalance, which rises as the change in the proportions of low and high level jobs increases relative to each other:

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

$\Delta_2 l$ and $\Delta_2 h$ are the change in the proportion of low-level and high-level jobs in year t compared with the average level of the previous two years. Hence, the value of the index is zero if the proportion of medium-level jobs has not changed from its reference value. The JPI distinguishes two situations where the share of medium-level jobs declines in both:

1. True polarisation: the proportion of both low-level and high-level jobs increases (first bracket);

2. Skills or wage upgrading: only the proportion of high-level jobs increases (second bracket).

The equivalent task-based single measurement of polarisation is the Routine Task Intensity Index (RTI), which is considered the best way to capture the impact of recent technological progress. The RTI index has become the standard measurement to track the task content of occupations. [116] Routine tasks consist of a repeated sequence of actions and are more easily replaceable by technological innovations. A higher RTI score thus indicates that an occupation is more 'routine-task intensive' and thus can more readily be automated. The RTI is calculated for each occupation as a relative intensity of routine tasks. [117] It is defined as the difference between the intensity of routine tasks (medium skill) and the intensity of non-routine tasks (analytical and personal):

$$RTI = \ln(rcog + rman) - \ln(nranalytical + nrpersonal)$$

Lastly, measurements tracking offshoring potential can vary widely and there is no consensus on the ideal measurement. [118] To investigate the impact of offshoring on skills mismatches, this section uses one of the standard measurements used in literature. [119]

Table II.1 illustrates the link between these three measurements relate in the euro area, with one direct measurement of polarisation (JPI index) and two measurements tracking the causes (RTI and offshoring indices). Overall, there seems to be a negative link between JPI and RTI indices, but a positive link between JPI and offshoring indices.

Table II.1: **Correlations between JPI, RTI and offshoring indices**

	JPI	RTI	Offshorability
JPI	1		
RTI	-0.1107*	1	
Offshorability	0.1625*	-0,0395	1

Source: Own calculations based on EU-LFS and O*net

[115] This section follows the index developed by Sparreboom, T., A. Tarvid (2016), Imbalanced Job Polarization and Skills Mismatch in Europe, Journal for Labour Market Research, 49, issue 1, p. 15-42. However, it applies the index to occupational groups classified by pay level instead of by skill level.

[116] Goos, M., A. Manning and A. Salomon (2014), "Explaining job polarization: routine-biased technological change and offshoring", *American Economic Review,* Vol. 104, No 8, pp. 2509–26.

[117] See Autor, David H., and David Dorn (2013). "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market." American Economic Review, 103 (5): 1553-97.

[118] See for example, Blinder A.S., A. B. Krueger (2013) "Alternative Measures of Offshorability: A Survey Approach," Journal of Labor Economics, University of Chicago Press, vol. 31(S1), pages S97 - S128. Firpo, Sergio & Fortin, Nicole M. & Lemieux, Thomas, 2011. "Occupational Tasks and Changes in the Wage Structure," IZA Discussion Papers 5542, Institute of Labor Economics (IZA).

[119] In particular this section applies the measurement of off-shorability created by Acemoglu, D. and D. Autor (2011), "Skills, Tasks and Technologies: Implications for Employment and Earnings", in Handbook of Labor Economics, to the EU-LFS data set using the same methodology as for the RTI.

Box II.2: **Empirical analysis: The link between macroeconomic skill mismatches and structural change in labour demand**

The empirical model to study the links between macroeconomic skill mismatches and structural change in labour demand in the euro area is based on a fixed-effects panel regression to control for unobservable country-specific factors. It is estimated for each structural change-related measurement (JPI, RTI and offshoring indices), according to the following formula:

$$SMM_{it} = u_{it} + \alpha_1 P_{it} + \beta C_{it} + \varepsilon_{it} \quad (1)$$

Whereby:

SMM_{it} is the macroeconomic skill mismatch indicator during the period t $\in T$ in country $i \in$ C, where C is the set of countries and T={2012,…, 2018};

α_1 is the estimated coefficient for the structural change-related measure (P);

P_{it} is one of the individual measurements of polarisation, routine task intensity or offshoring in country i and time t;

β is a vector of the estimated coefficients for the control variables (C);

C_{it} is a vector of controls in country i and time t;

u_{it} is the unknown intercept for each country i.

ε_{it} is the error term for country i and time t.

Variables used in the analysis:

- JPI, RTI and offshoring indices
- Unemployment rate
- GDP per capita, in log.
- Ageing is captured by the average age of the workforce.

To delve further into factors driving change in macroeconomic skill mismatches, the contributions made by selected explanatory variables to the total change in the macroeconomic skill mismatch indicator between 2002 and 2018 are estimated. Given C is the set of countries, the change in skill mismatch indicator may be approximated by the formula below:

$$\forall_{i \in C} S_i^{2018} - S_i^{2002} \approx \widehat{\beta_1} \Delta U_i + \widehat{\beta_2} \Delta G_i + \widehat{\beta_4} \Delta A_i + \widehat{\beta_5} \Delta R_i \quad (2)$$

Whereby:

S_i^{2018} and S_i^{2002} are the macroeconomic skill mismatch indicators in 2018 and 2002, respectively;

$\widehat{\beta_k}$ are the estimated coefficients for independent variables (k=1,2,3) from equation 1;

ΔU_i is the change in unemployment rate in country i between 2002 and 2018;

ΔG_i is the change in log of GDP per capita in country i between 2002 and 2018;

ΔA_i is the change in the average age of the workforce in country i between 2002 and 2018;

ΔR_i is the change in the routine task intensity index in country i between 2002 and 2018.

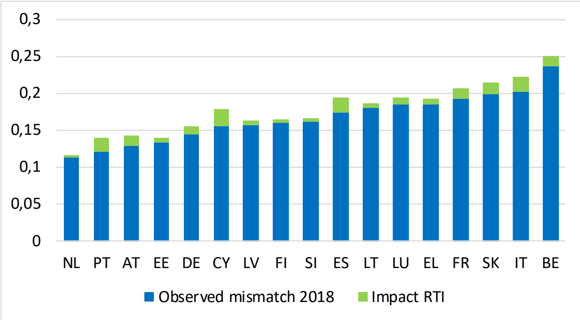
II.4. Macroeconomic skills mismatch and structural change in labour demand

To formally test the link between structural change in employment and skills mismatches, this section analyses the impact of different structural change-related measurements on the macroeconomic skills mismatches indicator (Table II.2). (120) Of the three measurements, only the RTI index seems to have a significant and negative link with skills mismatches in the euro area. This means that an increasing shift away from routine jobs is associated with an increase in skills mismatches. Technological change increases polarisation by reducing routine jobs, and this is associated with an increase in macroeconomic skills mismatches. Routine jobs are also more cyclical than non-routine jobs, which reinforces the correlation between both measurements (during an economic uptick, the skills mismatch will fall while routine jobs increase). (121)

To better explain the impact of technology-driven changes in employment structures, Graph II.7 plots the current level of skills mismatches and the predicted impact of a process of shifting away from routine work that would bring the degree of routine work in all euro-area Member States to the level currently observed in Ireland, which is the country with the lowest level of RTI in the euro area. The graph suggests that, with the exception of the Netherlands, which has a structure of employment similar to that of Ireland, most Member States would experience a rise in skills mismatches, as there is room for a further shift away from routine work. However, climate change policies might mitigate this process by adding middle-skilled, middle-income jobs. (122)

Table II.2 and graph II.8 suggest that the declining share of routine tasks in jobs has been associated with an increase in macroeconomic skills mismatches. Due to technological change, the skills demand is shifting towards higher skills and qualifications. In addition, there is increasing demand for highly educated workers, even in low-income jobs, and this demand might not be met fully and immediately by the skills available on the labour market, as it takes time for the education system and for adult learning to adapt. This is more apparent in middle-income countries, while in high-income countries, the increase in the supply of high-skill workers may have helped mitigate the effects of changes to the highest skills content in jobs.

Graph II.7: **Current and predicted macroeconomic skills mismatches if countries reach the level of shift away from routine work seen in Ireland**



Source: Own calculations using LFS and O*net data.

The impact of this shift away from routine work (measured by RTI) on skills mismatches seems to be greater in middle-income Member States (Table II.2). (123) Fast-changing technology accelerates the demand for different skills and creates mismatches unless supply keeps step. At the same time, technology replaces more routine jobs and makes it easier to outsource middle-skilled ones. Lastly, an ongoing process is taking place, in which employment is shifting from sectors with more routine-intensive jobs (e.g. manufacturing) to sectors with less-routine-based jobs (e.g. services), particularly in middle-income countries as high-income countries have largely completed this process. As a result, the shift away from routine work in middle-income countries might be faster and more intense, potentially increasing the skills mismatches as labour supply in these countries might find it more difficult to meet the fast-changing labour demand.

Graph II.8 shows how selected variables contributed to the total change in the macroeconomic skill mismatch indicator between 2002-2018. Though the shift away from routine work in the economy and the increasing age of the workforce were set to increase skill mismatches,

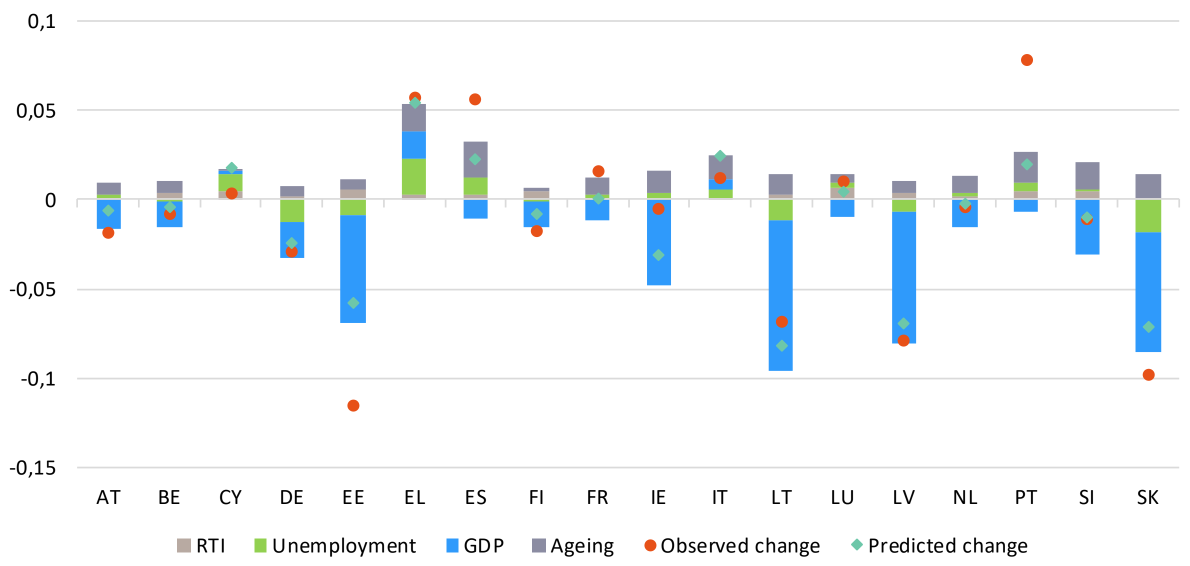
(120) See Box II.2 for details on the empirical strategy.
(121) C.L., Ryan, R.W. (2014) Labour market polarization over the business cycle. NBER Macroeconomics Annual, 29: 371-413.
(122) European Commission (2019), "Employment and Social Developments in Europe – Annual review 2019", Directorate-General for Employment, Social Affairs and Inclusion.
(123) Middle-income countries are defined as those with a GDP per capita that is below the EU average.

Table II.2: **Determinants of macroeconomic skills mismatches in the euro area, 2000-2018**

	Euro area			High-income countries			Middle-income countries		
VARIABLES	JPI	Off-shorability	RTI	JPI	Off-shorability	RTI	JPI	Off-shorability	RTI
Structural change measure	0.0002	-0.1672	-0.0727***	0.0009	-0.0472	-0.0522***	0.0004	-0.3325	-0.0902***
	(0.0015)	(0.1112)	(0.0193)	(0.0012)	(0.0859)	(0.0173)	(0.0027)	(0.2016)	(0.0302)
Unemployment rate	0.0016***	0.0020***	0.0017***	0.0024***	0.0029***	0.0027***	0.0013**	0.0020***	0.0015***
	(0.0004)	(0.0004)	(0.0003)	(0.0005)	(0.0005)	(0.0004)	(0.0005)	(0.0005)	(0.0005)
lngdp	-0.1203***	-0.1037***	-0.1190***	-0.0570***	-0.0372**	-0.0456***	-0.1312***	-0.1097***	-0.1334***
	(0.0117)	(0.0120)	(0.0112)	(0.0179)	(0.0174)	(0.0168)	(0.0162)	(0.0168)	(0.0150)
Average age of the workforce	0.0076***	0.0071***	0.0088***	0.0041	0.0013	0.0032	0.0076***	0.0073***	0.0093***
	(0.0019)	(0.0018)	(0.0018)	(0.0026)	(0.0025)	(0.0025)	(0.0028)	(0.0025)	(0.0025)
Observations	310	321	321	136	141	141	174	180	180
R-squared	0.5490	0.5449	0.5624	0.4094	0.3808	0.4204	0.5759	0.5789	0.5938
Countries	18	18	18	8	8	8	10	10	10
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

(1) Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
Source: Own calculations using LFS, O*net and AMECO.

Graph II.8: **Breakdown of changes in macroeconomic skills mismatches, 2002-2018**



Source: Own calculations based on LFS and O*net

these changes were compensated by other factors. In particular, the rise or fall in macroeconomic skill mismatches was largely driven by changes in the general economic conditions, particularly in middle-income Member States. General economic conditions are measured here by unemployment and GDP per capita.

II.5. Conclusions

This section examines the changes as well as the relationship between the well-documented process of structural change in labour demand and skills mismatches. It looks at multiple concepts and measurements of skills mismatches and structural change. The analysis yields a number of interesting results and new insights. Firstly, the level of skills mismatches fell during the recovery but there are significant differences across euro area Member States in both the level and the trend over time. Structural change in labour demand is also evident in most countries going through a process of shifting away from routine work and of decline in the share of middle-income occupations.

Current euro-area labour market trends hinder the process of reducing skills mismatches. Labour demand for skills is shifting towards higher skills and qualifications. Fast-changing technology is accelerating the demand for different skills, particularly more complex skills that can complement technology. At the same time, technology is replacing more routine work and makes it easier to outsource middle-skilled jobs. Results suggest that the declining share of routine tasks in jobs is linked to an increase in macroeconomic skills mismatches.

Although most Member States are exposed to the impact of the shift away from routine work and offshoring on skills mismatches, middle-income countries are more at risk. First, the shift away from routine work in middle-income countries might be more intense as they have more routine employment structures, potentially leading to more skills mismatches. Moreover, although in the short-term, certain middle-income countries may potentially benefit from job creation in routine occupations outsourced from high-income Member States, this will leave these countries more vulnerable to technology displacing routine work. Lastly, middle-income countries might find it more difficult to meet the fast-changing labour demand for more complex skills, as it takes time to upskill their workforces.

A policy response to address the consequences of this structural transformation can help reduce skills mismatches, increase productivity and improve the overall performance of labour markets. Hence, countries should put in place a comprehensive package of policies covering skills, lifelong learning, labour markets, social protection, as well as research and innovation.

As technology advances, and given the importance of certain jobs in the labour market, governments will need to promote flexibility and labour mobility as well as invest in education and training. This could enable workers to change jobs or even occupation, equipping them to be able to seize new opportunities and reduce the risk of job loss.

COVID-19 effects are further exposing these trends and will likely spur digital transformation of work and the workplace. Hence, in the current context, it is even more important that policy makers adopt appropriate policy strategies and options to help mitigate the impact of the postcrisis structural changes. In this regard, the Commission recently launched the Recovery and Resilience Facility and the new Skills Agenda, which should become key tools to facilitate the adaptation of education and training systems to support digital skills as well as to foster educational and vocational training for all ages.