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Qualification mismatch and occupational change: the role of demand, supply and institutional factors in explaining cross-national variations

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Abstract

The occupational structure of advanced economies has undergone significant changes over the past decades. On the demand side, technological change intensified and has been considered the main driver behind these transformations, with competing predictions concerning its impact on society. On the supply side, a very substantial educational expansion took place worldwide, allowing to cope with technological progress, boosting productivity and growth. The interaction between the two creates reasons for optimism through the upgrading of occupational structure, and pessimism due to the "hollowing out" of susceptible to automation middle-skilled jobs and the growth in low-skilled jobs. Furthermore, the imperfect match between demand and supply resulted in an increasing phenomenon of qualification mismatch and overeducation, questioning whether having higher education results in having a better job. However, the magnitude of these processes appears to vary across countries, with more promising upgrading trends in some countries and polarization in others. This suggests that a more detailed assessment of the role of demand, supply factors, and institutional characteristics might be important for drawing conclusions and developing policy remedies to address the challenges posed by rapid technological advancements.

In this dissertation, I analyse how the occupational structure has changed in 29 European countries over the past 15 years, investigating whether the technological change has been skill-biased or routine-biased and how these changes in occupational structure affected the risk of overeducation for individuals with different levels of education. I do so by analysing different sources of data and primarily the European Labour Force Survey (EU LFS). In the first part of the thesis, I provide a comparative assessment of changes in occupational structure based on different dimensions of job quality and task content of occupations. This assessment is followed by a multivariate regression analysis analyzing whether the cross-country dynamics of occupational change are explained by the different labor market institutions. In the second part of the thesis, I focus on the relationship between occupational structure and overeducation. I analyse how the incidence of overeducation varied across occupations and task-based occupational groups from a cross-country perspective. Finally, using a mixed-effects linear probability model, I explore how occupational change affects the risks of overeducation for different educational groups.

The findings suggest that changes in occupational structure can be simultaneously described as skill- and routine-biased, because the latter successfully explains the decline in the middle that the former does not account for. Routinization does not appear to preclude upgrading, and polarization is determined by the position of routine-intense occupations in the country-specific wage structure, explaining cross-country variation of occupational patterns. Stronger upgrading is noticeable in the countries with higher investments in R&D, education, training, and adult training. Stricter employment protection legislation for regular contracts and collective dismissals mitigates the “hollowing out” in the middle, while the impact of the minimum wage on employment in low-skilled jobs appears to be limited.

The evidence further suggests that upgrading of occupational structure and upskilling were accompanied by a rising incidence of overeducation, particularly in the period 2003-2010. Although it slightly declined in the period 2011-2018, a higher incidence of overeducation persisted among the tertiary-educated workers, especially in lower-skilled mildly-routine service occupations with a high degree of interactive tasks. Furthermore, while the risk of overeducation slightly declined for medium-skilled, it has not only persisted but increased for tertiary educated. These results point to a substitution effect, supporting a positional value of education for the labor queue: tertiary skilled workers substitute those medium-skilled, and the medium-skilled substitute the lower-skilled in mildly-routine intense occupations. Since these occupations are difficult to automate and are predicted to expand, the problem of overeducation is likely to persist in the next decades.

Contents

Introduction

The structure of employment has been continuously in the process of transformation. Technology has been considered its most important driver since the invention of the wheel, destroying and creating jobs, revolutionizing the process of production and at times fuelling conflicts and social unrest. Historically, there have been many instances of resistance and impediments to new technologies' adoption worldwide. The industrial revolution started in Great Britain and supported by the British government – as opposed to other European countries with strong resistance to innovations – was not an exception. In fact, it took decades and even centuries for new technologies, e.g. steam engine, spinning jenny, power loom, the factory system, to spread around the world. And while the technologies that emerged through the Industrial revolution allowed to increase production, communicate faster, and travel quicker, it had a profound impact on the occupational structure of society, detrimental for some groups of society and favourable for others.

Economists were among the first who tried to explain the changes in employment structure as well as why various groups of society were affected differently. Among others, Autor and Katz (1999), Acemoglu (2002), Goldin and Katz (2008) supported the thesis of Skill-biased technological change (SBTC), suggesting that technological developments caused the demand shift favouring higher educated workers and, thus, occupational upgrading. Recently, evidence of a more nuanced picture of the impact of technological change was documented, namely, routinization or Routine-Biased Technological Change (RBTC) (Autor et al., 2003; Goos & Manning, 2009, Goos et al., 2014). Within the framework of RBTC, automation leads to a declining share of jobs intense in routine tasks and raises demand for jobs intense in non-routine tasks. These tasks are found both at the top (high skilled jobs) and bottom (low-skilled service jobs), thus, driving polarization of occupational structure. Therefore, the predictions of both theories concerning changes in occupational structure focus on the relative position of specific skill (SBTC) or task groups (RBTC) in the hierarchy of earnings.

Analyzing changes in occupational structure across different countries and periods, scholars thus, identified its three main patterns: upgrading (monotonic growth

of jobs across all groups of occupations, stronger at the top and weaker at the bottom), polarization (simultaneous growth of high and low-skilled occupations and hollowing out of the middle), and mid-upgrading (growth in middle-skilled jobs) (Berman et al., 1998; Autor et al., 2003; Goos & Manning, 2009; Fernandez-Macias, 2012; Oesch, 2013). Vast support for polarization was found in the USA and UK from the 1980s, whereas findings for Europe were somehow mixed (Goos & Manning, 2007; Goos & Manning, 2009; Acemoglu & Autor, 2011; Wright & Dwyer, 2013). While studies on changes in employment structure have emerged in economics and were primarily the focus of labour economists, the issue has been increasingly getting attention from sociologists who were traditionally more focused on social inequalities rather than wage inequalities (Goldthorpe, 2004, 2013; Oesch, 2006).

Adopting the SBTC framework and occupation rather than a class-based scheme for analyzing occupational change, sociologists highlighted some of the critical weaknesses of the previous labour economists' approach. First of all, while some economists pointed out the possible role of the labour market institutions (e.g. Acemoglu, 1999), they were absent in their analysis of changes in employment structure. However, labour market institutions, such as trade unions or employment regulation, are likely to play a significant role in mediating the impact of technological change on employment structure, especially in explaining cross-country variations (Korpi, 1983; Kristal & Cohen, 2015, 2017; Oesch, 2015). Second, there has been an overwhelming focus on technological change as the primary driver of transformation in occupational structure. In contrast, some other important developments, such as the expansion of the "care economy", migration or, more in general, supply factors, were largely ignored (Wright & Dwyer, 2003; Dwyer, 2013; Oesch, 2013). Along with the impact of institutional settings, the role of specific characteristics of supply-side factors in affecting the direction of occupational change should not be underestimated.

While there might be some disagreements between different disciplines, the fact that technological change has been transforming the nature of jobs, shaping the demand for skills cannot be denied. Furthermore, compared to previous periods, the pace of change accelerated, emphasizing the importance of labour supply to support the "race" between technology and education. The supply of educated labour, particularly tertiary educated, has been increasing across developed countries since the 1970s (Freeman, 1975; OECD, 2013). Scholars and policy-makers have widely

praised the educational expansion, bringing positive economic and non-economic effects at the macro level and contributing to social and economic well-being at the micro-level (Hout, 2012).

In his book “Overeducated American”, Freeman (1975) was among the first to raise a concern concerning the negative consequences of educational expansion should it exceed the demand, leading to overeducation. The literature on overeducation has expanded ever since, with a large number of studies pointing at the persistence of the phenomenon (among others, OECD, 2011; Leuven & Osterbeeck, 2011; McGuinness et al., 2016). Nevertheless, it has been widely accepted that sustaining the supply of highly educated remains a priority as a substantial share of new and emerging jobs require workers with high education and skill level.

Considering the persistence of overeducation, this path of continuing educational expansion appears to be problematic, as an increasing level of educational attainment of the population does not automatically imply a better match between demand and supply. The match can only occur if the supply of highly educated is accompanied by the expansion of high-skilled occupations absorbing it. Otherwise, if the demand for high-skilled workers is limited and the share of middle-skilled occupations declines, overeducation incidence is likely to increase. While the failure of educational systems and labour market institutions were suggested to be important determinants of overeducation (Bol & Van der Werfhorst, 2011; Di Stasio et al., 2016; Levels et al., 2014; Verhaest & Van der Velden, 2013), very few studies considered changes in occupational structure as a possible explanation for the incidence of overeducation (Croce & Ghinoni, 2012; Zago, 2015).

On the one hand, this study aims to extend the evidence on patterns of occupational change across European countries, taking into consideration the role of demand, supply factors, and labour market institutions. On the other hand, it attempts to provide a more nuanced explanation for the variation in overeducation, taking into account the patterns of occupational change. Therefore, this analysis would allow us to establish which occupations in terms of job quality and task content have expanded or declined and how these dynamics affected the incidence of overeducation.

The main data source used in this research is the European Labour Force Survey 2003-2018 (EU LFS). Occupational change is assessed at ISCO MG level and

across quintiles, integrating information on earnings from the European Structure of Earnings Survey (2006, 2014) or the European Survey on Income and Living conditions where the former is not available. Occupational task indexes are constructed using the direct workers' assessment of their job content from the European Working Conditions Survey (waves 2005, 2010, 2015). Descriptive analysis is followed by multivariate regression introducing macro-level variables from the OECD database and EUROSTAT.

This dissertation is composed of four chapters. Chapters 1 and 2 present a literature review on occupational change and qualification mismatch from the perspective of the different disciplines, mainly sociology, economic sociology and labour economics.

Chapter 1 is organized into three sections, providing a detailed and comprehensive overview of how the different factors on the demand side (technological change), supply-side (human capital), along with mediating role of labour market institutions affect occupational change. More specifically, building largely on the labour economists' scholarship, the first section of Chapter 1 addresses the demand side explanation of the occupational change. It confronts two main theories with diverging implications for occupational structure: 'Skill-biased technological change' and 'Routine-biased technological change'. Also, it discusses in detail the methods employed in each of the aforementioned theoretical approaches and provides a systematic literature review of the main studies applying these theories in the analysis of occupational change in the US and the European countries. The second section focuses on the contribution of supply factors to occupational change, analyzing mainly educational expansion, which was largely overlooked by many scholars assigning a crucial role to the demand-side factors. The last, third section suggests an alternative and relatively novel explanation for diverging patterns of occupational change – the role of labour market institutions as mediating factors. It reviews economics and labour economics literature on the impact of Employment Protection Legislation (EPL), wage settings (Trade unions density and collective bargaining coverage) and "welfare" institutions (minimum wage and unemployment benefits) on employment dynamics. Drawing on the few comparative studies of occupational change in Europe with a restricted number of countries, it maintains that the institutions mentioned above affect not only employment/unemployment dynamics

but also occupational change. Furthermore, drawing on the insights provided by the literature on Varieties of Capitalism and Welfare states, which emphasize the relevance of institutional settings for social and economic dynamics, section three provides an overview of institutional impact to understand whether specific institutional configurations are helpful in explaining the patterns of occupational change.

Chapter 2 reviews the literature on qualification mismatch, and especially on overeducation. Section one provides a definition of qualification mismatch and overeducation, discusses approaches to its measurement and presents the critique that arose while pointing out the advantages and disadvantages of these various approaches. After reviewing the findings of multiple studies that identify the characteristics making individuals more susceptible to overeducation, it discusses its macro determinants. Section two traces the evolution of theoretical frameworks which explain overeducation, namely human capital, job competition, assignment and credentialist theories, and presents their implications for the persistence of phenomenon and individual earnings. Altogether, this leads to the question of how educational and labour market institutions affect overeducation incidence and persistence. Building primarily on economics and sociology literature, section three discusses how specificities of educational systems and labour market institutions affect overeducation. It reviews mainly comparative studies highlighting cross-country differences in educational systems and labour market institutions trying to establish their impact on overeducation.

The analysis presented in Chapter 3 addresses two main gaps identified through the literature review on occupational change. The first gap is the dominant focus on the demand side explanations of occupational change (technological change), which overlooks the role of supply factors and labour market institutions' characteristics. The second is the unidimensionality of job quality indicators prioritizing earnings over other dimensions. Additionally, while most of the studies focused on specific countries or a small number of countries, this research covers all the EU countries (except Malta), Switzerland, Norway and the UK over the 2003-2018 period. It provides an in-depth analysis of the patterns of occupational change across different dimensions and suggests possible explanations for cross-national variation. We might expect technological change to affect all the developed countries in the same or a very similar way. Supply-side factors (human capital) and characteristics of labour market

institutions that are more country-specific, on the other hand, are likely to play an important role in supporting and mediating the impact of technological change, contributing to cross-country variations.

The first sections of Chapter 3, thus, lay down the research questions and hypothesis with respect to occupational change in Europe. Section three introduces and describes the datasets used in the empirical analysis as well as the methods deployed in this research for constructing the job quality indicators and for the related empirical analysis. Section four presents the research findings. First, it addresses the issue of unidimensionality of job quality as identified by existing studies on occupational change, prioritizing the level of earnings and, at most, the level of education. It integrates indicators from job quality literature into the analysis of occupational change, namely skills (educational level), employment quality (share of involuntary part-time and temporary contracts), and work-life balance (share of workers with atypical work arrangements and long working hours). Considering the dimensions mentioned above and not exclusively wages allows for creating a more comprehensive picture of what regards job quality. Second, the analysis assesses the task content of occupations to understand whether it can explain their decline/expansion and whether it is in line with RBTC predictions. It also identifies the relationship between the nature of tasks and earnings. Sub-section four focuses on explaining cross-country variations in the patterns of occupational change across different institutional “families” of European countries. First, it traces developments in supply-side factors (educational expansion) and labour market institutions over time, trying to explain differences and similarities. Second, it tests the relationship between labour market institutions and patterns of occupational change empirically. The analysis results demonstrate that a widely diffused pattern of occupational upgrading in terms of earnings and education has been accompanied by routinization, explaining the decline in the middle. The picture is more nuanced with respect to employment quality: compared to the first two indicators, there is a rather visible increase in the share of workers in occupations with lower employment quality (part time and temporary contracts) and a poor work-life balance. Independently of the indicator used, the pattern of occupational change was more polarized during the 2003-2010, whereas the growth at the bottom of occupational structure slowed down or stopped from 2011 on. Regression analysis suggests that the impact of technological change on middle-skilled occupations was

partially mitigated by the strictness of employment protection legislation hindering the "hollowing out" in the middle and resulting in different rates of decline for this group across countries.

Chapter 4 is devoted to assessing the link between occupational change and overeducation. Acceleration of technological developments and the related changes in the nature and content of occupation altered the demand for skills. On the other hand, while substantial educational expansion has been taking place over the past 30 years across the developed countries, the problem of qualification mismatch arose, pointing out a possible misbalance between demand and supply. As interactions between demand and supply-side factors produce specific patterns of occupational change, it is also likely to affect the dynamics of overeducation, shedding light on how well the workforce skill composition matches the demand caused by technological change. Accordingly, we can expect occupational upgrading, strong decline in the middle or growth at the bottom of occupational structure with polarization to result in different incidences of overeducation due to job destruction at different levels of occupational structure. Therefore, while previous studies on qualification mismatch have focused mostly on individual determinants of overeducation and, to a lesser extent, educational system and labour market institutions characteristics, Chapter 4 of this research aims at bringing the two strands of literature — on occupational change and overeducation – together in order to assess whether there is a connection between the two, and namely, how different scenarios of occupational change are related to the job-education match. Section two lays down the research question and hypothesis guiding the analysis of the chapter. Section three presents the data and methods used to create the indicator of qualification mismatch and conduct empirical analysis. First, the empirical analysis investigates the incidence of overeducation and its dynamics over time and countries across different skill- and task-based groups of occupations. It tries to establish, in particular, the nature of occupations with a higher incidence of overeducation, both in terms of their skill level and task content. Second, it links the evidence of overeducation dynamics to the results that emerged from the analysis of the previous chapter on occupational change. By linking the two, it aims to explain whether there is a connection between different patterns of occupational change and the incidence of overeducation from a cross-country perspective. The last part of the empirical analysis assesses the association between the incidence of overeducation and specific occupational groups' dynamics across countries and over time. It tests, in

particular, whether and how the risk of overeducation for specific educational groups is affected by the patterns of occupational change. The results of the analysis point out at persistence of the incidence of overeducation, especially so for tertiary educated. It tends to increase most in the countries with an increasing share of employment in low-skilled service occupations, which are difficult to automate at the current stage of technological development. The findings, moreover, point out the presence of a substitution effect, with tertiary-educated workers substituting medium-skilled and the latter lower-skilled. This effect does not disappear with time, and the risk of overeducation for tertiary-educated appears, instead, to increase.

The concluding chapter summarizes and discusses the main findings and their policy implications. Taking into consideration the apparent presence of the link between occupational change and the incidence of overeducation, it suggests some possible avenues for future research encouraging more significant attention to the effect of education and training systems. Finally, it underlines that acquiring relevant skills, less susceptible to automation and more complementary to technology remains of utmost importance for assessing better quality jobs, avoiding unemployment and increasing productivity.

Chapter 1. Occupational change: drivers and scenarios

1.1. Demand-side explanation: Skill-biased and task biased technological change theories

Since the first Industrial Revolution of the XVIIIs century, the view on the impact of new technologies has been rather controversial. After centuries of strong resistance to innovations, the spread of mechanization led to the disappearance of middle-income jobs, made the skills of craftsmen redundant, increased economic inequalities and was accompanied by a falling labour share of income and growth of industrialists in profits (Acemoglu, 1999; Frey, 2019). Unsurprisingly, it resulted in massive unrest with workers burning down and smashing machines, among which Luddite's uprisings between 1811-1816 in England are most known. Who could have predicted then that the sacrifices of the workforce coming from labour replacing technologies and resulting in Engels's pause and "misery of the mass wage earners" (Frey & Rahbari, 2019) would have led to the prosperity of the future generations in the long term?

Almost a hundred years later, the invention of the assembly line by Henry Ford, breaking down operations into simple and repeatable tasks, allowed low-skilled workers to prosper. New industries and new jobs emerged as the Second Industrial Revolution "…led to the creation of new labour-intensive tasks" and "…generated jobs for a new class of engineers, machinists, repairmen, conductors, back-office workers and managers involved with the introduction and operation of new technologies" (Acemoglu & Restrepo, 2018). Automation was different from the XXs century mechanization, as newly emerged technologies augmented workers' productivity, increased the variety of jobs' for replaced workers and allowed wages to grow, creating a broad and prosperous middle-class (Frey, 2019). However, even within the context of these positive developments, "technological anxiety" persisted. In the 1960s, at the meeting of the American Federation of Labour, Congress of Industrial Organizations, J.F. Kennedy stated, "This [automation] is the revolution bright with the hope of a new prosperity for labour and a new abundance for America – but it is also a revolution, which carries the dark menace of industrial dislocation, increasing unemployment, and deepening poverty" (Kennedy, 1960).

The contest between these two views of technological impact became even more prominent with the ascent of computer technologies, undermining the positions of the middle class and increasing inequality between high and low skilled workers. The decline of the middle class was primarily linked to the decreasing costs of computers and their diffusion (Berger & Frey, 2016; Nordhaus, 2001). Nowadays, developments in Artificial Intelligence, Machine Learning, robotization threaten an even larger number of jobs: up to 47% can be digitized or automated within the next two decades, according to a widely cited work by Frey and Osborne (2013). AI is expected to have an even greater impact on the world of work than digitization and IT (Makrdidakis, 2017). In particular, software able to comprehend and use natural languages, self-driving vehicles and robots capable of implementing various functions might contribute to even more disruptive transformations and changes within and across occupations.

But how exactly has the technological change affected **occupational structure** in the past decades when its impact has clearly intensified? Scholars from different disciplines provided several explanations, pointing out different drivers behind these changes: demand factors, supply factors, or aiming to contribute to a more comprehensive understanding of this phenomenon, considered both. Different disciplines prioritized different drivers: the overwhelming majority of economists focused on demand factors, namely technological change and offshoring, whereas sociologists and political scientists emphasized the importance of supply factors and institutional characteristics. Among these, a particular contribution to the understanding of occupational change dynamics was made by labour economists.

Observing substantial changes in employment structure since the 1970s in the US, namely declining wages of low-skilled workers and their increasing unemployment, a growing number of scholars turned to search for an explanation of this phenomenon (Bound & Johnson, 1992; Katz & Murphy, 1992; Machin et al., 1996). Exploring the evidence from an earlier period, the scholars suggested that technological change was the main driver behind these transformations. Earlier studies on the relationship between technology and demand for skills identified a positive relationship between the two. Focusing on the manufacturing sector in the US, the UK, Denmark and Sweden from 1970 to the 1990s, the evidence provided by Machin et al. (1996) suggested complementarity between R&D intensity and human capital. Moreover, the

authors point out that human capital accumulation occurred more rapidly in the sectors that employed a higher share of high-skilled employees at the beginning of the period.

Focusing on the US during the 1960-1995 period, Autor et al. (1997) pointed out a similar relation, putting the diffusion of computer technology and its possible impact on the occupational structure at the centre of attention. The authors concluded that occupational and educational upgrading took place faster in the industries with higher intensity in computer utilization in the 1980s, while the diffusion of computer technology itself was responsible for increasing demand for higher-skilled workers already since the 1970s.

Goldin and Katz (1998) suggested that the positive effect of technological progress on skilled workers was noticeable in the US already in the 1910s, where the diffusion of batch and continuous-process methods of production favoured the demand for high-skilled labour. Acemoglu (1998) proposed a more nuanced picture of the relations between technological change and skills, “complementary not by nature, but by design”. The larger is the pool of skilled workers – the larger is the space for the emergence of skill complementary technologies fostering an upgrading. Contrasting the replacing character of technology in the XIX century favouring unskilled workers with the reversed trend in the XX century, Acemoglu (2002) highlighted the shift in the profit incentives. The supply of unskilled workers in the XIX century made profitable skill-replacing technologies, while the increasing supply of skilled labour in the XX century encouraged the development of “skill-complementary technologies” (Acemoglu, 2002).

Thus, juxtaposing high and low skilled workers, technological change (considered an exogenous factor) and, particularly, automation was seen as a major explanation for changing occupational structure in the 1970s with impact in two main directions (Acemoglu, 2002). On the one hand, the decreasing price of computer technologies incentivized firms to substitute expensive human labour, especially during the 1960s-to 1980s (Autor, 2015; Nordhaus, 2007;). On the other hand, automation requires a higher-skilled skilled labour force, boosting productivity through complementarity, reinforcing the demand for skilled labour, and positively affecting the wages of these workers overall, causing labour supply adjustments (Di Nardo & Pischke, 1997; Krueger, 1993). In this perspective, increasing stock of capital

equipment and high-skilled labour were considered complements, implying an increase in returns to education and higher wages compared to low-educated workers (Autor et al., 1998; Krusell et al., 2000;). Therefore, it was argued that technological change was skill-biased, causing an increase in skill premium for high-skilled workers, leading to a stagnation of average workers' wages and its decline for low-skilled workers in real terms (Acemoglu, 2002).

According to **Skill Biased Technological Change (SBTC)** theory and evidence, this non-neutral impact of technological change on two main groups of workers was expected to shift occupational structure upwards through increasing educational level attainment and better occupations placement (Machin et al., 1996; Machin et al., 1998; Goldin & Katz, 2008). Indeed, in line with this hypothesis, studies analyzing the period between 1960-1980 in the US pointed out at increasing demand for skilled labour with respective upwards shift of occupational structure and increasing wage premium for education (Levy & Murnane, 1992; Manacorda & Petrongolo, 1996; McIntosh, 2002). Particularly, the rising utilization of computers and R&D investments were considered the main explanatory factors in upskilling the US workforce (Autor, 1997; Berman et al., 1994; Machin et al., 1996). Overall, since the 1970s, most empirical evidence demonstrated the trend of increasing demand for high skilled workers and occupational upgrading both in the US and in other developed countries.

Support for the complementarity between human capital and technology (proxied by R&D expenditure and value-added) was found in the UK, Denmark, France, Japan, Germany and Sweden (Machin et al., 1996; Machin & Van Reenen, 1998). While pointing out two different types of employment shifts between and within industries, scholars highlighted that the changes during the observed period reflected a genuine upskilling process with a major shift within industries and not between, which would have represented changes in economies composition (Autor et al., 1997; Berman et al., 1994; Machin et al., 1996). Support for SBTC was also found in ten OECD countries during the 1970-1990 period with a shift towards skilled workers within industries and especially in the sectors of machinery & computers, electrical machinery and printing and publishing, which occurred despite increased or stable wages of skilled workers (Berman et al., 1998).

From the late 1980s onwards, scholars pointed out changing patterns of change in employment structure, namely decline in the middle-wage occupations and U-shaped growth of wages, undermining the hypothesis of occupational upgrading expected following the SBTC. Analyzing the American labour market comparing two periods of job expansion in the US (1960 and 2000), American sociologists Wright and Dwyer demonstrated how up to the 1980s, the job growth in the middle was accompanying job growth at tales of employment structure. Instead, job growth in the 1990s occurred disproportionally in the highest-paid quintile of employment distribution along with stronger growth of jobs at the bottom than in the middle (Wright & Dwyer 2003).

During the same period, analyzing the impact of computerization on skill demand during the 1960-1998s, Autor, Levy and Murnane (2003) came to an alternative explanation. The authors put task specificity of occupations at the core and suggested **routinization** as a cause of observed changes in occupational structure. They also underlined that occupations differ not only by skill but also by their task content, which being occupationally specific, remains overlooked if only skill level is considered. For example, analytical and problem-solving skills are at the core of managerial occupations, whereas finger dexterity and precision are more important for craft workers. Task content of occupations represents exactly this specific “bundle” of skills.

To analyze the task content of occupations, Autor et al. (2003) used the US Dictionary of Occupational Titles (DOT), providing information on occupational task requirements for the US occupations and three-digit level. The authors pointed out some limitations of the data that were likely to affect the precision of their analysis. These limitations referred to, among others, restricted sampling of occupations, particularly in the service sector, and omission of job skills, such as, for instance, interpersonal tasks particularly relevant for the service sector. The authors identified four groups of job tasks requirements. *Non-routine analytical* skills were captured by the extent to which occupations required Direction, control and planning of activities and quantitative reasoning requirements; *routine-cognitive* – by adaptability to work, setting limits, tolerance and standards; non-routine manual – by “eye-hand-foot” coordination; and *routine manual* – by finger dexterity. Autor and Dorn (2013) reduced the number of task groups retaining abstract and manual dimensions with the same

items while creating routine dimension being an average of “setting limits, tolerances and standards” and “finger dexterity”. Routine-cognitive and routine-manual dimensions were thus united into one. The final index was the measure of “routineness” in occupation calculated as the routine log minus the abstract and manual score logs.

The authors considered non-routine tasks resilient to automation due to their nature demanding flexibility, problem-solving capacity, adaptability, judgment, creativity, etc. Routine and easily programmable tasks are, instead, susceptible to substitution by computer technology. Advancements in computer technologies thus led to increasing relative demand for workers “who hold a comparative advantage in non-routine tasks”, or highly educated workers (Autor et al., 2003). Being diffused at the highest, but also at the lowest tails of employment distribution (e.g. care services), or so-called “technologically lagging” jobs, the decrease of middle-skilled jobs accompanied the growth at both tails.

Applying the routinization framework to the analysis of employment structure change in the UK since the 1970s, Goos and Manning (2007) provided similar evidence documenting the growth of “lousy and lovely jobs” compared to the middle. They suggested **Routine Biased Technological Change (RBTC)** be the driver behind these changes causing, as a consequence, **polarization** of employment structure. In the studies that followed, Goos, Manning and Salomons (2009) extended their work to the analysis of other European countries, identifying similar patterns of “pervasive job polarization” from 1993-to 2006 in Europe. Since then, RBTC became the leading explanation for polarization of employment structure, while the impact of offshoring and wage inequality as alternative explanations was significantly weaker.

Overall, these findings suggested the “hollowing out” of easily automated middle-skilled jobs (e.g. clerks, operators etc.), questioning the expectations of gradual upskilling and decline of low-skilled jobs as was foreseen by SBTC (Autor et al., 2003; Goos & Manning, 2009). In line with assumptions of automation impact, another demand-side factor – **trade and product demand** – suggested similar to RBTC expectations: while demographic change was expected to increase the demand for healthcare and personal services (Autor, 2008), offshoring (reinforced by technological change) contributed to decreasing demand for middle-skilled comparing to the high and low skilled individuals (Autor et al. 2003; Autor et al. 2006; Goos & Manning, 2009,

2014). Altogether, it implies that workers from occupations intense in routine tasks were forced to move down the occupational ladder into low-skilled non-routine manual jobs at the bottom of the wage distribution (Autor & Dorn, 2013). These were primarily low-skilled service occupations, such as personal and protective workers, which are still difficult to substitute by automation due to the nature of these occupations.

Thus, the diffusion of computers and robots and declining computer capital prices were generally seen as the main drivers of routinization replacing middle-skilled workers. Consequently, as similar evidence supporting polarization emerged across other developed countries, an increasing number of scholars turned to the RBTS framework for explaining changes in employment structure (Autor & Dorn, 2013; Goos & Manning, 2014; Spitz-Oener, 2006). The debate on technological change has, thus, shifted the focus from the discussion of technology versus skills in general towards specific job tasks and their substitutability (Acemoglu & Autor 2011; Autor 2013; Autor and Dorn 2013).

While routinization remains the most popular explanation for the dynamics of occupational change, several more nuanced observations and suggestions emerged. While, as supported by widespread evidence, middle-skilled occupations turned out to be “losers” following automation and computerization, the emergence and advancement of new technologies led to questioning whether it was the ultimate group to be affected by the developments. Focusing on the US, Deming (2017) suggested that the extent of social interaction determines the “survival” of the occupation. The author provided evidence of increasing relative employment share and wage growth for “social skill-intensive occupations” between 1920-2012 in the US, arguing that even non-routine jobs intense in analytical/cognitive skills might become redundant (Deming 2017). This finding is also in line with the study of Blinder and Krueger (2013), suggesting that non-routine jobs intense in human interaction are unlikely to be offshored or substituted by computer technologies.

Webb (2019), using a new method in assessing the impact of technology on occupations, namely linking job task descriptions and text from patents, provided new evidence on the job exposure to automation. The author found that exposure to the introduction of robots diminished with higher education. The case was similar to the effect of software, even though the impact of education was weaker. Finally, the author

assessed the impact of AI on occupations, underlying that its impact is very distinct from the first two technologies affecting very different occupations, including high-skilled ones. Paralegals and administrative judges are, for instance, more susceptible to automation by AI compared to lawyers. The tasks in the former occupations are cognitively intense but are standardized, whereas an important share of lawyers' tasks consist of negotiation and generally require fast reaction and problem-solving capacities. At the same time, some low-skilled jobs appeared to be less exposed to AI, such as retail and food services workers. Compared to robots and software, the impact of AI is, thus, different, and the exposure increases with higher education. Somehow in line with previous findings, the capacity to react, solve problems and interact remained among the bottlenecks for newer technologies. Refraining from pessimistic prediction, the author suggests that while AI will affect tasks and occupations – either substituting or complementing them – the specificity of labour supply is likely to impact employment and wages (Webb, 2019). In fact, using the US individual level panel data 2011-2018, the results of Fossen and Sorgner (2019) analysis suggest that exposure to advances in AI is associated with stronger job stability and wage growth, especially for those with higher educational levels and wok experience, indicating that AI is complementary to human labour. While the impact of AI on employment and wages is still unclear, the type of AI, the way it is developed and implemented as well as policies will have a crucial impact on its direction (Lane & Saint-Martin, 2021).

1.2. Supply-side explanation: human capital

While technological change affects labour markets similarly, the role of labour supply factors and compositional changes that might affect the dynamics of occupational change leading to cross-national variations should not be underestimated. For instance, it is difficult to deny the role of improving workers' cognitive skills and increased educational attainment in allowing to cope with the rapid advancement of technology and globalization and boost productivity and growth. Human capital entailing workers' knowledge, skills, and abilities is, in fact, at the centre of attention of endogenous growth theories, considering interaction and complementarity between education and innovations crucial for determining a country's economic growth and development (Acemoglu, 1997; Romer, 1986).

Investment in human capital, thus, became a key to the economic growth and success of nations (Becker, 1992; Goldin & Katz, 2008).

While, as discussed earlier, a large number of studies focused on technological change as the main explanation for changes in employment structure, several scholars pointed out that production technologies and jobs created by firms were determined not only by demand factors but also by the supply of skills available in the country (Korpi, 2009; Oesch, 2013; Scicchitano, 2010; Van Reenen, 1998). From the middle of the XXs century, the rapid development of informational technologies took place with the emergence of new occupations raising the demand for skilled workers (Berman & Machin, 2000; Goldin & Katz, 2008). In fact, existing studies show that while educational enrolment has been expanding from the beginning of the XX century, the most substantial increase occurred from around 1960 to 1970, allowing for wider access to higher education and, consequently, boosting productivity and economic growth (Schofer & Meyer, 2005).

In particular, if we recall the experience of the US – the country that received the widest attention in studies of occupational change – the supply of skilled workers had gradually and substantially increased from 1900 to 1980. The High school movement between 1910-1940 led to an increase in the number of youth with high school diplomas from 9 to 40%, and by the 1920s, one-fourth of the labour force were working in occupations requiring a high school diploma (Frey, 2019; Goldin & Katz, 2008). Demand for better-educated workers matched supply, or as Goldin and Katz put it, “education raced ahead of technology”, lowering inequality. Generally oriented programmes and an egalitarian US system allowed young people to acquire the skills necessary to respond to technological change.

While by the end of the XX century, European countries started to catch up with rates of educational expansion in the US, a “great reversal” took place in the US in the 1980s. Educational attainment slowed down, and technology started to “race ahead of education”, causing an increase in wage inequality (Acemoglu & Autor, 2011; Goldin & Katz, 2008; Tinbergen, 1977). In Europe, on the other hand, educational expansion continued.

It is worth underlining that educational expansion might not necessarily be considered a result of labour market demand. Different strands of literature point out

different drivers of educational expansion, such as public policy, the political struggle between groups to ensure better mobility for future generations, or institutional change (Collins, 1971; Schofer & Meyer, 2005). The massive educational expansion thus had not necessarily resulted in a perfect match between supply and demand, leading to the emerging problem of **qualification mismatch**, and more specifically, **overeducation,** which will be discussed later.

Assessing changes in educational supply thus becomes crucial for understanding occupational change dynamics. On the other hand, defining the patterns of occupational change appears essential for understanding workers with which skills have a higher risk of becoming redundant and developing measures for their transition to other occupations or retraining.

1.3. Occupational change and labour market institutions

Along with supply factors contributing to variations in occupational change scenarios across countries, the role of institutional settings mediating the impact of technological change cannot be ignored, especially considering institutional diversity within Europe. **Institutions** such as minimum wage, collective bargaining or unemployment benefits play an important role in job creation and, particularly, its quality (Acemoglu, 2002; Fernandez-Macias & Hurley, 2017; Oesch, 2013; Oesch & Murphy, 2017). While most studies focused on assessing the impact of the specific institution(s) on employment and unemployment dynamics, only a few comparative studies attempted to determine the role of labour market institutions on **occupational change** in Europe.

Trying to link occupational change to labour market institutions in his analysis novel and comprehensive analysis of occupational structure change in five European countries, Oesch (2013) referred to the work of Krugman. Observing increasing wage inequality in the US and growing unemployment in Europe during the 1980s, Krugman argued that a skill-biased change in labour demand drove both processes, but the variation in results was determined by the different extent of wage rigidity on the two continents (Krugman 1994). The policy solution for addressing the declining demand for lower-skilled lied, thus, in choosing between unemployment and wage inequality.

While since the 1950s, there has been an erosion in wage-setting institutions in the US with declining TU density and falling minimum wage in real terms, union density in Europe has been moderately increasing between 1960-1980s with strict regulation on minimum wages and hiring and firing restrictions (Card, 2001; Freeman, 2005; Howell et al., 2006). More specifically, the “welfare without work” strategy with generous benefits facilitated early retirement schemes and led to an “inactivity trap” and falling employment, being particularly harmful to youth, female workers, lower-skilled groups, outsiders and older workers (Boeri 2011; Eichhorst & Marx, 2021; Esping-Andersen, 1996; Gangl, 2003). Powerful unions and high wage floors, thus, prevented growth in low-skilled services and decreased inequality, but at the cost of rising unemployment. Deregulation, instead, fostered the creation of jobs in low-end services, boosting inequality. The two distinct patterns emerged in the US and Europe in the context of technological change, therefore, underline the importance of assessing the role of specific institutions as well as their configurations in explaining cross-country variations. Before proceeding with the analysis, it is important to discuss theoretical considerations concerning the impact of specific institutions on the labour market and previous empirical findings.

The associational power of workers reflected in union density and the extent of collective bargaining systems allows workers to exert influence on decisions regarding employment protection, job quality, and welfare spending (Checchi & Lucifora, 2002; Gallie, 2009; Korpi, 2006;). Unionized workers are more likely to increase their earnings (Bryson, 2007), accelerate wage growth (Kollmeyers, 2017), and prevent working poverty (Brady et al., 2013). On the other hand, middle earning workers tend to benefit more from unionization than lower-earning workers (Firpo et al., 2009), leading to inequality. Furthermore, analyzing 17 OECD countries during the 1960-1996 period, Bertola et al. (2007) found a negative impact of increasing wage rigidity on employment of young and old compared to prime-age individuals and prime-age women compared to men. The authors additionally suggested that wage rigidity caused an increase in female and young men's unemployment (Bertola et al., 2007).

Similarly, based on the analysis of 15 OECD countries between 1985-1994, Kahn (2000) suggested that higher union coverage and membership led to an increase in relative pay while lowering the relative employment of less-skilled men. This evidence, along with many other studies, pointed out dualization, or more precisely, its

political dimension where trade union members or insiders represented by the political system can exert power to protect their interests in the long run, while outsiders can not (Lindbeck & Snower, 2001; Palier & Thelen, 2008). While there has generally been a decline in trade union density and bargaining coverage during the past 30 years, the advantage of insiders over outsiders appears to persist (Eirchost & Marx, 2021; Häusermann & Schwander, 2010).

Strict Employment Protection Legislation (EPL) was considered to be another major explanation for persistently high unemployment and low productivity in European countries (Blanchard & Wolfers, 2000; Rueda, 2006). Deregulation was, thus, seen as a "recipe" to address this problem, particularly encouraged by OECD Jobs Study (OECD, 1994) and further promoted by the European Commission following the 2008 crisis.

The impact of employment protection legislation on the labour market has been a point of concern and debate for a long time, with ambiguous findings. Raising the costs of hiring and firing, EPL hampers labour reallocation, decreases employment and competitiveness, and slows down adjustments caused by external shocks, increasing unemployment incidence (Bentolila & Bertola 1990; Boeri and Garibaldi 2007; OECD 1994). Considering the insiders-outsiders divide, strict EPL thus has particularly negative consequences for women, youth, and lower-skilled workers and leads to workers' displacement favouring "insiders". Decreasing protection for permanent contracts lowers the barriers to the entrance of more disadvantaged workers. Greater flexibility in employment protection allows employers to adjust to market fluctuations more rapidly and effectively while boosting labour market mobility (Boeri & Jimeno, 2005; Martin & Scarpetta, 2012).

Overall, the evidence on relations between employment/unemployment and EPL is controversial. Some scholars argue for its detrimental impact (Nickell et al., 2005; Scarpetta, 1996), while others point to no link between the two (Howell et al., 2006). With respect to the EPL impact on the labour market segmentation, several studies concluded that asymmetric deregulation of temporary contracts has contributed to reinforcing labour market dualism (Boeri, 2011; Eichorst & Marx, 2011; Emmenegger, 2015). While it allowed employers to respond to market fluctuations

using temporary employees, it led to persistence in segmentation since the protection of permanent workers remained strong.

There has been less disagreement on the adverse impact of unemployment benefits (taking into consideration their level and duration) on employment/unemployment, even though some controversial findings emerged with respect to their long-term effects. Generous unemployment benefits were, in fact, another component of so-much criticized “welfare without work” strategy in Continental Europe (Esping-Andersen, 1999; OECD, 1994). It is conventionally accepted that generous unemployment benefits reduce incentives to look for a job, reducing workers' supply (Howell, 2007; Oesch, 2010). On the other hand, it was found that in the long term, they improve matching, leading to higher workers’ productivity (Acemoglu 1999), higher satisfaction and lower turnover (Estevez-Abe et al.,2001; Gangl, 2004).

Apart from the specific impact of single labour market institutions on labour market dynamics and occupational change, we should bear in mind that they make part of overall different institutional structures, and their interaction might affect these dynamics differently (Hall & Soskice, 2001). The two most influential theories analyzing institutions’ impact on the labour market and production system are Varieties of Capitalism (VoC) and Welfare states.

VoC was developed in the field of comparative political economy and suggests the presence of two extremely different types of production regimes developed in capitalist countries: Coordinated Market Economy (CME) based on strong non-market relations among institutions, and Liberal Market Economy (LME) functioning on the principles of competitive market arrangements (Hall & Soskice, 2001). The comparative advantage of CMEs consists in a strong focus and abilities for process innovation and production of high-quality goods in manufacturing, while LMEs are more successful in radical innovation developing new products and industries.

These differences in production are predetermined by the nature and extent of cooperation among economic actors. In CMEs, strong inter-firm relations, cooperation between trade unions and employers’ associations, and long-term orientation are combined with high levels of job security and investments in training aimed at the development of specific skills (Hall & Soskice, 2001; Estevez-Abe et al., 2001). In LMEs, on the other hand, competitive relations among economic actors, decentralized

industrial relations system and scarce investments in training incentivize the acquisition of general skills (Hall & Soskice 2001; Estevez-Abe et al., 2001). These two different strategies push for the creation of more secure jobs in CMEs and flexible and even precarious in LMEs. With respect to adult training, general skills acquired in LMEs could be complemented by on-firm training (Busemeyer & Trampusch, 2011). However, it is rarely the case considering the lack of incentives for employers. Through the strong influence of employers' associations and trade unions, companies in CMEs can be expected to invest in continuous training, better adapt their labour force to technological change, and prevent skill obsolescence.

VoC has been widely criticized for its static and simplistic approach, inappropriate under the process of liberalization (Crouch, 2005; Streeck, 2010), for underestimation of political and social impact on institutional change (Thelen & Hall, 2009), and the focus on the national level and neglect of internal diversities (Schroder & Voelzkow, 2016). The fierce critique came from liberalization theory pointing at the expected erosion of the distinction between CMEs and LMEs caused by the process of liberalization, deregulation, declining union density and collective bargaining (Baccaro & Howell, 2011), and the necessity to reduce social spending (Trampusch, 2009; Streeck, 2010).

As a response, Hall and Thelen (2009) expanded the previous framework, questioning the assumption of convergence as proposed by liberalization theory. They further argued that while the opportunity structure of actors had changed, national responses and institutional change continued to be moderated by specific institutional arrangements, further pointing at different trajectories of liberalization (Thelen, 2012).

While Hall and Soskice (2001) did not include a social policy in their framework, they recognized the connection between VoC and Welfare state theories. The authors pointed out the role of social policies in facilitating firms' relations with other actors, improving the quality of training and labour market turnover (Hall & Soskice, 2001). Different approaches to redistribution and social justice affect the labour market and the liberalization process differently, resulting in deregulation, dualization or embedded flexibilization (Thelen, 2012). Considering these premises, we can expect welfare institutions to play an important role in shaping adaptation to technological change,

with variation across countries and across different social and demographic groups within countries.

In a similar perspective considering institutional diversity, Oesch (2015) referred to the works of Streeck (1997) and Acemoglu (2003). The authors emphasized the role of institutions in constraining employers to choose between a “low road” and a “high-road” job strategy. The first one focuses on the creation of low-skilled, low-wages, low quality and low productivity jobs with no or little investment in training; while the second on the creation of high skilled, high paid, high quality and high productivity jobs (Crouch & Streeck, 1993; Acemoglu, 2001; Oesch, 2015). In this context, wage-setting institutions and social policies could constrain job creation, raising unemployment or foster firms’ investments in low-skilled workforce.

In line with this argument, in his analysis of change in occupational structure in Britain, Denmark, and Germany, Oesch (2015), discussing the work of Esping-Andersen on the welfare state (1990), suggested that differences in the patterns of occupational change are the result of the interaction between labour supply factors and welfare regimes, where the latter influence employment creation, affecting in particular creation of interpersonal service jobs at the bottom of occupational structure. The author finds evidence of an expansion of interpersonal service workers at the bottom of the wage distribution in the Liberal welfare regime in Britain, its stagnation in Denmark and Germany, and a strong expansion of professional and managerial occupations in all three countries between 1990 and 2008.

Analyzing occupational change in 15 European countries between 1995-2007, Fernandez-Macias (2012) links specific occupational change patterns with European institutional families: a tendency towards polarization in Continental Europe, upgrading in Northern countries and mid-upgrading in Southern countries. According to the author, those patterns were mainly driven by substantial labour market deregulation between 1990-the 2000s in Continental Europe, strong unions and compressed wage structures in Nordic countries, and adherence to European Monetary Union in Southern Europe, accelerating employment expansion.

Therefore, under the condition of a similar impact of technological change on all the advanced economies, in line with the discussed literature, we might expect that supply-side factors and the specificity of labour market institutions moderated the

impact of technological change on the occupational structure. Moreover, considering transformations in institutions themselves, especially following the economic crisis, we might explore further whether the reaction to and consequences of this shock led to similar results and reduced cross-country variation or whether the differences persisted.

1.4. Occupational change: approaches and measurement

While there have been many gloomy predictions regarding the disappearance of jobs due to technological change and digitalization, we continue to witness a mixed picture of transformations in occupational structure, which combines the emergence of new jobs and the disappearance of some “traditional jobs”.

The table in Appendix A provides a short review of the most relevant and influential studies on change in employment structure applying both SBTC and RBTC frameworks. As emerges from the literature review summary, changes in employment structure were mainly studied at the country level, partially predetermined by data availability. However, some studies provided a cross-country comparison (with frequently the same set of countries), trying to identify similarities, divergences and potential drivers for explaining the differences. There has also been a variation in periods of analysis and sources of information used to describe the patterns of change in employment structures across countries. While there has mostly been a consensus that up to the late 1980s, occupational structure shifted upwards across developed countries, the evidence on the period that followed has been somehow contradictory. Additionally, while the polarization scenario was confirmed by the studies on the US and UK, the picture for the European countries varied.

These variations in patterns of change in employment structure may, in part, be explained by the differences in the method for accessing the change. As discussed previously, it is directly related to the different assumptions of SBTC and RBTC theories. The former focuses on the interaction between skills, technology, and their complementarity's crucial role in explaining changes in employment structure. The latter underlines the importance of task content of occupations, defining the aspects of work that are more susceptible to automation. Consequently, an important difference in measurement lies between those testing the SBTC/RBTC hypothesis: the

proponents of the first focus on mean/median earnings or education level for different occupations (or combination of occupation and sector), and those of the second on the routine intensity of occupations and earnings.

Using the SBTC framework for analyzing the occupational change in five countries (Denmark, Germany, UK, Spain and Switzerland) over the 1990-2008 period, Oesch (2013) finds more support for occupational upgrading in all the countries except for the UK. Specifically, along with a substantial expansion in the upper tail of employment distribution, the author points out the noticeable decline of middle-skilled jobs in four countries but, except the UK, without growth at the lower end. Doing a comprehensive analysis taking into consideration both demand and supply factors, the author suggests the possible role of institutions (e.g. wage bargaining, minimum wage settings) in preventing the creation of jobs at the lower end in all countries but the UK with its liberal institutions and availability of low-skilled migrant labour. Similarly, underling the importance of supply side factors, Fellini and Fullin (2018), point out at an increase in the share of low-skilled jobs in Italy driven into a large extent by availability of immigrant workers, and especially increasing demand for care work resulting in overall downgrading of occupational structure.

In another comparative study, Oesch and Piccitto (2019) question the findings of job polarization in Germany, Spain, Sweden and the United Kingdom between 1992-2015, analyzing good and bad occupations across four dimensions: earning, education, prestige and job satisfaction. In contrast to other studies, the authors point out the strong expansion of high-quality jobs and stagnation or limited growth of bad quality jobs independently of the indicator used. The polarization trend in terms of earnings emerges only in the UK while other countries demonstrate the pattern of occupational upgrading.

Conducting a similar analysis for Italy over the 1992-2015 period, Piccitto (2019) finds evidence of occupational upgrading before the crisis (especially strong for women) and after, even though at a slower pace. The author, furthermore, looks not only at indicators of wage but also job satisfaction and prestige, demonstrating increasing work quality in Italy with growth at the upper tail, a decrease in the lowest quintile of “bad jobs”, and a slighter decrease in middle-skilled jobs.

Cirillo (2016) presented a more nuanced picture emphasizing the role of industry-level technological trajectories and occupations. The author finds limited polarization in the manufacturing sector due to the disappearance of jobs at the bottom and increased polarization for employment in services with the decline of middle-skilled jobs. Moreover, the author points to variation between the countries, confirming the polarization scenario in the UK but, in contrast to other studies, not in Spain (Cirillo, 2016). With similar considerations, negative relations between employment and jobs with routine tasks are found for the service sector while being weak for the manufacturing sector in Italy (Guarascio et al., 2018).

Generally, when applying the **RBTC** framework, scholars referred to the analysis of either change in shares of employment requiring different tasks inputs across times and industries or wage quintiles (as well as terciles or deciles) of occupations. Many authors found evidence of a decline in routine manual and routine cognitive tasks along with an increase in cognitive non-routine tasks in the US (Autor et al., 2003), West Germany (Spitz-Oener, 2006); UK (Goos & Manning, 2007), and 16 European countries (Goos et al., 2009). In the US, job polarization was found to be accompanied by wage polarization (Autor et al., 2006, 2008); so as in the UK (Goos & Manning, 2007) and 16 European countries (Goos et al. 2009), Norway, Sweden and into a lesser extent in Finland (Asplund et al., 2011). Goos, Manning and Salmons (2009), who first studied the occupational change in Europe, pointed out a “pervasive” pattern of job polarization caused by routinization. The finding implied the absence of any variation across European countries independently of their institutional differences.

The analysis of occupational change in Europe by Fernandez-Macias (2012) that followed, however, pointed to different results. The author employed a similar to Goos et al. (2009) framework but ranked and aggregated jobs into groups in a fundamentally different way. The jobs defined at 2-digit occupation and sector level were ranked by country-specific median wage, unlike in the study by Goos et al. (2009), who applied the UK 1994 wage to all European countries, which is, indeed, a strong assumption with regard to the wage structures. Additionally, while Goos et al. (2009) created three unequal groups of occupations based on their wage ranking (good, middling and bad jobs), Fernandez-Macias (2012) divided jobs into five quintiles containing around 20% of employment each based on countries’ occupation and sector specific wages at ISCO 2 digit. Consequently, Fernandez-Macias's analysis (2012) demonstrated

significant variations in occupational change patterns in Europe. The author rejected the universal trend of polarization in Europe and suggested the presence of different country scenarios: polarization, upgrading and mid-upgrading. Thus, taking into consideration the differences in wage structure across the countries and aggregating occupations into the groups differently led to contrasting results in these two studies. Using country- and occupation specific wages – that differ considering institutional variations – as well as creating equal wage tiers, Fernandez-Macias challenged the previous finding of the pervasiveness of the polarization in Europe, underlining the role of labour market institutions in explaining the cross-country divergences. While this approach is more empirically sound, and analysing occupational change using quintiles is helpful for illustrating overall dynamics, it might be ill-suited for understanding the possible drivers behind these transformations. This is due to the fact that dynamics in specific occupational groups might be hidden following the aggregation of different occupations into quintiles.

Similarly, since operationalization of routine tasks varied across different studies, and the support for routinization was not as strong in Europe as in the US, it is worthwhile discussing variations in the operationalization of the task content and its possible implications for occupational change.

RBTC was formulated in the US in a seminal paper by Autor, Levy and Murnane (2003, consequently ALM), arguing for the crucial role of occupational task composition in employment reallocation and comparative advantage of task execution between workers and “machines”. Computer capital was considered to be a substitute “for workers carrying out a limited and well-defined set of cognitive and manual activities, those that can be accomplished by following explicit rules”, and a complement to workers “carrying out problem-solving and complex communication activities” (ALM, 2003). The measurement of task intensity for each dimension (routine manual, routine cognitive, non-routine interactive, non-routine analytic, non-routine manual) was based on the information from the US Dictionary of Occupational Titles – expert-based assessment of task content of occupations.

The vast majority of studies that followed applied this or slightly more general classification distinguishing between routine, manual and abstract tasks (Autor et al., 2006; Autor & Dorn, 2013) to occupations both within the US and abroad (e.g. Goos & Manning, 2009 for Europe; Sebastian 2018 for Spain). Spitz-Oener (2006) applied the

analytical framework elaborated by ALM but used the German Qualification and Career Survey (2006), further adding an “interactive” dimension.

While these slightly different operationalizations produced similar results in country studies (US), it was not the case for cross-country comparison in Europe. Fernandez-Macias and Hurley (2017) took advantage of information from European Working Conditions Survey (EWCS), proposing a new framework for measuring the task content of occupations, and pointing out an important problem in the operationalization of routine in the work of ALM.

Particularly, they underlined the difficulty in defining the “routine”, suggesting that its conceptualization and operationalization remain at the author’s discretion (Fernández-Macías & Hurley, 2017; Fernandez-Macias & Bisello, 2017). In fact, one can hardly ask survey respondents to assess the risk of their job being automated, requiring some proxies to be found within the sources of information available, which might not perfectly describe the concept and cause significant variation of results using different data. For instance, in the ALM framework, finger dexterity is considered a measure of routine-manual intensity, which implies the susceptibility of occupations with high intensity in these tasks to automation. While in general, it might be true, especially for the jobs in the manufacturing sector, there are other occupations, for instance, artisans or musicians, for whom finger dexterity is an essential characteristic of the job but which is nonetheless can hardly be automated (Fernadez-Macias & Hurley 2017).

Moreover, applying information from DOT or O*NET and using this static framework does not allow to see variations within the same occupation and across time, which appear especially important considering advances in Machine learning and Artificial Intelligence discussed earlier. For instance, drivers' work that is intense in non-routine manual tasks following ALM might be automated with a further ascent of autonomous vehicles (Brynjolfsson & McAfee, 2011). Self-driving taxis, with or without safety drivers, already exist in Tokyo and Singapore, and the first experiment of the self-driving truck was successfully implemented in the US in 2016. These developments might affect changes in occupational structure in the future, though how fast will depend on the multiplicity of factors (Brynjolfsson & McAfee, 2011; Frey & Osborne, 2013).

In fact, Frey and Osborne (2013) argue that even the tasks that are currently defined as “non-routine” might be automated in the future with further advances in

coding. More precisely, the authors identify three “engineering bottlenecks” making tasks hard to automate, at least in the near future: perception and manipulation, social intelligence tasks (recognizing emotions, verbally communicating) and creative intelligence tasks (writing poems, drawing etc.). This finding points out the importance of considering more aspects than simple juxtaposition between routine/non-routine, taking into account the entire job content composition and possible “engineering bottlenecks”.

The most comprehensive task framework was recently developed by Fernandez-Macias and Bisello (2017). The authors classify tasks based on their contents (physical, intellectual or social); and methods and tools of work, which is achieved by combining data from EWCS, PIAAC, and O*NET (Fernandez-Macias & Bisello, 2017).

Therefore, the diversity of approaches to analyzing occupational task content is mainly predetermined by the authors’ conceptualization, operationalization, and data availability. The relation between the task content and occupational change, on the other hand, appears to vary across countries due to the differences in institutional setting, demand factors and technological developments (Cirillo et al., 2018; Fernández-Macías & Hurley, 2017; Fernandez-Macias & Bisello, 2017).

Overall, the reviewed evidence demonstrates an agreement on polarization in the US, and in the majority of studies in the UK, with more considerable variation across European countries. While single-country or, in some cases, groups of countries analysis prevailed (usually around 15 countries), there is a lack of studies using cross-country analysis at a larger scale (e.g. entire EU) and in a longer-term perspective. Nevertheless, this type of large-scale cross-country analysis could help further to shed light on the underlining causes of the diversity clearly highlighted by previous studies (Fernandez-Macias, 2012; Oesch, 2013; Oesch & Piccitto, 2019).

While the evolution of employment was primarily analyzed by focusing on earnings as an indicator of job quality or, in some cases, education level, it seems important to extend the concept. This would allow us to more precisely describe the quality of jobs created and the relation among different indicators of job quality. In fact, rather than simply destroying and creating jobs, technological change, globalization and consequent “tertiarization” of employment in the context of increasing deregulation

of the labour markets in the aftermath of the 2008-2009 economic crisis have had a profound impact on the quality of existing and newly created jobs.

As documented by Turrini et al. (2015), analyzing the European Commission labour market reforms database (LABREF), labour market reforms have intensified after the crisis, especially between 2010-2011. They mainly concentrated in the domains of job protection, wage setting and working time aimed at reducing regulation, especially in Southern countries. The incidence of measures reducing EPL for permanent and temporary contracts notably increased from 2008. In line with these findings on deregulation, the European Trade Union Institute pointed out the deterioration of employment quality and job security across the EU countries between 2010-2015 (Piasna, 2017). Thus, considering substantial changes in employment regulation, analyzing occupational change using earnings or skill level indicators solely might be reductive (Muñoz de Bustillo et al., 2011a; Muñoz de Bustillo et al., 2011b; Oesch & Piccitto, 2019).

While the literature assessing *overall changes in job quality* combines various indicators, studies that consider more than two indicators for the analysis of *occupational change* or the impact of technology on job quality are usually an exception, prioritizing earnings as a primary indicator of job quality. Job quality is, in fact, a multidimensional concept, where the dimensions of the job quality analysed by the researcher reflect traditions of respective disciplines. Thus, orthodox economists focus on pay; radical economists on power relations; traditional sociologists on the intrinsic quality of work and alienation; institutional tradition researchers on employment quality; medicine and health researchers on risks and health; and work-life balance researchers on working time arrangements (Munoz de Bustillo et al., 2011).

Despite these differences across disciplines, there have been some attempts to create a unique indicator of job quality, taking into account all these dimensions. More comprehensive job quality indicators were developed by the OECD, European Trade Union Institute (ETUI) and Eurofound. Thus, the definition of job quality by the OECD includes earnings quality, labour market security, and quality of working environment (OECD, 2013). Eurofound measures job quality using the European Working Conditions Survey (EWCS) data and covers seven dimensions: physical environment, work intensity, working time quality, social environment, skills and discretion, prospects

and earnings. ETUI combines information from different data sources such as EU LFS, EWCS, EU-SILC, ICTWSS and assesses wages, non-standard forms of employment, working time and work-life balance, working conditions and job security, skills and career development and collective representation (Leschke & Watt, 2014). The development of these indexes underlines the importance of considering more aspects of job quality than just earnings, which seems reasonable considering that a great part of an individual's time is spent at work, affecting personal well-being.

A summary of relevant to the EU context indicators currently used for monitoring job quality by ETUI (European Job quality index) and changes in occupational structure by Eurofound (Job quality index and Non-pecuniary job quality index) is provided below.

Dimensions and indicators of job quality					
	Wages	Employment quality	Working time and work-life balance	Working conditions and job security	Collective interest representation
European Job quality index (Leschke and Watt 2012)	Nominal compensation per employee in PPS deflated using CPI; In-work poverty	• Non-standard forms of employment (share of temporary and part-time non-voluntary employees); • Skills and career development - share of population participating in education/training; - prospects for career advancements	• Share of employees working more than 48 hours/week • The average share of workers on shift work, Saturday/Sunday work, night /evening work; • Voluntary part-time work; • WH fit with social and family commitment (subjective EWCS)	• Work intensity (speed, tough deadlines); • Work autonomy; • Physical work factors; • Risk of losing a job (EWCS)	• Collective bargaining coverage; • TU density (ICTWSS); • Consulted about changes in work organisation (EWCS)
Job quality index (Munoz de Bustillo 2011)	Nominal compensation in PPS	• Contractual stability; • Development opportunities;	• Duration; • Scheduling; • Intensity;	• Health and safety: - Physical risks • Intrinsic quality of work: - Skills;	

				- Autonomy; - Social support	
Non-pecuniary job index (Eurofound 2012)		• Contractual stability; • Development opportunities.	• Duration; • Scheduling; • Flexibility; • Intensity.	• Workplace risk: - Physical and psychosocial risks; • Intrinsic quality of work: - Skills; - Autonomy; - Social support	

While we might expect different measures to correlate, it does not seem to be confirmed in practice (Eurofound, 2013; Kallberg, 2011;). For instance, the correlation between occupational skills and earnings might depend on bargaining power and social norms and not only on skills and productivity (Bol & Van der Velden, 2015; Oesch, 2011). Different aspects of job quality may also vary across generations, disadvantaging labour market entrants and being predetermined mainly by institutional arrangements. As a result, studies taking into consideration more dimensions, as by Oesch and Piccitto (2019), who analysed employment change integrating job satisfaction and prestige score (ISEI), or Eurofound reports might provide a more nuanced picture of employment change across Europe (Eurofound, 2013, 2014, 2017).

Thus, in the context of technological change and labour markets' deregulation, assessing occupational change considering several aspects of job quality is essential. Focusing attention on earnings might prevent us from creating a fuller picture of changes in occupational structure and employment quality, hiding important variations that may be present both within and across countries.

Overall, the above discussed empirical findings demonstrate the **substantial impact of demand factors, particularly technological change,** on the type of jobs and skills in demand resulting in either upgrading or polarization. However, while it is evident that routinization prevailed in explaining occupational structure change and, specifically, its polarization, more recently, some scholars started to challenge the ability of RBTC to explain some noticeable trends. For instance, Beaudry, Green and Sand (2016) pointed to a decline in demand for highly skilled occupations in the US

since the 2000s, notwithstanding the growing supply of high-educated. They suggested the maturation of the IT revolution and the slowdown in IT investments as possible causes behind these trends. Similarly, no confirmation for routinization resulting in polarization was found in Germany (Spitz-Oener 2006), Spain (Sebastian, 2018), and very recently in the US (Autor, 2015). These findings suggest that while technology did significantly influence labour market dynamics, other factors shaping employment structure (or their interaction) were at play, and their role might have been underestimated.

1.5 Research gaps and the contribution of this research

First, since the main theories on the impact of technological change originated in the US, many studies naturally focused on this country, with less evidence for Europe, especially with cross-country comparison. However, taking into consideration differences across European countries, assessing the trends and identifying the possible causes of occupational change dynamics in Europe appear to be of particular interest. In fact, the evidence provided by some authors for Europe (Fernandez-Macias & Hurley, 2012; Oesch, 2013) suggest variations in occupational change patterns. Thus, it is important to answer the question, how comes, in the context of technological convergence, we still witness differences in the patterns of occupational change across Europe? Answering this question requires an assessment of the role of supply and labour market institutions, underestimated by literature. This study aims to address these gaps and provide an analysis of occupational change in Europe, focusing on the contribution of supply factors and labour market institutions to explaining cross-national variations. While, as evidenced by the literature review, most studies in Europe were focused on one country or a limited group of countries, this research covers all the EU countries, Norway, Switzerland and the United Kingdom. Malta and Iceland are excluded due to limited data availability.

Second, studies of occupational change primarily focused on testing either SBTC or RBTC hypothesis. In testing SBTC, it was operationalized ranking occupations (or occupations and sector of activity) by wage or educational level, consequently grouping them into terciles or quintiles. In testing RBTC, the vast majority of studies applied task intensities indexes developed for American occupations (using

US DOT) to the European ISCO classification of occupations. Both of these approaches might be problematic, but for different reasons. Assessing employment share changes through quintiles aggregating occupations based on earnings or educational level conceals the role of demand, supply factors, and institutional characteristics that might be **occupation-specific**. On the other hand, applying the task framework using the US sources for European countries also raises some questions. Apart from the discussed in the literature review concerns regarding the conceptualisation of "routine", identical task content of occupations in the US and Europe cannot be taken for granted, taking into account institutional diversities (Fernandez-Macias & Hurley, 2017).

To address both of these limitations, this research will examine changes in employment structure by applying both frameworks. Taking into consideration previously raised critiques, task-based categories for testing the routinization hypothesis will be created using direct information from workers in Europe. Doing so will allow us to assess the content of occupations that declined or expanded rather than looking simply at more general skill groups. It will also allow identifying the relationship between the task content, earnings and education and eventually shed light on which pattern better describes the occupational change in European countries and to which extent it is explained by routinization.

Third, as highlighted in the literature review, there is increasing attention to the issue of job quality. On the one hand, it reflects the importance of a job to the general well-being, while on the other – there is larger availability of resources for assessing it. Taking into consideration the "multidimensionality" of job quality (Muñoz de Bustillo et al., 2011a; Oesch & Piccitto, 2019), the current study integrates indicators from job quality literature into the analysis of occupational change. It includes skills (educational level), employment quality (share of involuntary part-time and temporary contracts), and work-life balance (atypical work arrangements and working hours). Considering all these dimensions and not exclusively wages will allow for creating a more comprehensive picture of the quality of jobs that have grown or declined.

Finally, while the educational expansion was crucial for the growth of the employment share of high-skilled occupations, more and more scholars pointed out at increasing incidence of overeducation, first in the US and then in Europe. The last chapter will bring together two strands of literature – on occupational change and

qualification mismatch – assessing the association between the two and trying to understand how workforce skill composition matched the demand posed by technological change. While a number of authors pointed out at persistence of overeducation, suggesting that labour market institutions and characteristics of educational systems play a crucial role in determining it, the role of the demand-side has been under-researched. Nevertheless, assessing the role of demand appears to be important if we consider a differential impact of technological change on various educational or task groups since it likely implies different risks of overeducation for various population groups. The empirical analysis in this research will first investigate the dynamics of over-education incidence across skill and task-based categories allowing us to understand better the link between technological change and overeducation. It considers not only the skill level of jobs that have been declining or expanding but also their task content, which is particularly relevant, taking into consideration routinization. Second, regression analysis will shed light on the association between occupational change and overeducation over time and across countries. Doing so will allow us to establish, in particular, how the dynamics of occupational change in specific skill and task groups influence the risk of overeducation for different educational groups.

Chapter 2. Overeducation: definition, measurement and determinants

2.1. What is overeducation, and how it is measured?

As previously discussed, technological development has been an important driver in occupational structure change, leading to, as argued by scholars, either to polarization or upgrading. The supply of educated labour, in this context, has been an essential factor in letting occupational structure shift upwards, as suggested by both SBTC and RBTC theories. With growing evidence of the positive impact of education on economic and social well-being, the process of educational expansion has been widely supported by policymakers and scholars and took place across all developed countries, initiating in the US in the 1970s and spreading to Europe (Goldin & Katz, 2008; Hout 2012).

It didn't take long when this optimistic view on educational expansion was questioned, among others, in Freeman's work "Overeducated American". The author raised his concern concerning the adverse consequences of educational expansion unless accompanied by a commensurate increase in jobs requiring high-skilled workers. In this scenario, graduates might be constrained to accept jobs requiring lower skill levels on the one hand and earn less than expected for graduates with a tertiary degree in a matched job. Since then, the literature on overeducation, its causes and effects have substantially expanded. The issue of mismatch has become a point of concern due to its particularly negative consequences for job satisfaction and earnings (at an individual level) and lower productivity, risk of unemployment, and restricted growth (at a macro level).

Several types of mismatch were identified in the literature: vertical mismatch (overeducation/undereducation, ovesrkilling/underskilling), skill gaps, skill shortages, horizontal (field of study mismatch) and skill obsolescence (McGuinnes & Pouliakas, 2016).

Among all, **education mismatch** and, specifically, overeducation have been the focus of most studies in the field (Groot & Maasen van den Brink, 2000; McGuinness, 2006). And while the literature on the matter has been growing ever since, neither a unanimously accepted definition nor agreement on its measurement was reached.

Very broadly, an individual is considered overeducated if their educational level exceeds the job requirements. Following this definition, the main question that arises is how education is measured. Since most of the studies employed a human capital perspective (Becker, 1976), educational attainment level has naturally been considered as a “proxy for skill level”, along with years of schooling (Quintini, 2011; Flisi et al., 2014).

This approach was consequently criticized, pointing out the inadequacy of educational qualifications to describe “skills” due to ignoring possible skills’ heterogeneity within the same educational level. The critique seems legit, especially considering the extent of educational expansion and its likely undermining impact on skill homogeneity. Several scholars tried to address this problem by introducing alternative measures of qualification mismatch using a direct response from individuals assessing the level of their qualification to job match (Chevalier, 2003; Hartog, 2000; Verhaest & Omey, 2006).

A further distinction was made between education and skill mismatch, where the first one describes the match between an individual’s qualification and the one required by the job, and the latter – is the extent of skills use acquired through education in the job. **Overskilling and underskilling** were significantly less explored due to the difficulties in the availability of data measuring skills. In fact, only a few national surveys include information on tasks and skills in addition to educational attainment levels. Therefore, studies assessing the extent of skill mismatch were conducted in the countries where such information was available (e.g. Allen and van der Velden, 2001 for the Netherlands; Green and McIntosh, 2007 for the UK; Mavromas, 2009 for Australia;). At an international level, assessment of the incidence of skill mismatch was facilitated by OECD surveys (IALS, ALL, PIAAC) and European Skills and Jobs Survey (2014) by CEDEFOP. Some scholars suggested using the Programme for the International Assessment of Adult Competencies (PIAAC) survey containing information on literacy, numeracy, and problem-solving skills (Hanushek, 2015; Quintini, 2014). Moreover, there has been increasing attention to the issue of **horizontal mismatch** – between the field of study and occupation (McGuinness et al., 2016; Nordin et al., 2010; Ortiz & Kucel, 2008; Verhaest et al., 2017), trying to establish its incidence and determinants.

Since there has been no agreement on a single measure capturing the concept of mismatch, the approaches to measuring qualification mismatch are discussed and summarized below.

Occupational classifications contain information on work characteristics allowing job analysts to assess which level and type of education are necessary for performing the job. This is a so-called *normative*, job analyst or objective approach based on the expert's evaluation. US Dictionary of Occupational Titles is one of the most famous examples of job classification. While this approach represents an objective assessment, it has a number of drawbacks such as underestimating the variation of qualifications within the same occupation; risk of overestimation or underestimation of educational level requirements due to the external changes since the update of these Dictionaries is rare (Halaby, 1994; Van der Velden & Van Smoorenburg 1997).

The statistical or realized matches approach (RM) is most frequently used due to the widespread availability of the data. It is based on assessing the distribution of years in school within occupation (or educational level) and then comparing each individual's years of schooling with a mean level of all individuals in the occupation (or mode educational level in occupation).

Similar to the normative approach, RM does not allow for heterogeneity within occupation; it is additionally sensitive to changes in demographic composition or the labour market, and the decision with regard to who is considered overeducated (usually one standard deviation from the mode) is arbitrary (Van der Velden & van Smoorenburg, 1997; Verhaest & Omey, 2006).

Last, subjective measure is based on workers' self-assessment, and it varies across studies due to the differences in questions in different surveys. Subjective indicators compare the individual's opinion on the level of education necessary to get the job or perform the job with the actual level of education of an individual, as well as simply whether the individual considers themselves under-/overeducated or matched for their job (Dolton & Vignoles, 2000; Verhaest & Omey, 2006). In some cases, specific reference is made to the different types of skills through education and their utilization at work (Allen & van der Velden, 2001; Barone & Ortiz, 2011). These measures are more frequently used in country studies based on national surveys. The

necessary information can be found only in PIAAC and the more recent European Skills and Job Survey at the international level.

The subjective measure is often criticized for possible lack of objectivity in assessing the level of education required for getting/performing the job and different criteria the respondent may refer to for answering the question (Dolton & Vignoles, 2000; Van der Velden & Van Smoorenburg, 1997). Keeping these drawbacks in mind, this measure is still unique in allowing to assess the aspects of qualification/skill mismatch that are not captured by objective or statistical indicators and shed light on the heterogeneity of educational level requirements in a specific occupation. The table below summarizes each approach's main strengths and weaknesses based on the previous literature.

Normative	Statistical	Subjective
How measured: Educational level assigned to each ISCO group based on ex-ante job descriptions. Mismatch is established by one standard deviation (more precise when there are dictionaries of occupational titles); Pros: • based on job analysts' evaluation Cons: • problematic for cross-country comparisons as the content of education at similar levels might vary across countries • becomes outdated due to job requirements change, technological change; • an assumption about the homogeneity of educational requirements within the occupation • an assumption about the truthfulness and accuracy of job descriptions.	How measured: distribution of workers' educational levels within the occupation is assessed by evaluating an individual's deviation from mean/mode in this occupation; Pros: • less heterogeneity than in the normative method • better suited for cross-country comparison Cons: • assumes homogeneity of educational requirements for all jobs within occupation (as NA); • the mode can be driven by the older cohorts and/or recent graduates with higher levels of education; • decision with respect to who overeducated is arbitrary.	How measured: 1) indirect self-assessment (match between job and education, qualification needed to get and do the job). 2) Direct self-assessment (individual states he or she feels overeducated) Pros: • allow to assess heterogeneity of qualifications within specific occupations; Cons: • can easily be biased

Therefore, there is no perfect measure of qualification mismatch, and the differences in what is measured among the three main indicators imply the divergences in the observed incidence of education mismatch. In fact, taking into consideration the drawbacks of specific measurements, more and more authors tried to combine different indicators obtaining substantial variation in the results, highlighting a weak

correlation between measures of education and skill mismatch (Allen & van der Velden, 2001; Flisi et al., 2017; McGuiness et al., 2006; Verhaest & Omey, 2006).

In addition to the conclusion of most of the studies with regard to the persistence of overeducation (e.g. meta-analysis by Leuven & Oosterbeeck, 2011), many studies assessed the effects of various types of mismatch on wages or workers' well-being (Allen & van der Velden, 2001; McGuinness & Sloane, 2011; Verhaest et al., 2017). Several studies have demonstrated that overeducated workers experience wage penalties compared to matched ones with similar education levels (Caroleo & Pastore, 2018; Levels et al., 2014; McGuinness & Pouliakas, 2016). The educational mismatch was also found to negatively affect job satisfaction (McGuinness & Sloane, 2011; Verhofstadt et al., 2007;). Moreover, under the conditions of stagnant demand and prevalence of temporary and low-paid jobs, tertiary educated workers might consciously choose to remain permanently overeducate due to the stability or overeducation trade-off (Ortiz, 2010).

At a macro level, mismatch and particularly overeducation were identified to have a negative impact on productivity (McGowan & Andrews, 2015), limit entrepreneurial willingness to invest in R&D considering lack of complementarity between technologies and skills (Scicchitano, 2010), cause cognitive decline and skill depreciation (de Grip et al., 2008) and GDP growth (Mavromas et al., 2007).

The issue of incidence of overeducation has been widely discussed in literature both from a country and cross-country perspectives (Croce & Ghighnoni, 2012; Di Pietro, 2001; Ghighnoni & Verashchaghina, 2012; Groot & Maassen van den Brink, 2000; Hanushek et al., 2015; Verhaest & Van der Velden, 2013). However, due to different methods used to measure the phenomenon, as discussed earlier, the results varied across studies (Quintini, 2011; McGuinness & Pouliakas, 2016).

Along with establishing the incidence of mismatch, these studies attempted to establish its determinants. Thus, human capital development was suggested as a driver at the micro-level, imbalances in demand and supply at the aggregate level, and expansion of education at the macro-level (McGuinness, 2006; Mavromas, 2009). The incidence and persistence of mismatch tend to be associated with the business cycle (Liu et al., 2012) in the short run and structural changes driven by technology in the long run (Mendes de Oliveira, 2000 for Portugal).

A higher incidence of mismatch was registered among young people compared to adults (Alba-Ramirez, 1993; Allen et al., 2013; OECD, 2013; Quintini, 2011); among individuals with a migrant background (Sloane, 2004; McGuinness, 2006; OECD, 2008; Quintini, 2011); individuals with disadvantaged background (Barone & Ortiz, 2011; Mavromas & McGuinness, 2012); part-time, temporary and unskilled workers (Borgna et al., 2019), workers in micro and small firms (Esposito & Scicchitano, 2022); graduates with social sciences and humanities background (Ortiz & Kucel 2008).

This brief discussion suggests that the issue of education has received a lot of attention from scholars. However, there is still no clear explanation of what causes overeducation and why it remains a persistent phenomenon. Since no unified theory of explaining mismatch has been developed so far, the literature has been relying on findings of labour market match theories discussed below. These major theories provide their specific and sometimes contradicting predictions with regard to the probability and persistence of mismatch and returns, which makes it particularly interesting for studying cross-country variations.

2.2. Why education “pays off”?

As discussed earlier, education was considered essential for supplying skilled labour to cope with technological change and improving productivity, thus, further reinforcing the demand for skilled labour. Labour market attainment in terms of occupation and earnings in this context was explained by **Human Capital Theory** (HCT), where higher levels of skill and productivity were seen as a result of education, pushing individuals to invest in it to succeed in the labour market (Becker, 1964). At the same time, supporters of HCT considered education certificates to reflect the knowledge and skills of individuals, being legitimate, merit-based devices for assigning positions within society (Bills, 2003). According to the proponents of HCT theory, individuals rationally choose to invest in education to increase their chances of success and higher earnings in the labour market. On the other hand, employers rationally select future employees according to their credentials and decide on their retribution. In this context, overeducation is considered to be a temporary phenomenon as the match between required and acquired qualifications would occur in the longer run. The assumptions made by human capital theory prevailed, suggesting the importance and

crucial role of educational attainment for the labour market and have been widely used by economists.

There is, however, a visible discrepancy between the predictions of HCT and reality. If there had really been efficiency in the labour market, the phenomenon of qualification mismatch wouldn't have occurred at all, if not only for a short period of time due to the labour market actor's adjustments. Instead, many of the studies discussed above found overeducation to be a persistent phenomenon (McGuinness, 2006; Leuven & Oosterbeeck, 2011).

The main assumptions of the theory had, thus, been seriously questioned. In his influential study "An overeducated American", Freeman provided evidence of a significant decline in returns from college in the US already from the 1970s, raising scepticism with regard to the effects of educational expansion. During this period, sociologists also challenged the HCT by suggesting that education was more a positional good than an indicator of productivity and questioning whether it was a short-term phenomenon. Following this line of thought, a number of economists (Duncan &Hoffman, 1981 for the US, and Hartog and Oosterbeek, 1988 for the Netherlands) questioned how easily and how fast firms can adapt their production considering changes in the input and possible rigidity of institutional arrangements.

Challenging the HCT assumptions, **the Job Competition model** developed later described the labour market organized into two queues of job vacancies and workers. Employers seek to hire employees with higher educational levels and productivity potential (education as signalling), predetermining workers' position in the queue on the basis of their education attainment level, thus, incentivizing them to pursue higher levels of education (Thurow, 1975). In this context, individuals invest in education to be better equipped to compete in the labour market and be relatively better educated compared to advance in the "queue".

Signalling theory questioned the HCT assumption of perfect information and a free and competitive market. It instead suggested that employers are forced to make their choices under the conditions of uncertainty: educational title and education itself do not imply productivity potential, which, instead, is more correlated with unobservable characteristics of individuals (Spence, 1973). Employers, in that perspective, make their investment decisions based on imperfect information and

consider education only as a signal of workers' predisposition to learn and as a source for estimating their productivity. Since acquiring education is costly, individuals with stronger abilities are expected to invest in education and obtain higher returns in the future. Following this assumption and relying on educational systems to screen and sort individuals based on their prior ability, employers will be inclined to hire individuals with higher educational attainment levels (Stiglitz, 1975).

Both aforementioned models allow for overeducation to exist. According to both theories, individuals are pushed to acquire higher levels of education in order to compete in the labour market and move up in the queue. On the other hand, employers are inclined to hire individuals with higher education levels independently of the level required by the job, making overeducation a persistent phenomenon.

Collins (1979) specifically pointed out a weak connection between education and skills required on the job. In this context, the value of education depends less and less on specific content and more on acquiring formal credentials to enter the next educational level or occupation (Collins, 1979). This process results in an increasing number of people obtaining **credentials** to enter more advantageous positions in the labour market, causing employers to raise educational requirements while job content remains the same and, consequently, pushes the education system to provide better-educated workers (Berg, 1971).

The main concern among the representatives of the credentialist variant of signalling theory was the loss of trust in educational credentials, suggesting that higher education was not anymore able to guarantee respectable jobs while educational expansion contributed to an increase in underemployment rates of graduates (Bills, 2003).

	Prediction with respect to mismatch	Prediction with respect to earnings
Human capital theory (Becker, 1964; Mincer, 1974)	A mismatch is a temporary phenomenon while firms are adjusting their production for fuller utilization of the labour force	Overskilled workers are likely to earn more and underskilled less compared to matched individuals with the same job.
Job competition (Thurow,1975) Education as "defensive necessity": the higher the number of qualified people, the more important it to invest in education to preserve one's place in the queue	A mismatch is a persistent phenomenon	Earnings are linked to specific jobs rather than workers' productivity.
Signalling (Spence, 1973)	Qualification mismatch is expected to increase with no impact on skill mismatch	

Higher accessibility of education encourages individuals to invest in it. Raising educational levels will push employers to upgrade educational requirements for hiring but not job tasks leading to educational inflation		
Assignment (Sattinger, 1993) Returns to additional investments predetermined by the match between job and worker	Working in a job below a worker's educational level limit skill utilisation and lead to lower wages, while working above one's level raises productivity. Educational mismatch leads to skill mismatch	Individuals working in jobs where a lower educational level is required usually earn less than those with the same educational level matched to jobs but more than those in the same job with the required educational level.

2.3. The role of institutional settings in overeducation: labour market institutions and education system

Following these perspectives, educational attainment in the context of educational expansion became one of the major explanations of the observed misbalance between skill demand and supply and, particularly, increasing overeducation incidence (Croce & Ghignoni, 2012; Davia et al., 2010; Verhaest & van der Velden, 2013).

To explain cross-country variation in the incidence of overeducation, scholars referred to the differences in demand and supply-side characteristics, mainly specificity of educational system and labour market institutions (Barone & Ortiz, 2011; Bol & Van de Werfhorst, 2015; Di Stasio et al., 2016; Verhaest & van der Velden, 2013). With regard to education system stratification, standardization and education system orientation (general vs specific skills) were found to affect the incidence of overeducation differently. Stratification describes whether the educational system distinguishes between educational tracks and when tracking takes place; standardization defines the extent to which the education system "meets the same standards nationwide"; and finally the last refers to the extent of occupational skills provision and skill specificity (Allmendinger, 1989; Muller & Shavit, 1998).

Strong vocational specificity combined with a great extent of stratification facilitates employers in selecting workers with specific occupational skills, whereas standardization enhances the signal provided by educational qualification. Thus, systems with a greater extent of standardization, stratification, and vocational

specificity ensure better results in matching and returns to skills (Bol & Van de Werfhost, 2011, 2013). The countries with a higher level of tracking and stronger occupational specificity are characterized by a lower risk of unemployment (Muller, 2005), greater job stability (Allmendiger, 1989), and lower risk of overeducation (Levels et al., 2014). Vocational specificity plays a particularly important role in improving matching at the start of the career (Di Stasio et al., 2015). The incidence of overeducation is also lower in countries with vocationally-oriented tertiary education systems (Verhaest & van der Velden, 2013). The downside of these systems is that such an efficient labour market allocation comes at the cost of inequality in educational opportunities, where the social origin of individuals affects their propensity to enter the vocational track (Bol & Van de Werfhost, 2013; Brunello & Cecchi, 2007; Capsada-Munsech, 2017). On the other side, higher rates of overeducation were registered among graduates in countries with general skills oriented systems (Ghignoni & Verashchagina, 2013; Verhaest & Van der Velden, 2013).

While education has been for a long time considered as a proxy for skills, only recently has it become possible to examine the actual competencies of individuals and evaluate the extent to which education reflects the skills possessed. As it emerged from several studies considering both education and skills measures, the incidence of skill and education mismatch varied from slightly to significantly within and across countries (McGuinnes et al., 2016). This finding implied that qualification does not necessarily reflect the actual skills, whereas overeducation does not necessarily mean overskilling (Borgna et al., 2019; Verhaest & Van der Velden, 2013). Therefore, in order to establish the reliability of the overeducation assumption, skill match should also be taken into consideration. Moreover, some scholars suggested that compared to overeducation, overskilling represents a more robust measure of skill underutilisation in the labour market. This is due to the fact that the former underestimates the innate ability and the skills acquired through employment experience (Mavromas & McGuinness, 2012; McGuinness et al., 2016).

The availability and analysis of both education and skill measures allowed us to observe a significant heterogeneity of individual skills within different educational groups on the one hand as well as illustrate how this heterogeneity varied across countries on the other (Heisig & Solga 2015, 2017). Linking both of these findings to the previously discussed theories of education and labour match raised the question

of the role and value of education for labour market attainment and labour market inequality in terms of occupation and earnings. Specifically, building on already developed literature on the diversity of educational systems and their labour market outcomes, several authors suggested the differences in strengths of signalling value of educational credentials to be essential for the labour market attainment, pointing out educational system transparency as crucial for employers' decisions (Bol & Werfhorst, 2011; Heisig, 2018). The most recent and comprehensive measure of skill transparency has been developed by Heisig (2018). The author sustains that the value of qualifications is stronger, where the gap between skills in different groups is larger and the skills within the group are more homogeneous (Heisig & Solga, 2015; Heisig, 2018). Constructing the index of internal homogeneity and assessing how it is influenced by the indicators of between-school variations in resources distribution, level of tracking, vocational orientation index, standardization of input and output, the author demonstrates significant variation across different countries covered by the analysis. Similar to previous research, through stronger within-group homogeneity, vocationally oriented educational systems with tracking contribute to greater transparency of educational titles and send a clearer signal about an individual's skills.

While some studies prioritized the role of educational systems in overeducation, others assessed its relation with the labour market institutions trying to explain cross-country variations in qualification mismatch. This strand of research, however, received much less attention. The impact of employment protection legislation on overeducation was studied most, but evidence on the matter was mixed, ranging from its diminishing impact on mismatch (Marsden et al., 2002), increasing overeducation (Di Pietro, 2002), fostering credential inflation through deregulation (Ballarino & Scherer, 2013), and insignificant effect on mismatch (Croce & Ghignoni, 2012; Verhaest & Van de Velden, 2017). Strict EPL was found to restrain the mobility of workers and discourage employers from hiring school leavers and low-skilled (Nickel, 1997), slower down school-to-work transition (Gangl, 2003), and increase the risk of graduates unemployment (Ryan, 2001).

A higher incidence of overeducation as a result of an increased proportion of the population with the same educational level was detected by Di Pietro (2002), linking it to the strictness of EPL preventing firms from adjusting to the supply of educated labour. The author argues that strict EPL may initially discourage employers from hiring

when workforce upgrading is needed to respond to technological change, preventing them from adopting new technologies and, thus, leading to a rise in the incidence of overeducation (Di Pietro, 2002). Strict EPL also restricts labour mobility, forcing workers to remain in unmatched positions, contributing to a higher incidence of overeducation and leading the economy to a “low skill low technology trap” (Di Pietro, 2002).

Van der Velden and Verhaest (2013) and Croce and Ghinoni (2012) point out the lack of association between the two, suggesting that strict EPL might have the opposite effect of discouraging new hiring and matching better internal workers. Supporting this assumption, Davia et al. (2017) find a lower share of overeducated workers in the countries with stricter EPL.

Similarly, the impact of unemployment benefits is not straightforward: unemployment benefits were found not to have any relevant impact on mismatch (Croce & Ghinoni, 2012) or improve the match between workers and jobs in the US (Farooq et al., 2020). Among other institutions, McGuinness (2006) pointed out the rigidity of wages adjustment as a cause of misallocation between skills and jobs. The findings on the effect of collective bargaining coverage and union density were conflicting. Assessing the former, several authors found a positive effect on overeducation (Croce & Ghighnoni, 2012; Verhaest & Van de Velden, 2017). On the other hand, analysing union density, Davia et al. (2017) concluded it negatively affected the incidence of overeducation.

Last but not least, the welfare state may play an important role on the side of labour demand. Nordic countries have been particularly known for the significant expansion of their public sector since the 1960s. Recalling the work of Esping-Andersen (2004), Barone and Ortiz (2011) suggested that Scandinavian countries, along with the Netherlands, have followed a “high-skill strategy”. High tertiary education attainment of the population in these countries was accompanied by a proportionate increase in high skilled jobs driven by public sector employment. As a result, we can expect the incidence of overeducation to be lower in these countries.

Furthermore, taking into consideration the limited number of studies analysing overeducation and institutional characteristics, Di Stasio and Van de Werfhost brought together literature on labour market match and education positionality. They

particularly tried to establish the conditions under which employers were more likely to reward education and individuals to invest in education, considering the value of education as a crucial factor (Di Stasio et al., 2015). Considering the specificity of the educational system, namely its vocational orientation, duality and corporatism index, the authors found a lower incidence of overeducation in the countries with a strong vocational orientation. Therefore, they suggest that in these contexts, the function of education as a positional good is less pronounced. Analysing returns to education, the authors point out that these countries fit better a social closure model with extensive bargaining coverage constraining wage adjustments. Instead, Central and Eastern European countries appear to follow the predictions of human capital theory with a low incidence of overeducation but higher returns to education due to the weakness of bargaining institutions. Northern European countries with a high incidence of overeducation and low returns were associated with job competition and queuing models with education functioning as a positional good. However, as the authors admit, several countries appeared not to follow the predictions emerging from the specificities of their educational institutions and wage bargaining systems, pointing out the possible presence of other factors not taken into consideration. These conclusions imply the necessity to pursue further analysis accounting for educational, labour market institutions and welfare characteristics.

As the literature overview highlights, specific features of the labour market and educational institutions are expected to influence differently hiring decisions of employers and individuals' investment decisions, affecting matching quality. On the other hand, we can expect the matching quality to be affected by changes in employment structure and job displacement.

Chapter 3. Occupational change in Europe: upgrading or polarization?

3.1. Introduction

As discussed in the Introduction and Literature review, there has been general agreement that technological developments and changes in production processes since the 1970s were important drivers of transformations of occupational structure across developed countries. However, certain divergences of opinions with respect to the direction of the impact of technological change have gradually emerged and were particularly pronounced among scholars from different disciplines, economics and sociology in particular.

For a long time, the issues of changes in employment structure were studied predominantly by economists and were largely focused on the US finding overwhelming support for polarization of occupational structure. Later on, a number of European scholars from non-economic backgrounds, mainly in sociology, have integrated technological change into their research on occupational change that previously focused on social class (e.g. Oesch 2011, 2013; Fernandez-Macias 2012). They also raised doubt on the pervasive polarizing effect of technological change on employment structure in some European countries, arguing, instead, for larger evidence of continuous upgrading. Differences in the labour market and wage-setting institutions and variations in supply factors (education, migration) were suggested as possible explanatory factors for divergences across European countries. While making a very important contribution, these studies often focused on the analysis of a small number of countries, representatives of different institutional families of European countries. Therefore, there is a lack of Pan-European studies on the one hand and evidence of occupational change from 2011 following the change in ISCO classification on the other. Furthermore, the discussion of the role of labour market institutions in reviewed studies is, overall, rather limited, even though we believe it deserves greater attention as technological change is at least partially embedded in the institutional environment.

This chapter aims to fill these gaps by providing evidence on occupational change across European countries between 2003-2018 on four main dimensions:

earnings, education, employment quality, and task content. It is followed by a discussion on possible causes behind specific patterns and multivariate regression to investigate the relations between the dynamics in specific occupational groups, supply factors and institutional characteristics. The analysis is primarily based on the European Labour Force Survey, integrating information on earnings from the European Structure of Earnings Survey and on tasks from European Working Conditions Survey.

3.2. Research question and hypothesis

The **occupational structure** of advanced economies has undergone significant changes over the past decades. The evidence of augmenting wage inequality between low and high skilled was initially uncovered in the US (Katz & Murphy 1992). This effect of technology on occupational structure favouring high-skilled workers through increased demand became known as a **Skill-biased technological change** (SBTC), and multiple pieces of evidence supporting this pattern in the US and European countries emerged (Berman et al., 1994; Machin et al., 1996; Machin & Van Reenen, 1998; Acemoglu, 1999; Goldin & Katz, 2008).

Educational expansion was considered crucial for reducing wage inequality and upgrading occupational structure (Goldin & Katz, 2008). The supply of highly educated workers in the US slowed down in the 1970s, leading along with new evidence of declining middling occupations to U-shaped growth of wages and paving the way to an emergence of an alternative explanation of technological change impact on employment structure. **Routine-biased technological change** hypothesis (RBTC) originated, once again, in the US in the influential study of Autor, Levy and Murnane (2003). It shifted the focus from juxtaposing high and low skilled jobs to the question of what can be automated, taking into consideration technological developments and thus juxtaposing routine and non-routine jobs. RBTC suggested that technological change was biased not towards skills, but specific tasks, predicting occupations intensive in routine tasks to decrease through automation and non-routine to grow. This explanation soon became predominant in describing changes in the occupational structure around developed countries (Autor et al., 2008; Acemoglu & Autor, 2011; Goos and Manning, 2009; Goos et al., 2014).

While fewer studies have focused on cross-country comparison, the most influential one by Goos, Manning and Salomons (2009, 2014) found support for

pervasive polarization in 16 European countries between 1993-2010. Several studies by sociologists had followed, questioning the methodology concerning job ranking and groupings, as well as findings of this widely cited paper. Fernandez-Macias (2012), among others, analysed 15 EU countries between 1995-2007 and found mixed patterns of occupational change: polarization and mid-upgrading in a few countries and upgrading in the majority. Even though applying different methods as discussed in the literature overview, the evidence on patterns of occupational change in Europe varied across countries, studies and periods.

It is worth mentioning that the impact of technological change on employment structure has been mostly studied by economists, prevalently focusing on **demand factors**. Supply-side factors were rarely taken into consideration as a possible explanation, especially among scholars within RBTC stream literature. Their role, however, along with institutional specificities, might be crucial for explaining mixed patterns of occupational change in Europe, which did not follow a homogenous trend of polarization as expected under the similar impact of technological change. Yet, few studies simultaneously assessed the role of demand, supply factors, and institutional characteristics to explain such variation (Oesch, 2013; Fernandez-Macias, 2014). It is surprising considering the crucial role of workforce skill composition in coping with the rapid advancement of technology and globalization (Van Reenen, 1998; Goldin & Katz, 2008; Oesch, 2013); and that of *labour market institutions* and production regimes in affecting job creation and skill formation system.

The main purpose of this Chapter is to provide a comprehensive overview of occupational structure changes trying to explain specific developments. It particularly aims to demonstrate *how European countries' occupational structures evolved in the past 15 years and whether they are better described by SBTC or RBTC predictions*. Expanding the number of countries and developing country-specific rankings on various dimensions allow to shed light on cross-country variations. Therefore, the final part of the analysis tries to establish whether labour market and wage-setting institutions explain cross-country and cross-time variation in the patterns of occupational change.

Numerous studies pointed out the importance of associational power of workers – expressed in terms of unionization rate or extent of collective bargaining – in exerting their influence with respect to various issues regarding employment, earnings, job quality or welfare sending (Korpi, 2006; Gallie, 2009, Rosenfeld, 2014). At the same

time, workers in manufacturing or middle-earning workers were found more likely to benefit more from unionization than those at the bottom of earnings distribution (Firpo et al., 2009), increasing inequalities.

With respect to Employment Protection Legislation (EPL), numerous studies pointed out its negative impact on labour reallocation and the creation of the insider-outsider divide, and thus, labour market segmentation favouring permanent contracts at the cost of disadvantaged workers (Boeri & Jimeno, 2005; Bertola 1990; OECD 2002a; Eichorst & Marx, 2011). Considering these factors, we might expect stricter EPL for regular contracts and higher union density to stifle the decline in middle-skilled employment (Hypothesis 1).

On the other hand, higher wage floors were considered an important impediment to the creation of low-paid jobs instead of the US (Krugman, 1996; Oesch, 2010, 2013). It is conventionally accepted that generous unemployment benefits reduce incentives to look for a job, reducing workers' supply (Card et al., 2015; Howell, 2007; Oesch, 2010). Stricter EPL and high minimum wages are thus, expected to limit job creation at the bottom (Hypothesis 2).

3.3. Data and methods

The main data source for the analysis is the individual level micro-data from the European Union Labour Force Survey (EU-LFS) for 2003-2018. The analysis covers EU countries, Norway, Switzerland, and the UK, whereas Malta and Iceland are excluded due to the lack of data. The sample includes the entire labour force of 20-64 years old. Having large country samples allows to directly calculate the indicators of employment quality and average education for each two-digit occupational group of the International Standard Classification of Occupations (ISCO). However, analysis of occupational change is complicated because there were significant changes in ISCO classification, and in 2011 ISCO08 substituted ISCO88. While some scholars used crosswalks to translate ISCO08 to ISCO88, others pointed out the incomparability of the two and suggested analysing changes by periods (Eurofound, 2013, 2014). In fact, while classifications are comparable at the one-digit level, 34 groups were created at the 2-digit level in ISCO08 instead of 28 in the old classification, splitting or introducing new occupations to address technological change. While it is possible to convert

ISCO08 to ISCO88, it will result in the loss of information. The current study will thus conduct a separate analysis for the 2003-2010 and 2011-2018 periods.

The analysis of occupational change in this study will be organised so as not only to establish the dynamics but also to assess whether the developments are better explained by the Skill-biased Technological Change theory (SBTC) or Routine-biased Technological Change theory (RBTC). In order to analyse occupational change, the study brings together the following indicators: 1) median hourly wage; 2) educational level; 3) employment quality and work-life balance; 4) task content of occupations. The first two indicators have been used to reflect the skill-biased change in the labour market, whereas the task content of occupations was at the core of the studies of the routine-biased impact of technology on the labour market. These indicators are calculated at ISCO 2-digit level in order to rank occupations on each dimension and consequently create quintiles for the analysis of occupational change. EU LFS contains information on educational attainment level and employment but lacks data on earnings and task content of occupations. These are integrated from the European Structure of Earnings Survey and European working conditions survey (EWCS), respectively.

Indicator of median hourly wage is integrated from the EU SES 2006 for the first period of analysis (2003-2010) and 2014 for the second (2011-2018). Since the survey did not cover Austria and Ireland, the same information for these countries is extracted from the European Union Statistics on Income and Living Conditions (EU-SILC) for the same years. Due to missing information at ISCO 2-digit in the EU LFS for Croatia and Romania, the two countries are dropped from the analysis in the first period. Similarly, the second indicator of mean educational level is defined for each 2-digit ISCO occupation at the beginning of each period, taking into consideration five levels of education: 1) primary; 2) lower secondary; 3) upper secondary; 4) post-secondary non-tertiary; 5) tertiary. The final employment quality and work-life balance index is an additive index created from the rescaled scores of several sub-components assigning them with different weights. The index on each sub-component represents a share of respondents reporting their work conditions. It comprises the share of temporary employees who couldn't find a permanent job (33.3%), the share of part-time employees who couldn't find a full-time job (33.3%), the share of workers working on atypical hours (16.5%) and the share of workers working more than 48 hours (16.5%).

Finally, information on the task content of occupations is integrated from European Working Conditions Survey, namely wave 4 (the year 2005) for the first period of analysis and wave 6 (2015) for the second, reflecting changes in ISCO classification. While the largest sample of the EWCS covers 35 counties, for consistency, only EU countries, Switzerland and UK are retained for analysis. EWCS provides individual-level data from workers on various aspects of their working conditions. It contains a number of questions allowing the assessment of task content of occupations, such as frequency of routine or manual tasks in the job, use of digital tools, the importance of problem-solving skills, etc. Table 1 in Appendix B contains the list of the questions used for the creation of the indexes. The indexes are pooled across countries and constructed at the ISCO 2-digit occupation level separately for the two periods accounting for a break in ISCO classification. Twenty-eight countries are included in the analysis (EU countries, Switzerland and the UK) with a sample of 24237 individuals for 2005 and 32336 for 2015. Considering small country samples in a number of countries (e.g. Estonia, Luxemburg, Cyprus, Slovenia), the final indexes are not country-specific, which requires assuming homogeneity across European countries. While it is still an important constraint since there might naturally be some heterogeneity in task content across Europe predetermined by institutional factors, it seems no more problematic than applying O*NET indexes developed based on the analysis of the US occupations.

In line with previous studies, the creation of the indexes proceeds in the following way. First, selected variables are normalized on a scale of 0 to 1. Second, pairwise correlations and Cronbach's alpha reliability test are used in order to assess the items' relevance and coherence for creating a scale. Third, principal component factor analysis is implemented to assess the consistency of variables and, finally, create the final scale.

Table 1 in Appendix B describes the variables used for the creation of the index and the results of correlations and reliability analysis. Overall, Cronbach's alpha score across all the proposed task dimensions varies between 0.6-0.7, which is acceptable, particularly considering the low number of items included in the scale.

As discussed previously, one of this research's objectives consists of assessing the change in occupational structure, taking into consideration multidimensionality of

job quality, considering such dimensions as earnings, employment quality and work-life balance, education, and task content. For this purpose, occupations are ranked on each of the four indicators and grouped into quintiles for the first three and terciles for the task content, allowing to establish the extent of “routineness” in occupation.

Each quintile contains around 20% of the total employment at the beginning of the period. Its composition is kept fixed, allowing to calculate the change in occupational structure between the beginning and the end of the period. Quintile one comprises the lowest quality jobs, whereas quintile five – has the highest. While the decision to keep quintiles fixed can be criticized, there has been evidence of little change in the hierarchy of occupations in terms of earnings as well as education (Oesch, 2015; Goos and Manning, 2009; Dwyer, 2013). Moreover, the research is conducted separately for two relatively short periods, potentially addressing and minimising this problem.

This method was employed by a number of scholars who previously analysed occupational change, starting with the work of American sociologists Wright and Dwyer (2003), and followed by a similar assessment in Europe by Oesch (2015), Fernandez-Macias (2012), Oesch and Piccitto (2019) and others.

Alternatively, Goos and Manning (2009) and later OECD assessed occupational change creating the groups of high skilled (ISCO MG 1,2 and 3), middle-skilled (ISCO MG 4, 7, and 8), and low-skilled occupations (ISCO MG 5 and 9). Following this approach assumes the homogeneity of earnings as well as education within each group – something that does not reflect the reality in Europe, as illustrated by the works of Oesch (2015) and Fernandez-Macias (2012). Using quintiles composed of occupations ranked according to specific indicators might, thus, be more advantageous if we assume the variability across countries, but using only quintiles for assessment of occupational might also hide some characteristics that are group-specific, e.g. task content of occupations. That is precisely why this study focuses on the multidimensionality of job quality and task content of occupations as well.

3.4. Empirical results

3.4.1. Is it skill-biased? Occupational change and earnings, education and employment quality

3.4.1.1. Evolution of employment by occupation

First of all, following OECD grouping of occupations, as Figure B.1 illustrates, there had been a substantial overall decline in Middle-skilled employment (ISCO Major Groups (MG later on) 4, 7 and 8), particularly strong during the 2003-2010 period. It occurred to a larger extent among MG 7 Crafts and related trades workers and MG 8 Plant and Machine operators and assemblers. The decline in employment share was stronger among the workers from the former group, between 2-4%, and took place in all the countries except Poland and Bulgaria. The decline was more contained for MG 8 Plant and machine operators, exceeding 2% only in 5 countries (Denmark, Austria, Ireland, Luxemburg and Slovenia), with a slight increase in Poland and Estonia. The employment share losses of these two semi-skilled manufacturing occupations were the highest in Slovenia (-7%), Ireland (-6%), Spain and Austria (-5%), Denmark, Luxemburg, Lithuania, Hungary and Portugal (-4%); and the lowest in Croatia and Estonia (<1%), with a slight increase in Poland (1%). The decline in these occupations at a more disaggregated level was largely driven by professionals in a sub-major group of Metal, machinery and related trades workers (72), Other Craft and related trades workers (74), as well as Extraction and building trades workers (71) in Ireland, Spain, Portugal and Latvia; and Machine Operators and Assemblers (82).

The decline was much less pronounced among Clerks (MG 4), with the exception of 5 countries where it exceeded 2 %: the UK, France and Switzerland (around -2%), Belgium (-3%) and Luxemburg (-7%). The group of Office Clerks largely drove the decline. In 10 countries, their relative share has slightly increased, especially in Spain, Romania, Cyprus and Lithuania (around 1%).

Overall, the relative share of so-called middle-skilled occupations declined across all countries with the exception of Poland, and only in three countries, it was below 2%, namely Estonia, Bulgaria and Croatia. In Romania, Czech Republic, Italy, Cyprus, Netherlands, Lithuania and Germany, it lost between 2-3%; Norway, Sweden, Greece, Finland and Latvia between 3-4%; Hungary, Spain, Portugal, Denmark,

France, Belgium and UK 4-5%; while the largest decline occurred in Switzerland, Austria and Ireland (-6%), Slovenia (-8%), and Luxemburg (-12%).

From 2011-to 2018, the rate of decline in these occupations in Norway, Sweden, Estonia, Italy and Netherlands 2011-2018 exceeded the previous period, remained around 6% for Switzerland and slowed down in the rest. Importantly, the employment in middling occupations during the second period slightly grew in Slovenia, Hungary, Slovakia and Romania, and declined in Poland, thus reversing the previous trend for the latter. The peculiarity of dynamics in CEE and Baltic countries can be explained by delayed, compared to other European countries, industrialisation. It started in the 1990s and became possible due to investments in machines and equipment, changes in organizational practices and the adoption of western know-how (Veugelers et al., 2017), which consequently let further expansion of the manufacturing sector.

Overall, from 2003-to 2018, employment share in middle-skilled occupations declined by over 5% in the majority of the EU countries and the UK, with the largest fall in Luxemburg (-15%), Switzerland (-11%), Ireland (-11%), Austria, Belgium and Portugal (-8%), Nordic countries (-7%), Estonia, Netherlands, Italy and Greece (-6%), France, Spain and UK (-5%). The countries with lower overall loss included Central and Eastern Europe (excluding Slovenia), Croatia, Germany and Cyprus (less than -3%).

Based on solely the analysis of change in the relative share of employment across 9 Major ISCO occupational groups, this evidence supports the widespread hypothesis of the decline or the “hollowing out” of middle-skilled jobs. Economic literature analysing the impact of technological change on employment structure and production (Autor et al., 2003; Autor et al., 2006; Acemoglu & Autor, 2009; Goos & Manning, 2007) suggests routinization as a leading driving cause behind these recent transformations. However, to be entirely in line with the routinization hypothesis, the declining share of employment in the middle of the distribution is expected to be accompanied by simultaneous growth at the top and the bottom, where high-skilled occupations with a prevalence of non-routine tasks component are concentrated.

It is, therefore, important to proceed with the analysis, assessing which occupations compensated for the decline of employment in the middle. With regards to high-skilled occupations (ISCO MG 1, 2, and 3), there was a significant continuity

through both periods, with an increasing share of employment in these occupations, particularly strong during 2003-2010. It is worth mentioning that this trend is in line with expectations of both SBTC and RBTC theories, where according to the former, the increase is concentrated in high-skilled occupations, and according to the latter in non-routine cognitive occupations, which overlap with high-skilled occupations.

The countries with the largest losses in the middle during the 2003-2018 period were among the ones that experienced strong growth in the employment share in high-skilled occupations: Luxemburg (+18%), Switzerland and Finland (+12%), Sweden (+11%), Denmark and Norway (+10%), Austria (+9%), Portugal, Italy and Slovenia (+8%). In Estonia, Poland and Lithuania, with a relatively modest decline among middle-skilled occupations, high-skilled occupations increased significantly: +13%, +12% and +11%, respectively. In Bulgaria, Hungary, Slovakia, and Romania, the relative share of high-skilled occupations instead declined, while in the remaining countries, the growth was moderate: between 3%-4% in the Czech Republic, UK, Greece and France; 5-6% in Germany, Spain, Croatia, Netherlands, Cyprus and Latvia; and 7% in Belgium and Ireland. This growth was mostly driven by the MG 2 Professionals (especially Business professionals and Social science and related professionals) and to a lesser extent by MG 3 (especially Finance and Sales associate professionals).

The dynamics among low-skilled occupations (ISCO MG 5 and 9) were more mixed between countries and between the two periods within countries. Employment share in these occupations expanded between 2003-2010 across all countries except Italy (-4%), Estonia (-3%), Luxemburg and Lithuania (-3%), and Finland, Croatia and the Czech Republic (<-1%). In Italy and Finland, losses in Elementary occupations in MG 9 exceeded gains among Service and sales workers in group 5, leading to overall negative dynamics. Romania and Bulgaria gained +7% and +4% respectively in the relative employment share of these groups, Portugal and Slovenia + 3%, and Ireland, Hungary, France and the UK around +2%.

However, only in a few countries, the trend of either growth or decline in these occupations was persistent over two periods: Romania (+9%), Bulgaria (+5%), Hungary and Greece (+3%), Spain (+1%), Estonia (-5%), and Finland (-3%). In all the other countries a little to moderate increase during the first period was followed by a

little or moderate decline during the second period and vice versa. For instance, an increase during 2003-2010 in Sweden (+1%) was followed by a 4% decline during the next period, while in Denmark decrease of 3% was followed by a 1% increase between 2011-2018. In the majority of the cases, the decline between 2011-2018 was weaker than the growth in the previous period. The only exceptions from these rule were the following countries with stronger decrease than growth in the preceding period: Sweden (from + 1% to - 4%), Poland (from + 1% to - 2%), Germany (from + 0,3% to -2%), Switzerland, Cyprus, Norway (from +0,3-1% to -1-2%). It is also worth mentioning that the growth largely occurred in MG 5 of Service and sales workers. The relative employment share in this group exceeded in many countries the relative employment shares of industrial occupations (MG 7 and 8) by the end of the period, being surpassed only by Professionals (MG 2) or Technicians and Associate Professionals (MG 3). By 2018 the group of Service and sales occupations employed the highest share of workers in Bulgaria, Croatia, Cyprus, Greece, Italy and Spain; and tended to be the second-largest in Austria, Denmark, Ireland, Latvia, Netherlands, Norway, Portugal, Sweden and the UK. An increase in its relative share compared to the other occupations was both due to a growth in absolute numbers as well as a decline in employment in other occupations, particularly MG 7 and 8.

As the present analysis demonstrates, employment growth in either high-skilled, low-skilled or both occupations was accountable for the decline in the middle, varying among countries and periods. It is also worth pointing out that only a few countries have demonstrated continuous trends through both periods.

This evidence suggests that employment change during 2003-2010 was more polarizing, while this trend reversed in the majority of countries during the next period. It is also important to point out that the growth at the bottom during both periods was driven to a larger extent by the MG5 Service Workers and Shop and Market Sales Workers, employment in which continued modestly increase during 2011-2018, while employment in Elementary occupations in MG9 tended to decline.

The stability of the upgrading trend during the two periods investigated characterized only four countries: Switzerland, Estonia, Finland and Poland. All four countries experienced a significant increase in the share of High-skilled employment and a modest decline in the Low-skilled. The first three countries have also undergone

a substantial decline in Middle-skilled jobs. In contrast, their share was largely unchanged in Poland during the first period and slightly declined during the second.

On the other hand, the polarisation trend persisted in Cyprus, Spain, Greece, Italy, and Portugal. Therefore, the majority of countries demonstrated different or slightly different trends for the two periods. Thus, Austria, Czech Republic, Germany, Ireland, Netherlands, Norway, Sweden and UK experienced a shift from **polarization** in the first period to **upgrading** in the second with different magnitudes of change. In Austria, Cyprus, Germany, France and the UK, the expansion of high-skill employment during 2011-2018 was weaker than the previous period, so was the decline among middle-skill jobs, except in Germany, where it has slightly increased compared to the previous period. In contrast, the share of employment in high-skill occupations during 2011-2018 exceeded and, in the majority of cases, doubled compared to the previous period in Ireland, Netherlands, Norway, Portugal and Sweden. It has also been accompanied by a more substantial decline in the share of middle-skilled jobs compared to the previous period.

Few countries show a quite distinct pattern, which cannot be described as either polarisation or upgrading. A typical polarization pattern is visible looking at the occupational change in 2003-2010 in Hungary and Slovakia, followed by a similar downgrading scenario combined with mid-upgrading in 2011-2018 in the two countries and Romania. This pattern is characterized by the decline in the relative employment share of high-skilled and an increase in those of middle-skilled and or low-skilled. In contrast, the polarization pattern in Slovenia in 2003-2010 changed to mid-upgrading with an increase in employment share in middle-skilled occupations and, to a lesser extent, high-skilled. The pattern of occupational change in Bulgaria can be characterized as downgrading in the first period and polarization in the second, the pattern that also emerged in Croatia in the second period.

The conducted analysis shed light on the dynamics of occupational change at the level of ISCO MG within and between the two periods. In line with many studies raising concern about disappearing middle-skilled employment since the 1990s in Europe or 1970s in the US (Vaughan-Whitehead, 2016; OECD, 2019), the analysis confirms that the job destruction had mostly taken place among middle-skilled and was particularly intense during the first period that comprised economic crisis and

recession. It thus supports evidence of a long-term trend of declining employment in the middle of occupational structure, driven, as suggested by the literature, by a shift from manufacturing to service industries.

Figure B.2 illustrates the time trend of employment growth in EU countries by occupation between 2003-2018. While up to 2008, most countries demonstrated overall stability of employment across occupations (except CEE countries, Ireland and Italy), there were clear changes in both rates and extent of change in the relative share of employment in certain occupations. Particularly, middle-skilled occupations in MG7 (Crafts and Trades related workers) and to a lesser extent 4 (Clerical workers) and 8 (Plant and Machine Operators and Assemblers), employment in which remained stable during 2003-2008 in Denmark, Finland, France, Germany, Greece, Netherlands, UK, Norway or expanded in Bulgaria, Croatia, Cyprus, Estonia, Latvia, Slovenia, Poland, experienced decline following the crisis. It is important to highlight that the decline in MG 7 seems to have been triggered by the crisis and recession, except for Hungary, Latvia, Portugal, and Romania, where it has been gradually declining already from 2003. Additionally, the share of employment among Crafts and Trades Related workers (MG 7) declined significantly compared to other occupations. It is especially true for the CEE countries, where the employment in this group was among the highest at the beginning of the period. Employment in occupations of Professionals (MG 2) and Technicians and Associate Professionals (MG 3) continued to expand and accelerated after the crisis.

This specific analysis illustrating time trend changes in the employment share of occupations during 2003-2018 not only supports the findings from previous research on the decline in the middle (Autor et al., 2003; Goos & Manning, 2007; OECD, 2019) but also highlights acceleration in job loss in this group following the crisis and recession. This is in line with the hypothesis of Jaimovich and Siu, pointing out a stronger decline in employment among middle-skilled during the economic downturns, leading to subsequent “jobless” recoveries mostly due to the employment contraction among middle-skill workers (Jaimovich & Siu, 2012; Autor, 2010; Goos et al., 2014).

Extending the period of analysis compared to the previous studies (e.g. Goos and Manning for 15 EU countries), it also illustrates that in most countries, polarization and decline in the mid-skilled occupations slowed down from 2011 on comparing to

the previous period. More countries demonstrated a polarizing trend between 2003 and 2010 than between 2011 and 2018. Additionally, extending the number of countries compared to previous studies allowed to establish a wider variety of patterns, which along with simple dichotomous polarization-upgrading, include mid-polarization, as in the analysis by Fernandez-Macias (2012) for 15 European countries, and downgrading.

The above-presented evidence might be considered a support to the routinization hypothesis. As discussed in the literature review, the loss of employment among middle-skilled has been largely linked to automation. The increasing diffusion of information technology and robots undermined the position of workers mainly employed in semi-skilled middle-paid manufacturing occupations intense in routine tasks (Autor et al., 2003; Autor et al., 2006; Autor & Dorn, 2013; OECD, 2019). However, to confirm routinization as a driver of transformations in occupational structure and polarization, further analysis establishing whether the occupations that declined were, indeed, routine is required.

Overall, the above-presented evidence partially undermines the assumption of the SBTC that expects weaker than in the middle growth at the bottom, or its decline, especially so for the 2003-2010 period. Instead, there appears to be slightly more support for RBTC, suggesting the decline in the middle to be accompanied by simultaneous growth at the top, among high-skilled non-routine cognitive occupations, and at the bottom, among low-skilled non-routine manual occupations. No straightforward conclusion supporting either scenario of RBTC/SBTC can be drawn for 2003-2018 as a whole: while routinization appears to explain the continuous decline in the middle, it fails to explain the lack of substantial growth at the bottom. On the other hand, SBTC fails to explain the decline in the middle of occupational structure. Routinization seems, thus, to be accompanying upgrading, but whether it leads to polarization will be explored in the following.

3.4.2. Occupational change and job quality: earnings and education

After having briefly explored the relative change in employment at the level of Major ISCO occupational groups, it is important to analyse the quality of the employment that declined or expanded. As discussed initially, employment change was more polarized considering broad skill level groups, with simultaneous growth in high skilled (especially professional) and low skilled (especially service) occupations, but has it led to polarization in terms of earnings? This section aims at assessing the quality of occupations that declined and expanded, extending the concept of "quality" from earnings to skill level and employment quality.

Before moving to the analysis at two-digit levels and quintiles, Figure B.3 illustrates the changes in occupational structure between 2003-2018 at the level of ISCO MG ranked by median hourly earnings. Assessing change at this level is important since quintile analysis which will be implemented at the latter stage, might hide some important occupation-specific dynamics due to a higher level of aggregation. Due to the same reason, quintile analysis complicates establishing whether the occupational change is driven by routinization or in general task composition of occupations. Furthermore, ISCO classification at one digit between two periods remained similar, allowing to compare changes across the entire 15-year period.

Figure B.3 does point to the polarization scenario when occupations are ranked by median hourly earnings. However, it also depends on where we draw the boundaries: dividing nine Major occupational groups into three, we can conclude that between 2003-2018 polarization took place in most of the countries, whereas Bulgaria, Greece, and Slovakia underwent a downgrading. A strong polarization pattern is visible in Spain, Italy and Romania, where the increase in the share of low-paid occupations was similar to that of high-skilled. The pattern of occupational change in Estonia, Denmark, Luxemburg, Norway and Sweden resembles an upgrading scenario with no growth or very limited growth in the employment share of occupations at the bottom.

It is worth pointing out that the growth among low skilled occupations was mostly driven by Service occupations from MG 5, while the share of Elementary occupations from MG 9 mostly declined. Additionally, earnings in the former group were higher than in the latter, meaning that the increase in employment was not at the extreme bottom

of the earnings distribution but closer to the middle. Only in several countries earnings in MG5 were the lowest: Bulgaria, Germany, Ireland, Romania and the UK.

Next, in line with the majority of studies by sociologists, we will analyse changes in occupational structure for the 2003-2010 and 2011-2018 periods focusing on the 2-digit level of occupations. Information on median hourly earnings was retrieved from the European structure of Earnings survey and then merged with LFS data. Occupations were rank-ordered from highest to lowest and grouped into fixed at the beginning of each period quintiles. Thus, quintile one comprises the lowest-paid occupations, while quintile five is the highest. Then the change in employment share is calculated as a difference between the end and beginning of each period.

Overall, the composition of quintiles four and five for 2003-2010 look very similar across countries (Figure B.4). They are composed of high-skilled occupations from ISCO MG 1,2, and 3. Referring to the task content of occupations defined in previous studies, these occupations are expected to be non-routine and intense in cognitive tasks (Autor et al., 2003; Autor et al., 2006; Autor & Dorn, 2013).

However, some 2-digit occupations from ISCO MG7 and 8 also frequently appear in quintiles 4 and 3. It includes Stationary plant and related workers (81), Extraction and building trades workers (71) and Metal, Machinery and related trades workers (72). In line with RBTC, intense in routine and manual tasks, these occupations appear to be middle-paid. At the same time, as we know from previous analysis, employment share in all three has been declining, especially so for Extraction and building trades workers and Metal, machinery and related trades workers, which is again in line with the routinization hypothesis.

The composition of the lowest-paid quintile one also looks very similar across countries. It is composed of occupations from ISCO MG 5 and 9 and, in some countries, Office clerks (41). In the framework of RBTC, most occupations from MG5 and 9 are considered to be non-routine manual and low-paid. Their increase, therefore, is expected to lead to polarization of occupational structure. Following the SBTC, being low-skilled employment in these occupations is expected to decline.

Most diverse are, thus, quintiles three and two. Even though they are mostly comprised of occupations from ISCO MG 4, 7 and 8, the composition varies from country to country. While employment decline in the middle is driven to a large extent

by manufacturing occupations, disaggregation at 1-digit allows noticing that in some countries, a “new middle” seems to emerge. It is mostly composed of occupations from MG 3 Technicians and Associate professionals, namely sub-Major group 32 Life science and health associate professionals. This trend is more evident for Nordic countries except Sweden and very slightly for Germany, Spain, and Italy. In the first case, a significant role in the creation of these jobs might be played by the social-democratic welfare state, while in the second driven by the ageing population and demand for care services.

Among manufacturing occupations, the only lower-paid sub-major group largely present in quintile two and only in a few cases in quintile one is Other craft and related trades workers (or Food processing, Woodworking, Garment and Other Craft and trades related workers in revised ISCO08). It is also among the most routine and manual-intensive, lower-skilled and declining occupations at high risk of automation. Employment in this group fell by 24% between 2006-2018 and is expected to continue to decline even though at a slightly slower pace (Cedefop Skills Intelligence Tool).

The picture is similar for the 2011-2018 period (Figure B.5). The decline among manufacturing occupations continued, even though it was weaker than in the previous period. It continued to be driven by occupations from the MG 7 than MG 8, especially mid-paid Building and related trades workers (71) and Metal, machinery and related trades workers (72). Both occupations experienced employment decline following the crisis, between 2006-2018: contraction in the construction sector led to a 7,4% decline in the former, whereas a decline in manufacturing and offshoring – led to around 14% in the latter (Cedefop Skills Intelligence Tool). While slight growth is expected in the employment of construction workers, a persistent trend of decline is predicted for Metal, machinery and related trades workers. Both occupations are at high risk of automation, and a higher skill level will be required to adapt to technological change and complement emerging technologies (Cedefop Skills Intelligence Tool).

Among lower-paid occupations, the sub-MG of Personal care workers demonstrated a continued growth trend. It was an exception to the majority of occupations falling into the first or second quintile with an overall declining employment share. In absolute terms, employment in this low-risk automation occupation grew by

15,8% between 2006-2018 and is expected to continue its expansion (Cedefop Skills Intelligence Tool).

Thus, in many cases, the composition of the quintiles, especially the dynamic of some occupations, drives the whole quintile's dynamics. This is why analysing employment change only at the level of quintiles of employment distribution might be misleading, especially if one tries to establish possible causes behind these changes. In fact, the content of occupations appears to play a certain role in explaining occupational change dynamics.

Looking at overall patterns of occupational change (Figure B.6), we find a confirmation of significant heterogeneity across countries and between the two periods. Occupations in quintile one (left) are lowest-paid and quintile 5 (right) highest-paid. Countries in the first three columns experienced upgrading through the 2003-2018 period, even though in some of them (column three), there was a very slight increase at the bottom during either the first or second sub-period. Estonia, Finland, Norway experienced upgrading with mid upgrading during 2003-2010, while it was the case in Germany between 2011-2018.

Ireland was the only country with a persistent pattern of polarization. Polarization in the first sub-period turned into upgrading in the second in the UK and Cyprus, and vice versa in France. Polarization in 2003-2010 in Slovakia and Lithuania and upgrading in Hungary turned into downgrading in 2011-2018. The pattern was similar in Greece, even though the growth in 2011-2018 occurred in the second and not the lowest-paid quintile. Croatia experienced upgrading, and Romania - experienced a combination of mid-upgrading and downgrading from 2011-to 2018.

Comparing these results to the analysis at one-digit, support for upgrading scenario for both periods is found only for Estonia and Finland. However, if we take into consideration only a slight increase in employment in MG 9 in Germany and Sweden and MG 5 in Switzerland (<0.5), they can also be included in the group of upgrading countries. Shift to downgrading is supported for Bulgaria and Romania. Slight polarization remains the case for Belgium, Czech Republic, Cyprus, France, Greece, Ireland, Portugal, Poland, Italy and Slovenia.

Linking these results with previous findings on the content of occupations, a few observations can be drawn. In line with RBTC theory, some of the routine intense

occupations (following the ALM definition) are found in the middle of earnings distribution and some cases, in the 2nd and 4th quintile. There was, indeed, a substantial decline in the employment share of these occupations, complemented by an increase in non-routine occupations at the top and the bottom of the earnings distribution. While an increase in the former is expected by both SBTC and RBTC theory, the growth in the latter is foreseen only within RBTC, leading to polarization of employment structure. While the analysis at 1-digit demonstrated a noticeable increase in non-routine manual occupations at the bottom, there is no evidence of polarization if more general changes in occupational structure at the level of quintiles are considered.

While median earnings were widely used by scholars in the analysis of occupational change, using it as a proxy for job quality, a range of scholars pointed out the importance of looking at educational level as a proxy for skill requirements (Fernandez-Macias, 2012; Oesch, 2015). Indeed, educational expansion contributed to the increase in the proportion of highly-educated workers, which is considered an important supply factors drivers of occupational change (Machin et al., 1996; Oesch, 2015; Goldin & Katz, 2008).

Labour force survey data was used for defining a mean level of education for each of the 2-digit occupations. The occupations were then ranked and grouped into quintiles at the beginning of the period. Figure B.7 suggests that in most countries, expansion occurred in occupations with the highest level of educational attainment.

Countries with upgrading and a combination of upgrading with mid-upgrading patterns are presented in the first three columns of Figure B.7. The clearest pattern of upgrading is visible in Austria, Switzerland, Finland, Ireland, Luxemburg, Norway, Portugal, and Belgium, with a monotonous increase from less-skilled to higher-skilled occupations. Similarly, the mostly upgrading pattern accompanied by slight growth in the middle and bottom-middle quintiles characterized Spain, Greece, Netherlands, Germany, Slovenia, Cyprus, Poland and Estonia. The pattern of slight polarization in Sweden and Italy in the first period changed to upgrading in the second, whereas the reverse occurred in Denmark and the Czech Republic. The employment share of occupations with the lowest level of education expanded over both periods in Bulgaria and during the second period in Hungary and Lithuania. In Slovakia and Romania, it was the share of occupations in the middle and bottom-middle quintiles that expanded.

The discrepancy between patterns of occupational change in terms of earnings and skills might be explained by the differences in occupational rankings. For example, occupational change in Bulgaria between 2003-2010 in terms of earnings was a clear example of polarization, while in terms of skills – a polarization with mid-upgrading. The cause of it was a substantial 3% increase in the share of Protective and service workers (52) that rank high on skill level fell in a 3rd quintile, while in terms of earning this occupation is in the first lowest-paid quintile.

Overall, the differences between the patterns based on two indicators of job quality appear to be mostly driven by Clerical, Manufacturing and Service and Sales occupations. As it was demonstrated in the previous analysis, some of the manufacturing occupations, especially those from the MG 8 of Plant and Machine Operators and Assemblers, fell most frequently in the lower-skilled quintile four but were mostly middle- and slightly above middle-paid paid (quintiles two and three). With respect to Service and clerical occupations, there was the opposite tendency: workers were generally higher-skilled but ended up in the lowest-paid quintiles. The analysis focusing on the level of education appears to confirm what is expected by the SBTC, namely continuous growth in high-skilled occupations. The additional observation that emerges is the presence of higher-skilled workers in lower-paid occupations, possibly pointing out the problem of qualification mismatch, the importance of skill specificity and the different values of these specific skills across countries, which will be explored further on in the analysis.

3.4.2.1. Occupational change and job quality: employment quality

Lastly, several scholars, mostly sociologists, referred to the multidimensionality of job quality concept. The definition of job quality and indicators varied across studies and fields and data sources used for the analysis. Taking into account differences in institutional arrangements regulating labour markets in Europe and assuming their impact on job quality, the present study creates a specific indicator of employment quality. It takes into consideration the share of workers with precarious characteristics of employment contract (involuntary temporary contract, involuntary part-time employment), atypical work arrangements (shift work, night work, Saturday/Sunday work), and precarious work-life balance (usual hours worked exceeding 48 hours).

Analysing this dimension seems to be particularly important, considering the consequences of Economic crisis and Recession. As well-known, liberalization of the labour market has been on the agenda in many countries as a tool to tackle unemployment and, later, to address the problem of labour markets segmentation (Boeri & Garibaldi, 2007; Eirchhost et al., 2019; OECD, 1994). These reforms concentrated in the area of employment protection legislation concerning both permanent and temporary workers.

Overall, the share of temporary contracts increased between 2003-2018, further triggered by the economic crisis, and only in a few countries did it decline after 2011. Netherlands, Italy, Croatia, Germany, Cyprus, France, Switzerland, Sweden, Slovenia, Finland, Poland, Portugal and Spain had the highest share of temporary contracts ranging from the lowest 7.94% in the Netherlands, 8.54% in Italy and 9.82% in Germany to 13% in Finland, 18% in Poland, 23% in Spain. Among these countries, the share of employment with temporary contracts declined towards the end period only in Germany (9%), Spain (19%), Finland (11%), and Slovenia (from 12 to 11%); it remained the same in Sweden (10%) and Poland (18%) and increased by around 3-5% in the rest of the countries. The share of those who agreed to temporary employment due to not finding permanent employment was between 5-10% in Italy, Cyprus, Finland, France, Greece, Croatia, Poland, Portugal, Sweden and Spain in 2003 and increased by 2018 from 6% to 14% in France and 19% in Italy, while falling in other countries.

A similar pattern emerges from analysing the changes in part-time employment, with only a few countries showing their declining share between 2003-2018: Ireland, Latvia, Lithuania, Poland, Romania and Sweden. The countries with highest share of part-time employment in 2003 demonstrated continuous growth up to 2018: Austria (from 17%to 22%), Belgium (16% to 20%), Switzerland (from 23% to 30%), Germany (from 14% to 19%), Italy (from 10% to 15%), Netherlands (from 32% to 40%), and UK (from 15% to 16%). The share of part-time employment returned to its pre-crisis level in Denmark (around 13%), Ireland (12%), and declined compared to 2003 in Sweden (20%) and Norway (14%). Involuntary part-time employment concentrated primarily among Clerks, Personal and protective service workers and Sales and services elementary occupations. Moreover, the share of respondents who did not want a

permanent job was highest among Office clerks, Personal and protective service workers, and Sales and Elementary occupations.

Before presenting the results of occupational change using the final index of employment quality, it might be useful to see how the dimensions of employment quality vary across occupations and countries.

Figure B.8 provides detailed information on the variation of different job quality dimensions across sub-major ISCO occupational groups. High-skilled occupations tended to have a very low proportion of workers with part-time contracts and slightly higher but still generally below 8% share of workers with temporary contracts. On the other hand, long working hours were rather diffused across occupations in these sub-MG, being especially high among Managers. Health professionals and health associate professionals were distinguished by a high share of workers with atypical working hours due to the prevalence of shift work in these occupations. Similarly, the share of workers with part-time and temporary contracts was very low across industrial occupations, which in contrast to high skilled occupations, had more favourable working hours' conditions.

Furthermore, more detailed occupational information at ISCO 08 allows us to notice some differences within major occupational groups. For instance, the share of workers with involuntary part-time and temporary contracts was higher among Personal service (51) and Personal care workers (53) and lower for Sales workers (52) and Protective service workers (54). The last group stands out because workers in this group are mostly public sector employees and include police officers, fire fighters, and similar. However, all four are distinguished by the highest share of workers with atypical working hours compared to the rest.

All six sub-major groups within the group of Elementary occupations with the overall lowest job quality had more than 10% of workers with an involuntary fixed-term contract. For Cleaners and helpers (91), Food preparation assistants (94) and Street and related Sales and Service workers (95), it was combined with a higher than 10% share of workers with involuntary part-time contracts. This might be not so surprising since workers in these occupations might see these jobs as a temporary solution before moving to better-paid and more skilled occupations. In general, there haven't been significant changes across different job quality dimensions between the two

periods. More detailed occupational classification of ISCO 08 allowed to distinguish the differences within Major occupational groups more clearly. Since it is rather difficult to compare cross-country variation at ISCO 2-digit level, the following analysis proceeds by focusing on job quality across ISCO MG.

Figures B.9 and B.10 illustrate the share of respondents reporting their work condition on each dimension across countries for 2005 (2006 for Bulgaria, Spain, Norway and Netherlands for which data on atypical work hours and usual working hours' variables was not available in previous years) and 2011. A clear variation of indexes across occupations within countries and, to a lesser extent, across countries is rather visible.

A high proportion of respondents working long and atypical working hours was widely diffused across countries. There was, however, less cross-country variation in atypical working hours than in the long working hours' dimension, determined mainly by the specificity of occupations and concentrated mainly among Service Workers and Shop and Market Sales Workers and Plant and Machine Operators and Assemblers. Instead, long working hours were prevalent among Managers and Legislators as well as Agricultural and Fishery workers. The proportion of workers with long working hours in these occupations was the lowest in Baltic countries, Hungary and Romania, and the highest in Austria, Cyprus, Spain, France, Greece and Italy.

With the exception of a few countries, the share of workers with involuntary temporary and part-time contracts was generally very low, below 10%. Overall, permanent contracts were less frequent in Southern Europe, followed by Poland, Croatia, France, Netherlands, and Nordic countries. In Spain, Poland and Portugal, more than 10% of respondents reported having involuntary temporary employment in most of the occupational groups, whereas in the rest, it was mostly the case for low-skilled occupations. Austria, Belgium, Switzerland, Germany, CEE (except Poland) and Baltic countries, as well as Luxemburg, Romania and the UK, had overall lower shares of workers with temporary and part-time contracts.

In terms of variation across occupations, the share of workers in involuntary temporary and part-time employment was highest among Service Workers and Shop and Market Sales Workers (MG 5) and Elementary occupations (MG 9) and lowest among High-skilled occupations (MG 1-3), Crafts and trades related workers and

Machine operators and assemblers in most countries (MG 7 and 8), and into a large extent Clerks (MG 4).

No substantial differences arose compared to the indexes in the second period, with the exception of a slight deterioration in the share of workers with involuntary temporary and part-time contract Service and Sales and Elementary occupations in Spain, Italy, Poland, Sweden, Belgium (only MG 5), and France, Greece, Hungary and Slovakia (only MG 9).

Comparing the shares of workers in specific working conditions between the two periods, two trends are particularly evident. First of all, the share of workers with long and atypical working hours remained largely the same. The proportion of workers with involuntary and part-time contracts remained similar between the two periods, even though some countries witnessed an increase in the share of workers with involuntary fixed-term contracts, especially among Service Workers and Shop and Market Sales Workers. As for cross-country variation, the index of job quality across all the occupations in the Southern European countries and Poland was higher than average, hence lower job quality. Those were the countries with higher share of temporary contracts across all the occupational groups.

While these findings are informative, as in the previous analysis, we might expect cross-country variation driven by differences in institutional frameworks. Variation in the overall index of job quality across 1-digit ISCO occupations and countries between 2005 and 2011 is illustrated in Figures B.11 and B.12. The higher is the index, the lower is the job quality. Comparing these two graphs, we might notice that overall little had changed, especially among high-skilled occupations, Clerks and Crafts and Trades related workers. At the same time, job quality among lower-skilled occupations had not improved and even slightly deteriorated in some countries.

Service Workers and Shop and Market Sales Workers, as well as Elementary occupations, were distinguished by the lowest quality of working conditions across all the countries. In particular, it was driven by a high share of workers with involuntary part-time and temporary contracts. Only Central and Eastern European and Baltic countries (except for Poland) demonstrated comparatively better job quality in these occupations. On the other hand, countries of Southern Europe and Nordic countries (with the exception of Denmark for Elementary occupations) were characterised by

consistently lower job quality in these two occupations. Whereas in both country groups, it was mostly driven by a higher proportion of workers with involuntary temporary contracts, Sweden and Germany were characterised by a higher share of workers with involuntary part-time contracts, negatively affecting job quality in these occupations. While there were some variations across countries, the lower job quality in these occupations is a point of concern, taking into consideration the employment growth in these occupations is expected to continue.

Instead, the job quality was highest among high and medium-skilled occupations, where the workers were more likely to work atypical (industrial occupations), or long working hours (high-skilled occupations and Clerks), rather than having a temporary or part-time contract. There was generally little cross-country variation regarding job quality among these groups.

As in the case with other indicators, Figure B.13 describes occupational change when occupations are ranked by the job quality index. Very few countries experienced a continuous increase in occupations with the highest job quality during both periods, namely Finland, Greece, Ireland, Lithuania, Poland, Sweden and Slovenia. Austria, Belgium, Cyprus, Denmark, Italy and UK exhibited negative dynamics in the top 5th quintile, whereas it was mixed for the rest. A clear pattern of occupational upgrading in terms of job quality occurred only in Estonia, Poland and Croatia (the data for Croatia is available only for the 2011-2018 period). Despite very slight growth at the bottom in Denmark and Sweden in 2003-2010, the dynamics of occupational change in these countries, along with Latvia and Luxemburg, can also be characterized as upgrading with mid-upgrading.

At the same time, a slight increase at the bottom during both periods took place in Belgium, Switzerland, Italy, Netherlands, being stronger in Bulgaria and Hungary. Out of these countries, only Italy and Hungary preserved the downgrading trend, whereas mid-upgrading or its combination with upgrading took place in others. Share of employment in quintile one declined in Estonia, Finland, Lithuania, Luxemburg and Poland and varied between the two periods in the remaining countries. It resulted in upgrading in Estonia and Poland, upgrading with mid-upgrading in Finland and Lithuania, and mid-upgrading in 2003-2010, turning into upgrading in 2011-2018 in Luxemburg.

More substantial changes in many countries occurred in the quintiles in the middle and differed between the two periods, making it difficult to classify with a simple upgrading/downgrading dichotomy. Overall, the share of workers with higher job quality in quintiles 4 and 5 tended to increase in more countries during the second period compared to 2003-2010. This rather mixed picture emerges due to a substantial cross-country variation in occupational rankings based on the job quality index.

Figures B.14 and B.15 demonstrate occupational change by quintiles disaggregated by Major ISCO groups. Share of employment in quintiles with higher job quality (quintiles 4 and 5) increased in the countries with stronger growth among occupations in MG 2 Professionals or MG3 Associate professional, with the exception of Health Professionals, Health Associate professionals and Legal, Cultural and Social associated professionals that in most countries were part of the quintile 3. Instead, the negative dynamics in quintiles 4 and 5 were driven by the declining share of employment in MG 4 Clerical workers and MG 7 Craft and trades related workers. Despite being in the “middle” of occupational structure when ranking is based on earnings or skills, most of the occupations in this group were distinguished by higher levels of employment quality, with the exception of Customer Service Clerks and Building and related trades workers that ranked lower on job quality index. As previously discussed, only in a number of countries did some of the occupations in the MG 7 ranked low on the overall job quality index, namely Southern European countries and CEE countries, and it mostly regarded the group of Building and related trades workers.

Many countries witnessed an increase in the share of occupations with a lower job quality index. The growth in quintiles one and two was driven by an increase in the share of Service and sales occupations, particularly personal care and Personal service workers. Instead, the decline was a result of decreasing employment share in MG 6 Agricultural and fishery works, MG 8 Plant and machine operators and Assemblers (in particular Stationary Plant and related operators), and MG 9 Elementary occupations. As discussed previously, the low ranking on job quality in MG 5 and 9 was a result of a higher share of temporary and part-time contracts, reflecting more precarious working conditions, whereas, for MG 8, it was driven by a large proportion of workers with atypical working hours.

The composition of mostly declined middle quintile three varied across countries the most. Its eventual dynamics were, thus, influenced by the occupations it was composed of. The growth in this quintile was driven by Health Professionals (MG 2), Health and Associate Professionals (MG 3), and Managerial occupations (MG 1). The decline, instead, was mostly driven by occupations from MG 7, MG 8 (especially Machine operators and Assemblers) and, in some countries, MG 4 (Customer service Clerks in particular). The growth in this quintile took place in those countries where an increase in the employment share of high skilled occupations outpaced the decline in medium-skilled occupations.

Overall, the growth in the lowest job quality quintile 1 slowed down between 2011-2018 (Figure B.15), confirming the trend when occupations were ranked by earnings but had not disappeared. With the exception of a few countries, the growth of higher quality jobs was rather contained, whereas jobs with medium quality tended to decline. Unless it was outweighed by the decline of Office Clerks and Building and Related trades workers, the share of employment in high-quality jobs increased in the countries with a growing share of Professional occupations, particularly Business and Administration professionals, Information and Communication Technology professionals and Business and Administration Associate Professionals.

The pattern of occupational change based on the index of employment quality differ from the previous two. A clear upgrading pattern is visible only in Estonia, Poland and Croatia, whereas in the rest of the countries in columns one and two, upgrading was accompanied by an increasing share of employment in the middle quintiles, and in columns three and four, the middle-bottom quintile two. The pattern of occupational change in the UK, France, Belgium and Cyprus changed from mostly downgrading to upgrading in the first two and mid-upgrading in the rest. The Netherlands remained slightly polarized in 2011-2018, along with the Czech Republic, Slovakia, Austria and Spain, which were mostly going through upgrading and mid-upgrading during the 2003-2010 period. Bulgaria, Italy and Hungry showed a more visible trend of downgrading that persisted in the last two countries in 2011-2018. The pattern in Ireland was a combination of mid-upgrading and downgrading with comparatively stronger growth at the bottom quintiles.

Several conclusions may be drawn with regard to job quality. First, there appeared to be certain variations across countries, which might be linked to the diversity of institutional frameworks. It is, however, more noticeable in some dimensions than others. On the dimensions of contractual stability, Southern European countries stood out with the highest shares of involuntary temporary contracts, along with Poland, France and the Netherlands. In Spain and Italy, it was combined with a higher than average share of workers with involuntary part-time contracts, which was also the case in Nordic countries, especially Sweden. Across countries, a higher share of workers with these two conditions was concentrated among Services and Sales workers (MG 5) and Elementary occupations (MG 9).

Comparatively to other dimensions of job quality, more workers experienced working longer than average working hours. This phenomenon was rather diffused across countries and especially among higher-skilled Managerial occupations (MG1), Agricultural and Fishery workers (MG 6), and to a much lesser extent, Professionals (MG 2). The share of workers with long working hours in these occupations was lower in CEE, Baltic and Nordic countries and reached 40% of workers or more in MG 1 and MG 6 in Austria, Belgium, France, and countries of Southern Europe with the exception of Portugal.

As in the case of long working hours, atypical working hours were rather widespread across occupations and countries. The highest share of workers with this working condition was concentrated among Services and Sales workers (MG 5), Plant and Machine Operators and Assemblers (MG 8), and to a lesser extent, Elementary occupations (MG 9). The share of workers with atypical working hours reached or exceeded 20% in MG5 and MG8 in most of the countries, being the highest in Germany, Finland, Luxemburg, Netherlands, Slovenia, Slovakia and the UK. Variation across groups of countries with respect to this dimension does not appear straightforward, and occupation seemed to play a crucial role independently of country institutional specificity.

Regarding the final job quality index, it varied more across countries among sub-major groups of Legislators and senior officials (11 in ISCO88), Chief executives and senior managers (11 in ISCO08), Hospitality, retail and Other service managers (14 in ISCO08), Teaching professionals (23 in ISCO88 and ISCO08), Customer Service

Clerks (42), Protective and Service workers (51 in ISCO88) and Personal service and Personal care workers (51 and 53 in ISCO08), Extraction and building trades workers (ISCO88) and Building and related trades workers (71 in ISCO08), and all the occupations in MG 9 and Assemblers (82 in ISCO08). For instance, among Teaching Professionals, the index was lowest - hence job quality was highest – in most CEE countries except Poland, the Czech Republic, and Baltic countries (below 10). Instead, it was highest in Southern European countries except for Greece, Belgium, Finland, and France (around or exceeding 20). Job quality in the expanding group of Personal care workers was highest in Baltic countries, Austria, Hungary and Ireland and lowest in Southern European countries, France, Sweden, Finland, and most of the CEE countries (Czech Republic, Poland, Slovakia and Croatia). The pattern for Elementary occupations (MG 9) was quite similar, with lower indexes of job quality across Southern European countries, some of the CEE countries (Poland, Hungary and Slovakia), Finland and Sweden.

Second, while certain cross-country differences were more visible in some dimensions than others, the largest variation occurred across occupations. The average index of job quality was highest among Professionals (MG 2), followed by Craft and Related trades workers (MG 7), Technicians and Associated professionals (MG 3), Clerks (MG 4), Managers (MG 1), Plant and machine operators and Assemblers and lowest among Service and Sales workers (MG 5) and Elementary occupations (MG 9). This finding is important since while high-skilled occupations and occupations from MG 7 and 8 are well-compensated and fall into middling quintiles, occupations from MG 5 score low in terms of job quality and earnings while being generally and comparatively higher-skilled. It is especially problematic taking into consideration the increasing employment share of this group.

Last, there was no significant change in terms of job quality between the two periods. The only exception from the case were occupations from MG 5 and MG 9, with a slightly lower index in the second period. Unfortunately, there is no possibility of directly comparing job quality change at a more detailed occupational groups' level since both MG 5 and 9 were revised in the new ISCO 08 classification. For instance, ISCO88 sub-major group 51 included a number of 3-digit occupations that became separate sub-major groups in ISCO08.

3.4.3. Is it routine biased? Occupational change and task content of occupations

The present analysis aims at assessing whether the changes in employment structure can be better described as routine biased as expected by the proponents of RBTC theory. In contrast to SBTC focusing on skill level as a predictor of job growth/decline and wage inequalities between high-skilled and low-skilled, RBTC suggests the level of "routineness" of occupation – distinguishing between low, medium and high level – to be a crucial element in determining employment and wage dynamics.

Once again, it is worth stressing the difference between tasks and skills, which are closely linked but represent two different concepts. Acemoglu and Autor defined task as a "unit of work activity that produces the output" and skills as "worker endowments of capabilities for performing various tasks" (Acemoglu & Autor, 2011). Skills possessed by individuals are necessary to implement tasks, whereas the combination of different tasks forms jobs. Following this definition, individuals' skill level can either match the task requirements of a job or be below/above the required level, causing mismatch, as will be discussed later.

Task framework was first provided in the influential work by Autor, Levy and Murnane (2003), "*The Skill Content of Recent Technological Change: An Empirical Exploration"*, putting forward the argument of routinization. Using information from the US Dictionary of occupational titles and later Occupational Information Network (O*NET), providing specific information on occupations over a range of dimensions (worker characteristics, worker requirements, experience requirements, occupational requirements etc.), the authors proposed to classify tasks with respect to two dimensions: routine and non-routine on the one side, and manual and cognitive (further distinguished into analytical and interactive) on the other. This original classification of tasks in the *routine-manual, routine-cognitive, non-routine manual, non-routine analytical, non-routine interactive* was further applied by a range of scholars to Europe (Goos & Manning, 2007) and Germany (Spitz-Oener, 2006). In 2006s work, Autor, Katz and Kerney (2006) proposed a simplified taxonomy unifying two routine task categories and distinguishing between *routine, abstract and manual,* which was later applied by

Autor and Handel (2013), Autor and Dorn (2013) to the US, Goos et al. (2014) to 15 European countries, and Sebastian to Spain (2018).

The vast majority of studies have, thus, used the task definitions using the US DOT or O*NET sources, applying them through the crosswalk to the ISCO 88 classification. While administrative assessment of task content of occupations might be advantageous due to the objective analysis conducted by experts, its application to relatively heterogeneous European countries might be questioned. Unfortunately, there are no similar sources of information available for the European countries (with the exception of single countries, namely the Czech Republic, Germany and Italy), and the only possible alternative for similar analysis remains a European Working Conditions Survey (EWCS) conducted by Eurofound. The subjectivity of EWCS based on the individual assessment made by employees regarding their work, working conditions, and other aspects can also be considered an advantage. Since Europe is still quite heterogeneous, collecting information directly from workers for analysing job tasks can contribute to a more precise description of the task content of occupations.

Fernandez-Macias and Hurley (2016) were the first to use EWCS to assess the task content of jobs in Europe. Following previous studies, they defined routine and cognitive task categories, adding a social interaction and trade index in order to test the routinization hypothesis. The most comprehensive task framework was recently developed by Fernandez-Macias and Bisello (2017), covering all the dimensions from previous findings, combining the information from several resources and applying it to EU countries. Combining data from EWCS, PIAAC, and O*NET, the authors classified tasks in accordance with their contents (physical, intellectual or social); and methods and tools of work.

In the present analysis, task indexes are constructed using defined by other authors' dimensions with minor changes in terms of items used and a number of task categories. More specifically, *routine, manual, cognitive, and interactive task categories* are developed in order to assess the content of occupations. The first three are drawn from the ALM framework but without directly distinguishing between routine and non-routine tasks. An interactive index is added following Deming (2017) and Fernandez-Macias and Hurley for 15 European countries (2016). So far, the latter appears to be actually the only study that used EWCS to assess the level of

routineness in occupations in Europe, while others gave preference to directly applying O*NET data for the creation of task indexes.

Thus, the construction of task indexes in the current analysis in part overlaps with the work by Fernandez-Macias and Hurley (2016), with a difference of introducing *manual* task category and slightly changing the items used for the creation of other task categories (except social interaction index that is identical to the one constructed by Fernandez-Macias and Hurley).

ALM defines *routine* tasks as the ones following clearly defined rules and procedures that can be "accomplished by machines following explicit programmed rules" (ALM, 2003), the quality that makes them susceptible to automation. However, it appears difficult to measure "routineness" following this definition, especially in the survey, as workers are unlikely to be aware of which of their tasks can be "accomplished by machines". ALM use the "Eye-hand-foot coordination" variable to define non-routine manual tasks and "finger dexterity" – routine manual. In fact, this theoretical definition of "routine" might not coincide with what can be perceived by workers as routine. For instance, driving might be considered routine from the worker's point of view, while up to now, this task seems to be difficult to automate at a large scale (ALM, 2003; Brynjolfsson & McAfee, 2012). However, considering most recent developments in AI, automation of driving does not seem impossible, which implies that what is considered routine might change over time.

The routine index should, thus, reflect to which extent occupational tasks can be codified and implemented by machines, whereas other task indexes describe task variety and demonstrate which occupations are rather likely to be complemented than substituted by technology. For instance, tasks related to perception and manipulation, creative and social intelligence representing so-called "engineering bottlenecks" (Frey & Osborne, 2017), require higher skills and are less likely, as of now, to be replaced by machines and AI.

Taking advantage of survey data, the present analysis operationalizes routine tasks taking into consideration the level of repetitiveness and monotonicity, assuming that the more repetitive and less diverse jobs are, the easier it might be to define rules for replacing them with technology. Instead of focusing on juxtaposing routine/non-routine, it rather seeks to assess the task composition of occupation, assuming it might

be more difficult to replace tasks requiring workers to learn, react to unforeseen situations, use digital technologies or interact with others, reflecting the diversity of tasks within occupations.

While the availability of data allowed ALM to distinguish between analytical and interactive tasks, where the former was mostly related to mathematical knowledge, and general educational development and the latter to responsibility, direction, control or planning of the activities, the present analysis introduces cognitive scale and interactive scale separately, as in Fernadez-Macias and Hurley (2016). Furthermore, in the framework of the current proposal, the interactive scale rather describes the level of communication required than supervising character of the occupation. Since there are no items available to describe numerical or literacy skills, operationalization of cognitive scale includes the presence of task complexity, ability to find solutions to problems, frequency of working with digital devices and the importance of learning new things.

Manual tasks were distinguished by the presence of physical activities at the job, particularly carrying or moving heavy loads, uncomfortable working positions, and repetitive hand or arm movement. It differs from the operationalization of ALM, who differentiate directly between routine-manual and routine non-manual tasks, being constrained by the variables available in DOT and allowing only for their combination and not separate indexes. Moreover, what is considered manual in both of these measures seems to be different: the routine manual is defined as the “ability to move fingers, and manipulate small objects with fingers, rapidly or accurately”, while non-routine manual as the “ability to move the hand and foot co-ordinately with each other in accordance with visual stimuli”. Thus in one case, the manual seems to be associated with “finger dexterity”, while in the other with “hand-eye-foot coordination”.

The interactive dimension was constructed taking into consideration the level of communication activity in the occupation with non-colleagues on the one side and the dependency of the worker's pace on dealing with customers on the other side. It, thus, can have high scores in both high-paid and low-paid service occupations.

Table 1 in Appendix B provides information on task dimensions and variables used for their creation.

Figure B.16 illustrates the average score for ISCO88 occupations (on the left) and ISCO08 (on the right) on each dimension, allowing thus, to shed light on their relative importance in occupation. Once again, unfortunately, there is no way to confront two classifications. While the name of the group at 2-digit might be the same, the occupations included in this group might differ. For instance, with the aim of distinguishing specific tasks and degree of responsibility, primary and pre-primary school teachers were part of either MG 2 “Teaching professionals” or MG 3 “Technicians and associate professionals” in ISCO88. In ISCO08, those from the latter group, namely primary education teaching associate professionals (331), pre-primary teaching associate professionals (332) and special education teaching associate professionals (333) school teachers were integrated into the MG 2 Professionals, creating specific categories of Vocational Education teachers and several specialized categories of teachers (ILO 2012). Overall, there has been significant reshuffling with the creation of new 2-digit sub-major groups with new professions and integration of some professions from the previous classification, making a direct comparison, especially with relation to the task content, difficult. Overall, the ISCO08 classification with more detailed sub-major groups subdivisions seems to be better suited and more relevant for describing the task content of occupations considering technological change and the emergence of new occupations.

Referring to Figure B.16, two observations can be immediately made. First, moving top-down, the share of routine and manual tasks increases, while generally cognitive and interactive decreases. A combination of the high and above-average level of cognitive and interactive intensity at the top – among Managers, Professionals and Associate Professionals and Technicians – is as frequent as a combination of a high level of routine and manual tasks among mid- and low-skilled industrial occupations, and to a lesser extent Service and sales and Clerical occupations. The two latter groups of occupations represent a slight exception, with a combination of an above-average share of routine, cognitive and interactive tasks for Clerks and routine and interactive or only interactive for Personal and Service workers.

Another observation to make is the presence of Routine tasks in almost all occupations. More specifically, the share of routine and manual scores is higher in occupations from MG 7, 8 and 9, but there is also a clear within-group variation. For instance, Precision, handicraft, printing workers have almost equal task share on both

dimensions, while Extraction and Building trades workers are clearly more intense in manual than routine tasks. Stationary plant and related operators, machine operators, and assemblers have the highest share of routine tasks. It is around the average for Drivers and mobile plant operators who, at the same time, have rather high intensity on both routine and interactive indexes.

In the work of ALM ten most routine-intense occupations included all the major sub-groups from MG 4 Clerks (Office and Customer service clerks), MG 8 Plant and machine operators, MG 7 Craft and related trades workers, and one sub-MG of Labourers in mining, construction, manufacturing and transport from MG 9 (Sub-major group 91). In contrast, in the present analysis, occupations with higher average routine task scores do not include subgroup 83 Drivers and mobile operators from MG 8; sub-major group 72 Metal, machinery and related trades workers from MG 7, and sub-major group 41 Office clerks from MG 4. The top ten most routine occupations using ISCO88 classification include, instead, all occupations from MG 9 Elementary occupations (91 Sales and Service Elementary occupations, 92 Agricultural, Fishery and related labourers, 93 Labourers in mining, construction, manufacturing and transport), all occupations from MG 7 except Metal, machinery and related trades workers (72), Customer service clerks (42) and Machine operators and assemblers (81) and Stationary plant and machine operators (82). The share of routine tasks is close to average for occupations in MG5, Life science and health associate professionals (32), Metal, machinery and related trades workers (72), and Drivers and mobile plants operators (83). The major difference thus lies in the classification of the two last-mentioned occupations and occupations from MG5 and MG9 considered non-routine manual in ALM but resulting being moderately routine following the present definition based on workers' assessment.

The picture is similar for the ISCO08 classification, whereas its more detailed definition of occupations better clarifies the differences between and within groups. For instance, among Clerks, the share of routine tasks is the highest for Other clerical support workers scoring lowest on the cognitive dimension compared to the other occupations in the group. The cognitive intensity is higher for Numerical and Material Recording Clerks and General and Keyboard Clerks, and interactive – for Customer Services Clerks. Revision in MG 7, moving minor sub-group 711 (Miners, shot firers, stone cutters and carvers) from sub-major group 71 in ISCO88 to sub-major group 81

Plant and machine operators in ISCO08 led to decreasing the level of routine tasks in sub-major group 71 Building and Related trades workers in ISCO08. Similarly, greater details in MG 5 Service and Sales workers allowed to highlight the differences in task composition between Protective service workers, Sales workers, Personal service workers and Personal care workers. Among those, Personal care workers are the ones with the lowest share of routine tasks and second lowest on manual tasks (after Protective service workers), but highest on the share of interactive tasks and second-highest on Cognitive tasks.

Greater differentiation in MG 4 and 5, in fact, highlighted a higher than average level of routine tasks among Clerks (except Numerical and material recording clerks), as well as Sales and service occupations (excluding Personal care Protective service workers). It somehow supports the ALM thesis considering Clerks to be prevalently routine and service occupations non-routine manual. However, rather than scoring above average on manual, Personal care and protective service workers have the highest share of interactive tasks and below the average of manual tasks (except for Personal service workers in ISCO 08 classification). At the same time, there was little variation with regard to the top routine occupations, which remained composed of occupations from MG 9 (Cleaners and Helpers, Labourers in mining, construction, manufacturing, and Transport, Food preparation Assistants Street and related Sales and Services workers and Refuse workers and Oher Elementary workers), MG 7 (excluding Metal, machinery and related trades workers as well as Electrical and electronic trades workers), and entire MG 8.

In part, this last finding contradicts studies by the economists putting forward the RBTC hypothesis. In their framework (ALM for the US or Goos and Manning for 15 European countries), Clerical workers and Crafts and Related trades workers are considered “middling” in terms of earnings, and most routine intensive occupations, as discussed earlier. In the present analysis, in line with findings by Fernandez-Macias and Hurley (2016), middling occupations are not necessarily the most routine intense, while this is true for less-skilled and lower-paid Elementary occupations from the MG 9. Moreover, in the classification of ALM, occupations from MG 9 are considered intense in non-routine manual tasks, while here, they demonstrate a high level of intensity in both routine and manual tasks.

On the other hand, using EWCS 2010, Fernandez-Macias and Hurley (2016) strongly (and in part rightly) argue regarding comparatively high routine intensity among low skilled Elementary occupations, which are found at the bottom of skill and earnings distribution. However, they appear to underestimate somehow the still substantial level of routine intensity among low and mid-skilled industrial occupations. As they point out, based on their findings identifying Elementary occupations as most routine, routinization should then have a similar to SBTC effect, causing a decline in the employment share of low-skilled and low-paid routine intense occupations at the bottom. However, the presented evidence illustrates that routine-intense industrial occupations were found not only at the bottom but also in the middle of the skill and wage hierarchy. Hence, the decline of routine occupations might not necessarily lead to SBTC.

Ranking occupations on each of the indexes (Figures B.17 and B.18), it can be clearly seen that there is a strong negative correlation between routine and cognitive (-0.8), manual and cognitive (-0.8), and manual and interactive indexes (-0.7); a strong positive correlation between routine and manual indexes (0.9).

The more routine the occupation is, the more intense it is in manual tasks and less intense in cognitive and generally interactive, even though some occupations are exceptions to this rule. While the vast majority of occupations are indeed located in two diagonal quadrants, several occupations stand out. Clerical occupations intense in routine tasks are, as expected, intense in cognitive tasks but are also above average in interactive task content, especially for Customer service clerks. Similarly, Personal service workers (51), Sales workers (52), Food preparation assistants (94) and Street and related sales and service workers (95) are intense in both routine and interactive tasks. While the first two ranked around average on manual tasks, the latter two are intense in these tasks. Adding a distinct interactive dimension allows, thus, to better define the content of occupation and possibly better clarify its specific relation with technology and impact on employment. The level of interactive tasks in occupation is, in fact, represents an obstacle to automation, a “bottleneck”. Still, it appears that “interactivity” is not an obstacle per se but rather that the entire occupation content should be considered. For instance, we might expect that sales workers (e.g. Cashiers with high routine and interactive intensity) can be more easily substituted by

automation than Personal care workers. This is, in fact, what we are witnessing today with the expansion of self-checkouts or the emerging trend of cashier-less stores.

Additionally, updated ISCO08 classification with a greater number of occupational sub-major groups allows for detecting more substantial within-group variation. Among elementary occupations, Cleaners and Helpers (91), Labourers in Mining, Construction, Manufacturing and Transport (93), Agricultural, Forestry and Fishery Labourers (92), and Refuse Workers and Other Elementary occupations (96) have a high share of routine and manual tasks, and low of interactive tasks. On the other hand, Food preparation assistants (94) and Street and Related Sales and Service Workers (95) show above the average level of interactive tasks while being very similar to the entire group values of routine and manual. Personal Service workers (51), Sales workers (52) and Customer Service Clerks (42) remained among the most intense occupations on the interactive dimension, below average on manual (except Service workers, which slightly exceeds the average), and above average on routine. Personal care workers (53) and Protective Service workers (54), instead, demonstrate below the average scores on routine and manual dimensions and mid- (54) to high (53) on interactive.

Furthermore, larger variation emerges among Major Occupational groups 7. Separated into a sub-major group, Electrical and Electronic Trades workers (74) stand out with higher cognitive intensity, similar to that of high-skilled Professional and Associate professionals and Technicians groups. It is followed by a sub-major group of Metal, machinery and Related Trades workers (72) with a close to an average share of cognitive routine tasks and Handicraft and Printing workers (73) with the same share of cognitive tasks but much higher routine intensity. Among MG 8, Drivers and mobile plant operators continue to show a distinctively high score on the interactive dimension compared to other occupations of the group while having a very high share of manual tasks and an average of routine.

A number of relevant to the previous research observations emerge from this analysis. Revision of ISCO classification with an increased number of sub-major and minor groups led to larger within-group variation, especially regarding middle and low-skilled service workers. Focusing on the first period, we might have more easily agreed with Fernandez-Macias and Hurley (2017). They point out a high level of routine

intensity in Elementary and service occupations concentrated at the bottom of wage and skill distribution. Their decline is expected, thus, to result in a skill-biased scenario of occupational change with upgrading. However, as discussed before, the " routine " level varies, especially in MG 5. These occupations are not necessarily found at the bottom of the skill-wage distribution, and their share has actually increased compared to the group of Elementary occupations. Similarly, several industrial occupations demonstrate a high share of routine tasks, which is somehow underestimated by Fernandes-Macias and Hurley (2017). Using a more detailed and updated ISCO classification, considering the impact of technological change on the occupational structure seems important for assessing the content of old and newly emerged occupations and the link between task content and earning, especially when one tries to explain the occupational change.

The relation between task composition, earnings and skills

Figures B.19 (for ISCO88) and B.20 (for ISCO08) depict the relationship between the ranks on the Routine scale and Earnings. First of all, the correlation strengths vary between the two across countries. Overall, Spearman's correlation coefficient between the two measures is -0.7 for ISCO88. The relatively low Spearman correlations between around -0.5 to -0.6 characterize Lithuania, Denmark, Greece, Finland, Estonia, Netherlands, Sweden, and Germany; between -0.6 and -0.7, Belgium, Bulgaria, Cyprus, Ireland, France, Norway, Slovakia, Spain, and the UK; and around -0.8 Switzerland, Poland, Austria, Belgium, Italy, Latvia, Slovenia, Hungary, Luxemburg, Portugal and Romania. With respect to the second period of the analysis with updated ISCO08 classification, results look overall similar but allow for assessment to a greater extent of within-group variations. Spearman's correlation between routine and earnings ranking is stronger (-0.8), ranging from -0.7 in Austria, Bulgaria, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Lithuania, Latvia, Poland, Romania and Sweden to -0.9 in the UK.

There is, thus, an overall moderate to the strong negative association between the level of routine and earnings. However, there are some notable exceptions to this rule, which emerge in almost all countries. Particularly, some highly-routine occupations from MG7 and 8 can often be found relatively high on Earnings' ranking (below 15th) compared to other occupations with a similar position on routine ranking (mostly Elementary occupations). This finding requires further investigation of the role

of labour market institutions, as these “outlying” occupations represent, to a large extent, semi or low-skilled manufacturing jobs, where collective bargaining and unionization might still have a significant impact on wage structure (Acemoglu, 2002; Oesch, 2011).

Furthermore, there is less dispersion in earnings among high-skilled non-routine occupations across countries, which increases moving towards the mildly routine and then highly routine occupations. This dispersion becomes particularly evident with a shift to a more detailed ISCO08 classification. For instance, Personal care workers (53) rank only a few positions away from Health professionals (22) and Health and Associate Professionals (32) in terms of routine intensity, which is relatively low. Nevertheless, the latter two are among high paid occupations, while the former is well below the average and close to Elementary occupations in terms of earnings.

Overall, there is a clear negative relationship between the level of routine and earnings. Occupations intense in routine tasks are frequent not only at the bottom (Sales and services Elementary occupations) but also in the middle of the earnings distribution. Indeed, we do find routine intense low-paid occupations at the bottom, as suggested by Fernandez-Macias and Hurley (2017). Still, we should not underestimate the fact that a number of routine-intense industrial occupations are indeed the middle, as in the works of ALM (2003) and Goos and Manning (2009). While these scholars, using the US data, seem to overestimate the prevalence of routine intense occupations in the middle, Fernandez-Macias and Hurley (2017), according to the current analysis results, seem to underestimate it.

Additionally, Service and Shop and Market Service workers (sub-major group 51 and 52) classified as a non-routine manual by ALM, result in being close to average on routine intensity ranking and mostly low-paid, as in ALM. Revision in ISCO MG 5 in ISCO 08 distinguishing between Personal service workers (51), Sales Workers (52), Personal care workers (53), and Protective service workers (54) allows a better illustration of the variation in routine content in this group, where Protective service (54) and Personal care workers (53) rank below average on routine intensity comparing to Sales workers (52) and Service workers (51). Fairly enough, it seems to be much more difficult to automate the tasks of firefighters or health care assistants than cashiers or waiters. In fact, self-service kiosks or automated ordering machines

are becoming a substitute for the latter occupations. Therefore, the task content of sub-major groups 54 and 53 appears closer to non-routine classification, as in ALM. However, while they are classified as non-routine manual in ALM, the present analysis suggests that manual intensity in these occupations is below the average. They, instead, can be better described as non-routine interactive occupations. Based on the previous discussion, the sole level of routine intensity in occupation does not seem to explain entirely the differences in earnings and, thus, requires further investigation on the relation between the earnings and other task categories.

Figures B.21 and B.22 demonstrate correlations for the ranks on the Cognitive scale and Earning across countries. The higher intensity in Cognitive tasks is clearly associated with higher earnings. There is a much stronger linear relation with a Spearman correlation of 0.8 for all countries, ranging from a minimum of 0.7 in Finland, Sweden and Lithuania to 0.9 in Hungary, Slovenia and Romania. Managerial and Professional occupations, Physical and engineering science associate professionals and Other associate professionals from MG 3 rank highest in terms of earnings and cognitive task intensity. Larger variation, weakening correlations in some countries, is evident in the middle of the ranking, where occupations that score high and relatively high on the cognitive scale (e.g. Office and Numerical clerks, Life science and associate professionals, Teaching and associate professionals), are below average on ranking by earnings, whereas some occupations with a lower share of cognitive tasks (71 Extraction and building trades workers, 73 Precision, handicraft craft printing and related trades workers, 81 Stationary plant and related operators) rank higher. It is worth mentioning that occupations from MG 7, except for Other craft and trades related workers (74), are usually found around the average in terms of share of cognitive tasks, which is in line with the usually requested second skill level for these occupations. As an example, workers in these occupations are expected to have technical and practical knowledge and skills to construct buildings, repair and make machinery or equipment, make jewellery, precision instruments, etc., which leads to above-average levels of routineness and manual tasks, but requires understanding and knowledge in the specific field.

As Figure B.23 and Figure B.24 illustrate, the relation between earnings and interactive index is less clear: while the correlation is rather low (0.3) and positive, it follows a curvilinear pattern, as in Fernandez-Macias and Hurley (2017), which is not

surprising taking into consideration that the indexes are identical. Occupations with high intensity in interactive tasks are found both at the top and the bottom of the earnings distribution. The first includes the vast majority of high-skilled occupations. The second – Clerks, Service workers from MG 5, Sales and Service Elementary occupations (sub-major group 91), Drivers and mobile plant operators, and in some cases, Teaching associate professionals (33). Overall, occupations that score low on the interactive scale tend to be lower paid (except for a few industrial occupations as discussed previously), with increasing variation towards the middle and the top with a significant gap between interactively intense high paid occupations (professional and managerial occupations) and low-paid service occupations.

Since the analysis of employment structure change is often assessed by looking at the changes in skill composition, Figures B.25 to B.28 demonstrate the relations between skills level and task content indexes. The correlation between skill level and all four indexes is rather strong: -0.8 with routine and manual, 0.9 with cognitive, and 0.6 with interactive. A higher skill level is strongly positively associated with a higher share of cognitive tasks and, to a lesser extent, interactive tasks, and negatively with the shares of routine and manual tasks. It suggests that the relationship between skill level and task content is stronger than between task content and earnings. Thus, the higher skill level does not necessarily imply higher earnings and depends on the nature of the occupation.

The average correlation between earnings and skills is around 0.8: 0.6 in Estonia, Finland, Sweden; 0.7 in Cyprus, Denmark, Spain, France, Greece, Italy, Lithuania, Norway; and between 0.8-0.9 in Austria, Belgium, Bulgaria, Switzerland, Czech Republic, Germany, Hungary, Ireland, Luxemburg, Latvia, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia and the UK.

As Figures B.29 and B.30 illustrate, higher skills do not necessarily imply higher earnings unless it reaches tertiary education level, which is mostly the case for Managers, Professionals and in some cases, Technicians and Associate Professionals. Possible exceptions from this case are Life science and Health associate professionals (32) and Teaching and Associate professionals (33), where their higher educational level does not always correspond to higher earnings. On the other hand, as discussed previously, earnings in semi-skilled industrial occupations in

MG 7 and 8 with a high share of routine and manual tasks rank higher than expected from their respective skill level. The education level in these occupations is, in fact, very similar to that of the Elementary occupations. Along with labour market institutions' explanation for these divergences, skill specificity and the value of skill specificity in different economies might play a role in explaining these differences, and it will be explored further in this analysis.

Instead, occupations from the MG 5 rank higher on education level (ranking below 20th in ISCO88 and around 25th in ISCO08) but are among the lowest-paid along with Services and sales Elementary occupations. The only exception is the sub-major group of Protective service workers (54), which are largely public service jobs. The pattern is similar for Clerks that rank around the middle or higher on skill distribution (especially Office clerks) but are around the average or, in most cases, below the average on the earnings distribution. Both occupations are quite routine intense, in the first case accompanied by the higher interactive intensity and in the latter cognitive intensity. The routine character of these occupations might, thus, penalize them in terms of earnings and occupational dynamics, especially in the case of Clerks, whose tasks are more susceptible to automation. While interactivity does not seem to “pay” in occupations in MG 5, they are so far harder to automate, which is partially due to the high level of interaction required in these occupations.

Figures B.31 and B.32 illustrate the pattern of occupational change based on the final task intensity index created through PCA. The first tercile is composed of the least routine cognitively and interactively intense occupations, whereas the third – routine and manually intense occupations. While there is certain cross-country variation, it is clear that overall, the occupations with the highest share of decline were those with higher intensity of routine tasks, and especially a combination of routine and manual intensity (Plant and Machine Operators and Assemblers, Elementary occupations). Similarly, there was a noticeable decline among mildly routine and cognitively intense occupations falling into the second tercile (Clerks). Instead, the employment share of cognitively and interactively intense occupations increased in most countries and was accompanied by the expansion of mildly-routine interactive occupations, namely Service and Sales workers of MG 5.

While the decline in routine and manually intense occupations primarily concentrated during the 2003-2010 period, it continued even though weaker during the second period in the majority of the countries. In some countries, there has actually been a very slight growth in occupations intense in routine tasks: in Bulgaria (Metal, machinery and related trades workers 72, and Stationary Pant and Machine operators 81), Romania (Drivers and mobile plant operators 83), Czech Republic (83), Hungary (81, 83), Slovenia (72), Slovakia (81), Latvia (Building and related trades workers 71 and 83), Denmark (81 and 83) and Ireland (71). Apparently, only the countries of Central and Eastern Europe, out of which 4 (Czech Republic, Slovenia, Slovakia and Hungary) had a substantial share of employment in manufacturing and construction, witnessed an increase in the share of routine-intense occupations. The stability and growth of employment in these occupations started to slow down and were particularly undermined by the economic crisis with a growing share of employment in services (Astrov et al., 2021).

Similarly, there has been a substantial decline among intense in routine and cognitive tasks Clerical workers during 2003-2010, which has slowed down during 2011-2018 with some trend of growth for mildly routine and intense in cognitive tasks group of Numerical and material recording clerks. The only exception to the general pattern of a declining share of routine occupations were some occupations from MG5, mainly Personal care workers intense in routine and interactive tasks. Its growth had mostly concentrated during the 2003-2010 period but was also preserved in a number of countries from 2011-to 2018. The share of employment in these occupations increased most in Bulgaria, Spain, Ireland, Portugal, Romania and the UK during the first period and persisted in Romania and Portugal during 2011-2018, joined by Cyprus, Greece and Slovakia.

On the other hand, occupations which share expanded over both periods were primarily high skilled occupations with higher intensity of cognitive and cognitive and interactive tasks, significantly driven by the subgroup of Professionals. During the second period, the growth pattern in these occupations largely persisted across all the countries, albeit the growth slowed down.

With respect to the link between occupational change and task content, this analysis does support the routinization hypothesis, especially evident in the first period

of the analysis. Routine intensity seems to penalise occupations in terms of employment, especially when combined with high intensity in manual tasks and, to a lesser extent, cognitive tasks.

Instead, the intensity of cognitive tasks appears to be crucial in predicting occupational growth, especially in combination with interactive intensity. Similarly, the interactive intensity seems to impede, so far, the decline in lower-skilled and mildly routine service occupations. While an increase in the first group is in line with both RBTC and SBTC theories, growth in the latter is more in line with RBTC predicting expansion of non-routine low skilled occupations. While ALM defines these occupations as non-routine manual, their task content in this analysis slightly differs: occupations from the MG5 can be described as mildly routine and highly interactive (or even non-routine highly interactive in the case of Personal care (53) and Protective service workers (54) in ISCO 08), and from MG9 (Food preparation assistants, Street and related Sales and service workers) – as highly routine and manual. In fact, employment in personal care and services has expanded substantially and is projected to increase further (Cedefop Skills Intelligence Tool). Elementary occupations, on the other hand, have a larger share of tasks exposed to automation, and while their very minor interactivity might create some impediments, advances in robotics and AI might be crucial in determining the dynamics for occupations in this group.

Finally, Figures B.33 and B.34 illustrate occupational change at ISCO 2-digits, considering task complexity/routine intensity and ranking on earnings simultaneously. First, these figures confirm that high-paid least routine and most complex occupations substantially expanded and that in most cases, it was due to an increase in some occupational groups more than others (especially Professionals). Second, mildly routine occupations were the ones that “stretched” more across the ranking scale, being not only in the middle (Clerks) but also at the bottom (Services and Sales workers). Third, the most routine Elementary occupations concentrated mainly at the bottom, but there was some dispersal among some industrial occupations from this group. Taking into consideration these variations, the placement of most routine occupations on the earnings scale was decisive for determining the pattern of occupational change.

From the picture that emerges from the analysis of this section, SBTC appears to operate together with RBTC with the share of high-skilled non-routine occupations that increase, most-routine occupations that tend to decline and mildly routine occupations that either expand or decline depending on whether the routine intensity is combined with a high share of cognitive or interactive tasks. However, whether the interaction between the two processes results in polarisation depends on where these most routine occupations fall in the hierarchy of earnings and whether they are at the bottom. Polarization, thus, does not appear to be as “pervasive” as several influential studies suggested. However, it should be kept in mind that the operationalization of task content in this study and the other studies using US DOT classification differ, and particularly so with respect to the task content of the middle and bottom occupations. If occupations from MG5 didn’t fall in the middle as mildly routine but, instead, at the bottom, as with studies using DOT defining them as non-routine manual, we would have certainly seen polarization in more countries.

Overall, the relations between Cognitive intensity appeared to be crucial in determining higher earnings independently of the extent of interactivity of the occupation. Interactive tasks intensity leads to higher earnings if combined with higher cognitive task intensity, being lower otherwise. Routine and manual intensity, instead, is associated negatively with earnings, with the exception of a number of industrial occupations, for which task content explanation fails. Taking into consideration this exceptionality of industrial occupations and observing rather evident cross-country variation with respect to earnings hierarchy, in particular, the analysis that follows tries to shed light on the role of labour market institutions in occupational change.

3.4.4. Labour market institutions as mediating factors: explaining the patterns of occupational change in Europe

The conducted analysis demonstrates that contrary to expectations of convergence across European labour markets under the impact of technology, we are still witnessing significant variations in the patterns of occupational change. While on the one hand, it might be a result of the differences in supply factors specificity (educational composition and migration), on the other hand - country institutional characteristics, and especially their variety in the European context, can be expected

to play a significant role in determining these patterns. In fact, a large number of studies dedicated significant attention to assessing the impact of specific labour market institutions on labour market dynamics, especially in the aftermath of the economic crisis and recession followed by a period of labour market reforms. For instance, a large volume of economic literature focused on the impact of employment protection legislation (EPL) on employment and unemployment (Blanchard & Wolfers, 2000; Boeri & Jimeno, 2005; Scarpetta, 1996). Similarly, the role of trade unions in attaining more generous social policies, protection or equal pay was underlined (Korpi, 1983; Kristal & Cohen, 2015; Kollemeyer, 2017).

The following analysis aims to contribute to the literature in several ways. First of all, it tries to assess the impact of labour market institutions on occupational change rather than employment/unemployment dynamics in general. While there have been only a few studies linking occupational change and labour market institutions covering a limited number of countries from different "institutional families'" (Oesch 2013,2015, Fernandez-Macias, 2012), the findings do point out the possible important role of labour market institutions in mediating the impact of technological change. The present analysis contributes to the literature by expanding the number of countries and covering different combinations of institutional characteristics while considering the specific country patterns of occupational change. It includes Central and Eastern European countries in the analysis, which were largely ignored by previous literature. Secondly, the study extends the period of analysis, allowing to trace occupational change dynamics in the longer term, capturing the period before, during and after the economic downturn. Thirdly, taking into consideration labour market institutions "reform activism" in European countries following the Economic crisis (Turrini et al., 2015), it allows shedding light on whether it brought a larger convergence among countries from different institutional families. Last but not least, it tries to understand whether there is an association between specific labour market institutions and occupational change through a regression analysis, focusing in particular on their role in preventing routinization and decline in the middle.

Occupational change, labour supply and institutional arrangements: preliminary evidence

In line with previously discussed possible explanations for divergent occupational change patterns, Figure 35 demonstrates occupational dynamics change across time and different European regime types. What emerges from these graphs is a similarity of trends between countries within the same group and broader differences among institutional families, especially regarding employment in low skilled occupations.

What can possibly explain the divergences in occupational change patterns, considering that all the countries were influenced by technological change and globalization? Below, we will try to provide an explanation that takes into consideration supply factors, as well as labour market institutions. Based on the literature review, the present analysis focuses on assessing the role of Employment Protection Legislation, union density, wage bargaining coverage, replacement ratio and minimum wage institutions on change in employment patterns in different country groups.

A large amount of literature suggests a significant role played by the trade unions in reducing inequalities and the risk of poverty, ensuring stronger job protection and generosity of social benefits (Korpi,1983; Biegert, 2017). Labour unions were also found to be strengthening workers' power in the context of technological change and routinization, lowering demand for routine-intensive tasks (Kristal & Cohen, 2015), and ensuring growth in earnings relative to other occupations in the US (Parolin, 2019). Figure B.36 demonstrates how the union density rate has changed during the past 15 years. While it stayed relatively stable in some countries (e.g. Belgium, Norway), most countries experienced a ranging from mid to substantial decline.

Many studies have pointed out the role of EPL on employment dynamics. Strict regular EPL has been associated with a higher long-term unemployment rate, a more advantageous position of prime-age men in the labour market, labour market segmentation, and difficulty adapting to structural changes (Blanchard & Wolfers, 2000; Bentolila & Bertola, 1999; Eichhorst and Marx, 2011; Boeri 2011). Many European countries turned to reform their employment protection legislation, initially driven by the aim of fighting high unemployment existing in the EU countries. More recently, the importance of reforms was underlined in order to tackle the problem of

labour market segmentation with strongly protected “insiders” and “outsiders” (Eichhorst & Marx, 2011; Häusermann & Schwander, 2010).

In line with SBTC, relative employment shares in high skilled occupations had grown everywhere and exceeded 5% in most countries, with slight negative dynamics only in Bulgaria, Slovakia and Greece. Overall, countries from Nordic, Baltic and Conservative groups and the UK experienced a substantial increase, while the growth was modest in post-communist Central European countries and Southern Europe. However, rates of employment share growth among high skilled in Poland and Slovenia in the former group and Portugal in the latter substantially exceeded the rates of other countries within these groups. It is worth pointing out that while the share of employment in this group was already relatively high in Slovenia, Poland, and Portugal's increase departed from the lowest compared to other countries’ levels.

As discussed previously, educational expansion across the continent and an increase in the supply of tertiary-educated was an important driver in increasing the share of high-skilled jobs. As Figure B.37 illustrates, the share of the population with only lower than the primary, primary and lower secondary levels of education decreased in almost all the countries, and with the exception of Southern European countries, it accounts for only 20% of the population or less. Instead, the share of tertiary educated increased very substantially and, in many cases, doubled, allowing for an upgrading of occupational structure provided there was enough demand to absorb this supply.

On the other hand, there is also confirmation of a declining share of occupations in the middle, namely Crafts and trades workers (MG 7) and Plant and machine operators (MG8). As it has been widely discussed in the literature, technological change and consequent routinization, along with competition with low-cost producing countries, appear to be the main drivers of this widespread trend affecting, particularly, the manufacturing sector. A recent study by Bruegel found that installing one robot per thousand workers contributed to a 0.16-0.20 decline in the employment rate (Chiacchio et al., 2018). This finding is similar to the identified by Acemoglu and Restrepo 0.2 decline in employment to population ratio in the US accompanied by a 0.42% drop in wages (Acemoglu & Restrepo, 2020). While it is difficult to detect whether specific institutions in European countries are able to slow down this process, they might have

a crucial role in preventing the wage decline of employed in these occupations. In fact, while Chiacchio et al. (2017) found a displacement effect, they didn't find a robust confirmation concerning the impact of robot adoption on wages.

Larger within and across-group differences are noticeable for the low-skilled Elementary and service occupations. While there had been a general tendency toward growth both in relative and absolute terms, the growth rate varied. It is worth mentioning that in this analysis, the group is composed of ISCO MG 5 and ISCO MG 9, making the eventual trend combination of different dynamics in the two Major occupational groups. Generally, the increase was driven by a growing share of employment in MG 5 Service and sales workers, whose position in terms of earnings ranged from the 3rd to 5th quintile. As suggested by Oesch, jobs at the bottom segment of the labour market are most influenced by wage-setting institutions, which contributes to greater divergences across countries: the lower is the bottom's quintile median wage compared to the workforce's median wage – the fewer impediments there are for expansion if these jobs (Oesch, 2013). The minimum wage establishing the cost of labour at the bottom, thus, may influence its demand (Oesch, 2013).

While the role of supply factors appears to be crucial, the impact of labour market institutions in moderating technological change leading to the variation in the patterns of occupational change can not be ignored. In trying to explain these divergences, the analysis that follows combines the labour supply and institutional explanations attempting to shed light on the causes of these differences within and across institutional families.

Nordic countries, Benelux countries, Switzerland, UK, Germany and Ireland were the ten countries with the highest relative share of employment in high-skilled occupations in 2003. By 2019 Germany and Ireland lost their positions to Estonia and France, which gained an 8% increase in employment share in these occupations. The growth in high-skilled occupation was strong also in absolute terms: the number of professionals almost doubled in Luxemburg, Norway, UK and Denmark and increased substantially in the Netherlands, France, Finland and to a lesser extent Ireland; and in the UK, Ireland, Finland, France, Sweden and Luxemburg it was accompanied by an increase in the number of Associate professionals and Technicians. What is peculiar

to these countries with a significant share of high-skilled workers reaching around half of the total employment?

First of all, they are distinguished by a high level of tertiary education attainment across all age groups (except young people in Germany). Between 30-40% of 55-69 and 40-50% of the 35-54 years old population obtained tertiary education in Nordic and Benelux countries and Ireland, UK, Estonia, and Switzerland. In comparison, the rate was below 20% for the first age group and below 30% for the second in CEE countries (except Poland and Slovenia, where around 30% of 35-54 years old obtained tertiary education), Italy, Portugal and Romania.

These countries spent more on education as a percentage of GDP, including tertiary education, and it was above 5% in Nordic countries and slightly less in Benelux countries. Investments in R&D in these countries were also the highest, with the exception of Luxemburg with a decline towards the end of the period. In fact, these countries were at the forefront of IT adoption and already had a high share of IT capital in the mid-1990s (World Economic Forum, 2018). In particular, Scandinavian countries were at the “forefront of new technologies adoption and innovations” and are distinguished for their high level of ICT literacy (Fagerberg & Fosaas, 2014).

The situation has been slightly different for the countries of Central and Eastern Europe and Southern Europe. As we recall from the previous discussion, the economic history of CEE and Baltic countries diverged substantially from other EU members. In the 1990s, a substantial amount of jobs created in state-owned Soviet-era industries were destroyed due to inefficiency and lack of competition. This period was followed by deindustrialisation between 1990-1995 and re-industrialisation from 1995s to 2008s leading to strong economic growth, boosted by increasing FDI in the region, technology importation and trade expansion on the one hand, and cheap and skilled labour on the other (Naude et al., 2019). Following the EU accession, the growth has been particularly unprecedented in Baltic states, so-called “Baltic tigers”, boosted similar to other CEE countries by FDI. The economic crisis hit them the hardest, but the recovery was rather fast. Compared to the rest of Europe, while western EU countries were deindustrialising, CEE countries were still in the process of industrialisation.

Following the economic crisis and FDI decline, “home-grown innovation” had not replaced technology importation, which, combined with tightening labour markets

due to demographic structure and emigration leading to labour shortages, impeded private investments and economic growth (European Investment Bank, 2019). Even though the growth resumed following the crisis, it significantly slowed down. The countries of the region experienced continuous emigration since the accession into the EU, which further accelerated following the economic crisis (OECD 2013; European Investment Bank 2019;). During the 2000s, Lithuania lost the highest share of its population (-13%), followed by Latvia (9%) and Estonia (6%) (OECD 2013). The extremely pressing problem of the declining population was further aggravated because those emigrating were mostly young and highly educated people, especially so in Lithuania and Latvia (OECD 2013).

The share of the population with tertiary education has increased and almost doubled between 2003 and 2019. While in most of the CEE countries, it was largely due to an increasing level of education among young people, the tertiary education attainment level in Estonia was high for the 55-64 years old group as well, close to the indicators of Nordic countries (Figure B.38). Furthermore, while the level of tertiary education attainment had been growing up until 2010-2013, the number of graduates declined in CEE countries afterwards, most in Lithuania and Slovakia and to a lesser extent in Poland and Slovenia.

Analysing the relative employment share dynamics in these countries, it might be said that they were “catching up”, generally departing from 32-35% employment share among high skilled occupations at the beginning of the period. Somehow weaker compared to other countries' growth can be explained by still high importance of manufacturing (less so for Romania and Bulgaria), the delayed process of tertiary educational expansion, low level of participation in lifelong learning and labour shortage (Naude et al. 2019; Astrov, 2021). The supply of workers remains insufficient to satisfy the demand, and shortage occupations overwhelmingly require higher education (Astrov, 2021). While in relative terms the share of high skilled occupations has increased during the 2003-2018 period, the growth in absolute terms was very modest and mostly driven by the group of Professionals, with instead declining share among the group of Managers and Associate professionals and Technicians in Lithuania and Latvia. Skill shortage and lack of investment in research are among the factors threatening most to undermine what has been achieved in economic growth and lock these countries in the middle-income trap (IMF 2016; McKinsey 2013).

Southern countries (except Italy) have undergone through similar changes, but earlier in time. While Italy had been experiencing strong economic growth following the II World War, the political regime changed in Greece, Spain and Portugal moving from dictatorship to democracy in the 1970s, leading to increased economic openness. With the accession to the EU, Manufacturing exports from Portugal and Spain grew rapidly, boosted by inward investments providing technology and capital and facilitated by access to European markets and low cost of production (Royo, 2007). This had not happened in Greece, where overregulation of the economy and lack of bureaucratic transparency prevented investments leading to low economic growth (Neubaumer, 2015). Only with accession to EMU did Greece experience stronger GDP growth between 2000-2007. However, it was driven by high capital inflows from European countries directed towards the housing sector, with only a minor increase in production capacities and the necessity to import to satisfy country demand (Neubaumer, 2015). The perspectives of the EU enlargement to the East and decline of competitiveness were considered among the reasons causing the decline of FDI in the late 1990s, which, coupled with the “China shock”, led to the decline of the industrial sector and slow expansion of service sector (Branstetter et al., 2014; Martin & Turrin, 2003).

As for Southern European countries, both demand and supply factors explain a lower share of employment and slower growth in high skilled occupations. The diffusion of IT was low compared to other European countries, so was productivity brought down by inefficient management practices reducing the demand for high-skilled workers (Schivardi & Schmitz 2019). The industries in Italy, Portugal and Spain remain prevalently specialized in low-skill and low-tech activities (Teixeira, 2001). On the other hand, these countries (with the exception of Spain) have been lagging behind in terms of tertiary education attainment levels. The share of the population with above than lower secondary level of education in these countries was the lowest, reaching 52% in Italy, 61% in Portugal, 62% in Spain and 77% in Greece in 2019. While there had been an increase compared to the beginning of the period – 26% in Italy, 49% in Portugal, 50% in Spain and 60% in Greece in 2005 – they were still below an EU 2019 average of 78%.

Educational attainment level has been particularly low in Portugal, with more than half of adults (52%) having lower than upper secondary education in 2018, significantly above the 22.5% EU average. Tertiary attainment level was higher among

young people (25-34). It reached 35% in 2018 from 23% in 2008 and was more than two times higher than that of the 55-64 years old rate of 14% (OECD 2019). Employment share in high-skilled occupations has been expanding during the entire 2003-2018 period, both in relative and absolute terms. The increase in relative share in these occupations has been steepest compared to other countries, with around +10% expansion, while in absolute terms largest contribution has been made by Professionals whose employment more than doubled between 2008 and 2019. While the situation was slightly better in Spain and Italy, the share of low-educated remained high among the middle and older-aged population, and, peculiarly to these two countries and Portugal – also among youth.

While this analysis confirms the expansion of higher-skilled and paid occupations, it also points out divergences and their possible causes. Investments in R&D as well as education and training, and supply-side factors, namely educated labour, appear to be crucial for upgrading occupational structure. The experience of Southern European and Central and Eastern European countries demonstrates that educational expansion alone does not necessarily lead to strong growth among high skilled occupations and highlights the importance of reinforcing a greater match between demand and supply factors.

Slightly in contrast to diverging trends among high-skilled occupations, decline among Crafts, trades, plant and machine operators group was universal. Still, once again, there were differences in the pace and the extent of the decline across country groups and, in some cases, within these groups. The strongest decline took place in Southern European countries, the countries with the highest share of employment in these occupations at the beginning of the period, and Ireland, all strongly hit by the economic crisis.

The gradual decline was evident in the group of Conservative countries, accelerated in the period after the economic crisis in all countries except Austria and Belgium. It slowed down around 2012 in all the countries of the group except Switzerland, where it continued to decline. Similarly, the employment share of middle-skilled declined most following the crisis in Nordic countries, except Denmark, where it was evident even in the pre-crisis period, with an overall stronger decline compared to the entire group.

As for Post-communist and Post-soviet countries, the employment share of this group was either growing or stable before the crisis. Afterwards, a gradual decline occurred in the former group, with further recovery to the pre-crisis level in the case of Hungary and Poland. The drop in employment share after the crisis was very drastic among the Baltic states, with only slight gains between 2010-2013 and a continuous decline afterwards.

The peculiarity of these two groups of countries consists in still comparatively high relative employment share in the middle of occupational structure and low at the bottom, with the exception of a few countries. As discussed previously, employment in the middle remains relatively high due to the importance of the manufacturing sector, particularly the automotive industry (McKinsey 2013). Nevertheless, employment in these occupations in absolute terms is declining, driven especially by the group of Crafts and trades workers – the trend which is in line with the rest of the EU.

Considering the universality of relative employment share decline among these occupations, technological change and offshoring seems to confirm their main role in this process. Trade unions, with their declining density going on for decades (Figure B.36), were apparently not able to slow down this job destruction process but rather protect their members from wage decline.

Labour unions were found to strengthen workers' power in the context of technological change and routinization, lowering demand for routine-intensive tasks (Kristal and Cohen, 2015) and ensuring growth in earnings relative to other occupations in the US (Parolin, 2019). Their position, however, seems to be undermined by technological change itself (Biegert, 2017; Kristal and Cohen, 2017).

Peculiarly, trade union density and bargaining coverage were actually at their lowest levels in the CEE countries (with the exception of Slovenia) compared to the UK and Ireland. Still, the share of employment in these middle-skilled and middle-earning occupations was the highest. At the beginning of the period, trade union density exceeded 40% only in Slovenia, falling below 25% by 2018 across these countries. The reason for such a low union density has its historical roots. Up to the 1990s, there was generally one union with compulsory membership, whose primary role consisted of implementing national policies, being a transmission belt for the party's policies.

Afterwards, a steep decline in union density occurred following a change from compulsory to voluntary membership, further accelerated by the economic crisis. In most of the CEE countries, collective agreements are decentralised and take place predominantly at the enterprise or individual level, with the sole exception of Slovenia with a major role at the sectoral level, Slovakia and, to some extent, Hungary with a mixed system (van Gyes et al., 2007). With respect to their function, Magda (2017) concludes that, overall, trade unions had succeeded in protecting their members following the crisis of 2008 and that medium and high skilled workers do benefit from collective bargaining, ensuring their higher wages.

While protecting their constituencies, trade unions, on the other side, contribute to labour market dualisation, leading to an increasing number of workers in a precarious situation (Hassel, 2014; Palier & Thelen, 2010). The period before and after the crisis was characterized by the implementation of reforms aimed at further relaxation of legislation, especially for temporary contracts, thus reinforcing labour market segmentation. As discussed earlier, the number of workers with fixed-term contracts has generally increased across the continent.

As Figure B.39 illustrates, EPL for regular contracts was relaxed in many countries, whereas the evidence for temporary contracts was mixed. Among Nordic countries, EPL for regular contracts was relaxed only in Finland, while it was strengthened in Denmark, still having the lowest index among this group of countries. At the same time, EPL for temporary contracts in Demark was made stricter while being liberalized in Norway and, particularly, Sweden. Within the group, the index of EPL for temporary contracts was the laxest for Sweden and Denmark and the strictest for regular contracts in Sweden.

Among the group of conservative countries, EPL for both types of contracts remained intact in Austria, Luxemburg and Switzerland and for regular contracts only in Germany. EPL for regular contracts was liberalized in France and re-regulated in Netherlands and Belgium, whereas it was strengthened for temporary contracts only in the Netherlands. Within the group, but also in a cross-country perspective, the index for EPL for regular contracts was the highest in France, the Netherlands and Germany, and temporary contracts in France and Luxemburg.

The regulation concerning EPL in CEE countries in the 1990s was rather restrictive compared to the average OECD level, close to the EU 15 level. However, this has changed during the pre-accession period following the employers' criticism pointing out strict regulation as an impediment to competition in goods and services (Nesporova, 2002). Thus, there was a tendency toward liberalization of EPL, even though with visible differences across the group's countries, particularly with regard to the regulation of temporary employment. The Czech Republic and Latvia were the countries with the most restrictive regulation for permanent contracts, followed by Slovakia, Poland, Lithuania and Slovenia. In contrast, EPL in Hungary and Estonia was least restrictive, similar to Anglo-Saxon countries. The picture is different regarding temporary contracts, where the regulation was most liberalized in the Czech Republic, Poland and Hungary at the beginning of the period and re-regulated in Estonia and Slovakia by the end of the period.

The index of EPL for both types of contacts was the highest for Southern European countries (less so for Spain). Following the financial crisis, all the countries liberalized EPL for both types of contracts. Compared to other countries, EPL for regular contracts remained relatively strict in all the countries but Spain, while for temporary contracts – in all countries but Italy (as for 2018 data).

Since laxer EPL facilitates the creation of jobs in lower-paid segments of the labour market, we might expect it to be related to the creation of jobs at the bottom of the employment structure, thus leading to polarization.

In fact, divergences both across and within-country groups are more evident for Elementary and service workers. There was a slight growth in these occupations among post-communist countries (except Bulgaria), countries from the conservative group (except Switzerland), and a strong growth among Southern countries (except Portugal). Instead, trends of decline emerged among Nordic countries (except Denmark), Post-soviet countries, where low-skilled employment shares fluctuated but declined compared to the beginning of the period, and somehow surprisingly, in Liberal UK (after 2015) while remaining persistently high in Ireland.

It is important to remind that Service and elementary workers are brought together in this analysis, meaning that the final result might be driven by stronger dynamics of the decline/increase of one specific group, as discussed in the analysis at

ISCO MG. The growth was mostly driven by Protective and service workers, which were found in the lowest quintiles of employment distribution by earnings. In line with Oesch (2013), this might indicate the specific role of wage-setting institutions in regulating job creation at the bottom. Moreover, most studies point to the negative impact of minimum wage on job creation, especially for low skilled workers (Neumark & Wasche, 2006).

With respect to minimum wage, all the CEE countries with an overall relatively low share of employment in low-paid occupations at the beginning of the period have established minimum wages since 1990. According to the OECD data (Figure B.40), minimum wages were at the lowest level with respect to mean wage in the Czech Republic (0.36), Estonia (0.37), Hungary and Slovakia (0.39); and with respect to median wage in the Czech Republic (0.41), Estonia (0.43), and Slovakia (0.49). It was, instead, highest within the group in Slovenia and Romania (0.58), and Poland, Lithuania and Latvia (0.51). If set high, as discussed previously, the minimum wage is expected to negatively affect job creation at the bottom of the occupational structure. This, however, does not seem to be entirely confirmed as the share of employment at the bottom expanded in Lithuania, Latvia and Romania and declined in Estonia and Poland.

Within the conservative group and in a cross-country comparison, France stood as the country with the highest minimum wage relative to median earnings, followed by Luxemburg (0.54), Germany, Netherlands and Belgium (around 0.47), whereas there was no statutory minimum wage in Austria. Employment in low-paid quintiles increased in all four countries, especially in the first 2003-2010 period. While during the first period, it concentrated in many cases at the bottom and lower-bottom quintile, during 2011-2018, low-paid occupations had grown in Austria, Belgium and Switzerland (in quintile 2), France and Luxemburg (quintile 1) with no growth in Germany and Netherlands. With a comparatively higher level of minimum wage within the group, France was the clearest example of polarizing tendencies with growth both at the top and the bottom.

Among Southern countries, the only country without minimum wage was, and remains, Italy. While it was set high in Portugal, it was among the lowest in Spain and Portugal from a cross-country perspective. This group of countries was the only one

where the share of employment in low-paid occupations expanded significantly, with stronger growth between 2003-2010. While it is difficult to detect these dynamics in quintile analysis where different occupations are often merged into one quintile, it is clearly visible looking at the occupational change at the level of Major ISCO groups. It, thus, appears that the minimum wage in this group of countries was not able to prevent the job growth at the bottom.

It is important to keep in mind that in some countries, including those not having a statutory minimum wage, collectively-agreed wage floors for specific sectors and occupations might be in place, affecting job creation at the bottom in a similar to a minimum wages way (Oesch, 2010).

The impact of collective bargaining coverage on the creation of low-paid jobs is difficult to establish. There has been a limited increase in employment share in Elementary and service occupations during the first period in the Nordic countries with high union density and collective bargaining coverage. The growth in the first period was followed by a decline in the second, with the exception of Denmark. However, we should also keep in mind that the level of EPL for both regular and temporary contracts in this county was the lowest in the group and overall.

Employment in low-paid occupations increased most in Southern countries with a higher level of collective bargaining coverage and lower union density, and this growth occurred at the bottom of the occupational structure. The increase was particularly high in Greece, where the level of bargaining coverage plummeted from around 100% to 25% following the economic crisis and adjustments. In the case of these countries, neither collective bargaining nor comparatively stricter EPL for regular and temporary contracts or minimum wage has succeeded in preventing the growth at the bottom.

As for the group of Conservative countries, the growth between 2003 and 2018 was highest in France and Netherlands, followed by Austria, Belgium, Germany and Switzerland. Austria, Belgium, France and Netherlands were characterized by a high level of bargaining coverage (between 75%-100%), while it was weaker in Germany and Switzerland (50-75%). Trade union density remained relatively high only in Belgium and declined to around 25% in the rest. Employment growth in low-skilled occupations was more limited in Germany and Switzerland, with a comparatively lower

level of union density, bargaining coverage and EPL for temporary contracts, and in the case of Switzerland, also for regular contracts.

Among the Liberal group countries, the employment at the bottom increased in both during the first period and Ireland during the second. The level of collective bargaining and union density was low in both, similar to the CEE countries' level. EPL for regular and temporary contracts was the weakest in cross-country comparison, even though it was slightly re-regulated, whereas the minimum wage was among the lowest in Ireland and above 50% of the median wage in the UK. Most literature on occupational change characterized these two countries as polarized ones. And while it is true for the first period, there was a visible trend of decline among Elementary and Service occupations in the UK since approximately 2015, becoming more drastic after 2017 and close to flattening in Ireland. While the discussed here labour market institutions have undergone very slight changes, one probable explanation for what happened in the UK might be the supply factor, namely the decline of immigrant labour. The issue of severe labour shortage, particularly in low-skilled jobs in the service sector and agriculture that immigrants previously filled, has been a serious concern in the UK following Brexit.

There has almost been no employment growth in low-skilled occupations in CEE countries during the first period, except in Bulgaria. During the second period, Bulgaria was joined by Lithuania, Slovakia, Hungary, Croatia., The growth was concentrated in the bottom quintile in Bulgaria and Hungary and the two lower quintiles in Lithuania and Slovakia. In Slovenia and the Czech Republic, very slight growth occurred in the lower-middle quintile. With the exception of Slovenia, all the CEE countries had a low level of bargaining coverage and union density. On average, the minimum wage was around 50% of the median in most countries and around 40% in the Czech Republic and Estonia. EPL for temporary contracts was strictest in Estonia and Slovakia and laxest in Latvia, Lithuania, Hungary and the Czech Republic. These institutional arrangements seem to be pertinent in explaining the downgrading in Hungary and partially Latvia, but they are not sufficient for understanding the different dynamics in polarizing Lithuania, Slovenia and upgrading Poland, which were close on all the indicators. Similarly, all being equal, with stricter EPL on regular and temporary contracts in Slovakia, we could have expected lower expansion at the bottom, whereas in reality, the occupational structure in the country was strongly downgrading.

As it is evident from the analysis, it appears to be somehow difficult to establish the clear role of labour market institution/institution. First of all, even within the same group, different "constellations" of labour market institutions emerge, making it impossible to reduce their impact to only one dimension. Second, the indexes describing these institutions were not constant, or quite the opposite; institutional change has been in place, especially following the economic crisis.

Following this initial exploratory analysis, we try to go beyond descriptive analysis and test whether there is an association between the labour market institutions and changes in employment shares of specific occupational groups. Since there has been a widely diffused increase in the share of high-skilled/high-paid occupations, we focus on the groups with larger variation across countries, namely: medium-skilled and most routine occupations reflecting the extent of the "hollowing out" in the middle. We do not test the association between low-paid/low-skilled occupations and labour market institutions since the same institutions keep a substantial share of low-skilled out of the labour market. The implications of these institutions for a change in the share of relative employment are, thus, not straightforward. Testing the association between medium-skilled and most-routine occupations and labour market institutions, instead, should allow us to understand better whether the latter were able to slow down the impact of technological change and routinization in particular. As discussed previously, certain institutional configurations, e.g. strict EPL, could protect "insiders" or workers in highly unionized industrial occupations.

The following models are estimated:

1) *MedSkilled*=$\beta 1 Adjcov + \beta 2 Unden + \beta 3 BargLev + \beta 4 EPLreg + \beta 5 EPLcoldis + \beta 6 EPLtemp + \beta 7 GDPgr + \beta 8 HumREsST + \beta 9 RD + i.year + \varepsilon$

2) *MostRout*=$\beta 1 Adjcov + \beta 2 Unden + \beta 3 BargLev + \beta 4 EPLreg + \beta 5 EPLcoldis + \beta 6 EPLtemp + \beta 7 GDPgr + \beta 8 HumREsST + \beta 9 RD + i.year + \varepsilon$

Where the dependent variable is the share of employment in medium-skilled occupations (1) and most-routine occupations (2), regressed on: the extent of Adjusted bargaining coverage, union density, the predominant level at which wage bargaining occurs, including (Local or company, Intermediate or alternating between the sector

and company bargaining, Sector or industry, Intermediate or alternating between central and industry, Central or cross-industry), Employment protection legislation for regular and temporary contracts as well as collective dismissals, while controlling for GDP growth, Share of human resources in science and technology and share of investments in Research & Development. The regression includes time fixed effects, and standard errors are clustered at the country level.

Tables 1 and 2 below report the results with a number of specifications. First, the results of pooled OLS with clustered SE at a country level with variables of wage-setting institutions, employment protection legislation are presented, followed by two full models including control variables. These last models include time-fixed effects with SE clustered at a country level. One of the first things we can point out is a gradual increase in explanatory power R2 through different specifications as we move towards the full model, meaning institutional variables do possess explanatory power associated with changes in employment dynamics.

TABLE 1: Change in the share of Middle-skilled occupations				
VARIABLES	1	2	3	4
Union density	-0.112***		-0.0271	-0.00391
	(0.0381)		(0.0261)	(0.0320)
Bargining coverage	-0.0284		-0.101**	-0.111***
	(0.0399)		(0.0408)	(0.0391)
EPLreg		3.244*	3.218**	3.008**
		(1.672)	(1.315)	(1.257)
EPLcoldis		2.076**	2.680***	2.536***
		(0.981)	(0.583)	(0.627)
EPLtemp		-1.296	0.168	0.388
		(1.239)	(0.635)	(0.668)
GDP growth			0.0871	0.0548
			(0.100)	(0.134)
Human resources in Science and Technology			-0.543***	-0.455***
			(0.0816)	(0.0917)
Investments in R&D			2.028**	2.328**
			(0.740)	(0.861)
Time fixed effects	NO	NO	NO	YES
Constant	36.87***	19.88***	35.21***	36.70***
	(2.698)	(4.228)	(3.697)	(3.983)
Observations	310	310	310	310
R-squared	0.194	0.169	0.622	0.796

TABLE 2: Change in the share of Most-routine intense occupations						
VARIABLES	1	2	3	4	5	6
Union density	-0.156**	-0.155**		0.0110	0.0365	0.0569*
	(0.0572)	(0.0578)		(0.0311)	(0.0333)	(0.0303)
Bargaining coverage		-0.0260				-0.0936***
		(0.0514)				(0.0333)
Intermediate/alternating sector and company	-1.420			-3.392*	-2.978	
	(3.850)			(1.842)	(1.958)	
Sector or industry	-3.370			-6.947***	-6.180***	
	(3.833)			(2.109)	(2.165)	
Intermediate/alternating central and industry	-1.599			-6.830**	-6.030**	
	(4.801)			(2.834)	(2.555)	
Central or cross-industry	-0.238			-7.964***	-7.139***	
	(3.647)			(2.452)	(2.441)	
EPLreg			2.936	2.339***	2.421**	2.287**
			(1.997)	(0.836)	(0.932)	(0.996)
EPLcoldis			-0.141	0.514	0.585	0.435
			(1.304)	(0.775)	(0.771)	(0.743)
EPLtemp			1.095	2.437***	2.248***	2.351***
			(1.744)	(0.660)	(0.561)	(0.701)
GDP growth				0.117	0.162	0.166
				(0.0792)	(0.160)	(0.127)
Human resources in Science and Technology				-0.691***	-0.768***	-0.785***
				(0.0853)	(0.0880)	(0.0848)
Investments in R&D				1.385	-1.071	0.798
				(0.902)	(0.795)	(0.943)
Time-fixed effects	NO	NO	NO	NO	YES	YES
Constant	31.58***	31.04***	16.49***	38.40***	37.28***	39.75***
	(2.955)	(2.865)	(5.399)	(5.194)	(5.328)	(5.573)
Observations	310	310	310	310	310	310
R-squared	0.261	0.229	0.119	0.746	0.797	0.790

As suggested by Hypothesis 1, there is a strong and positive association between the EPL for regular contracts and EPL for collective dismissals and share of employment in middle-skilled occupations. Their effect remains strong and positive across different specifications, including the final one controlling for other factors, meaning that a 1-point increase in the degree of EPL for regular contracts results in an increase in the share of middle-skilled occupations by 3 percentage points, whereas that of EPL for collective dismissals – by 2.5. Higher strictness of regulation of regular contracts and collective dismissals thus appear to restrain the "hollowing out" process in the middle.

On the other hand, we do not find evidence of a strong positive effect of wage-setting institutions on the share of employment in medium-skilled occupations. The association with union density is not significant, while that with bargaining coverage is significant and negative but small. The impact of trade union density could be limited due to the continuous trend of de-unionization that has been going on since the 1970s, weakening the power of the unions. The small negative association that emerged between the extent of collective bargaining coverage and the share of employment in the middle might be possibly explained by trade unions' orientation to protect the insiders at the cost of declining employment. Findings from the previous studies suggest that trade unions have a rather limited ability to influence employment levels while playing a more important role in limiting wage inequalities compressing the distribution of earnings (Autor, 2010; Card, 2001; Firpo et al., 2009).

Among the two variables that proxy technological change, the association between the employment share of medium-skilled occupations and the share of human resources in science and technology is slight but negative, whereas between the former and investments in R&D is strong and positive. While R&D investments are considered to impact productivity positively, their impact on employment is not straightforward. As discussed in the literature review, technology can be either labour-replacing or labour-complementing, whereas R&D can focus on product or process innovation, affecting labour demand differently. Some authors suggested that it is product innovation that leads to decreasing demand for blue-collar workers (Greean & Guellec, 2011). Several authors additionally pointed out the importance of local labour market characteristics. Ciarli et al. (2018) suggested that in low-routinized areas, investments in R&D are associated with an employment decline in non-tradeable

services (e.g. accommodation, construction and retail), while employment in manufacturing grows. Analysing the adoption of robots in manufacturing in 17 developed countries, Graetz and Michaels (2018) point to a negative impact of robots' adoption on low-skilled workers and a positive for high- and medium-skilled. Taking into consideration the findings from studies discussed above as well as the specific institutional context in Europe, which is likely to favour R&D investments that are more employee-friendly than in the US, the strong and positive association between investments in Research and Development and employment share of medium-skilled workers does might not be surprising.

Association between Human resources in research and technology and share of employment in medium-skilled occupations was, instead, negative. Human resources in science and technology appear to be a more straightforward indicator of a technological bias as it refers exclusively to the workers in science & technology where tertiary education is normally required (overwhelmingly Professionals and Technicians and Associate Professionals ISCO occupations). In fact, a one percent increase in the share of Human Resources in Science and Technology is associated with a 0.5 decline in the employment share of medium-skilled workers.

According to RBTC theory, the decline in the middle of the occupational structure is driven by routinization. These occupations are more susceptible to automation, being routine-intense and, hence, the demand for this type of task is decreasing. Before presenting the regression analysis results, it is worth pointing out that the level of "routineness" of occupation is defined following the PCA analysis using the European Working Conditions Survey based on subjective workers' assessments. It, thus, does not perfectly overlap with task categories and routine intensity of occupations employed by the majority of studies based on US DOT.

The effect of EPL for regular contracts remains strong and significant. A one-point increase in the strictness of EPL for regular contracts is associated with between a 2.3%-2.4% increase in the share of employment in most routine occupations, depending on the model specification. Furthermore, the strictness of EPL for temporary contracts becomes significant and is associated with a similar and positive 2.3%-2.4% effect on the employment share of routine-intense occupations. As discussed before, this group of occupations is composed of some industrial occupations and the group

of Elementary occupations, with a higher share of workers with temporary contracts. As is known from theory, the strictness of EPL for regular and temporary contracts affects hiring/firing decisions due to the turnover costs. Therefore, the positive and significant association of these variables confirms this expectation.

In contrast to medium-skilled employment share, there appears to be a stronger association between the share of employment in most routine occupations and wage-setting institutions, namely the level at which collective bargaining occurs. The employment share in these occupations tends to be lower in countries where collective bargaining is more centralized. Bargaining set at the industry or sector level, and intermediate between the central and industry level is associated with a 6% decline in the share of employment in most routine occupations, whereas when it is centralised, it reaches -7%. This relationship between the share of routine-intense occupations and bargaining level might be influenced by the significant presence of low-skilled elementary occupations in the group. Low-skilled benefit more from economy-wide bargaining than company one, with multiple pieces of evidence highlighting the role of a centralised wage-setting system in reducing wage differentials that restricts job creation at the bottom and even pushes low-skilled out of the labour market (Bentolila & Bertola, 1990; Kahn, 2000).

Finally, an increase in the share of human resources in science and technology is associated with a decrease in the share of most routine occupations. It is in line with both RBTC and SBTC since these occupations are high-skilled and non-routine.

The results seem to support the role of labour market institutions in hindering the “hollowing out” of employment share in the middle and that of most routine occupations. The strictness of EPL for regular contracts and collective dismissals is positively associated with the share of middle-skilled employment, whereas that for regular contracts and temporary contracts for most-routine occupations. Technological change, proxied by the percentage of human resources in science and technology, is, instead, associated with a decline in these groups of occupations.

3.5. Conclusions

This chapter had the objective of analysing the patterns of occupational change, trying to establish whether the occupational change is better described by skill-biased technological change or routine-biased technological change while shedding light on the possible role of labour market institutions in the process. Instead of applying the framework of either RBTC, as it has been predominantly done by economists or SBTC, recently adopted by sociologists for assessing changes in occupational structure, this analysis assessed occupational change following both perspectives. Taking into consideration the substantial variation of the previous finding with respect to occupational change patterns (Appendix A), occupational change in the SBTC perspective was assessed at different levels of ISCO occupational groups and using alternative indicators, such as earnings, level of education and employment quality. With respect to the RBTC framework, the analysis of task content of occupations was implemented using the European Working Conditions Survey, which appeared to be more suitable than assigning task indexes developed for the US classification of occupations.

The important rationale behind applying both frameworks was the assumption that wage structures in Europe were not homogenous, especially considering institutional differences and their impact on wage structures. Hence, routine occupations might not necessarily be considered as simply middle-paid or low-paid (Fernandez-Macias and Hurley 2017). After establishing which occupations declined and expanded in terms of job quality and their task content, the analysis proceeded to establish the causes behind heterogeneity of occupational patterns, including educational supply factors and the role of labour market institutions.

The results of the present analysis of occupational change for the 2003-2018 period tend to largely support the findings from previous research (ALM 2003; Goos & Manning; OECD, 2019), especially with respect to the declining share of middle-skilled occupations and growth of high-skilled occupations. The expansion of high-skilled occupations and upgrading was confirmed in most countries even when the alternative indicator of the educational level was used to assess occupational change, suggesting upskilling.

On the other hand, the results were rather contradictory when the quality of employment and work-life balance were used as indicators for assessing occupational change. The growth in high-quality jobs was more limited, with a larger magnitude of changes in the middling quintiles. Despite variations across countries, higher-quality jobs with a low share of workers with involuntary and part-time contracts were usually composed of some industrial occupations (MG7), occupations from MG4 Clerks and MG2 Professionals. Since the first two tended to decline and the group of Professionals to expand, the growth in quintiles four and five was often limited.

It is worth pointing out that the composition of the bottom quintile one and, in part, two was rather similar to when the 2-digit occupations were ranked by earnings or education. They were composed to a larger extent by occupations from MG5 Service and Sales workers and MG9 Elementary occupations. More polarized or downgrading patterns of occupational change in employment quality emerged in the countries with stronger growth in these two groups of occupations and was rather diffused. Therefore, while assessing occupational change using earnings or education indicators, clearer upgrading patterns were clearly visible. On the other hand, mid-upgrading with slight polarization patterns of occupational change and limited growth at the top was mostly the case when focusing on employment quality.

Independently on the indicators used, the patterns of occupational change, however, differed across countries, which is in line with a number of cross-country studies conducted in Europe (Oesch, 2013; Fernandez-Macias, 2012), and, more importantly, varied depending on the level of analysis. Assessing occupational change focusing on one-digit ISCO groups and quintiles of two-digit occupations grouped on the basis of their position on the wage ranking yielded slightly different results. The main reason behind this was that quintiles were composed of different occupations with a similar level of earnings. While the employment share of some of these occupations increased – which was clearly visible at ISCO MG levels – the strong decline in other occupations drove the entire quintile's dynamics.

Analysis using quintiles of occupations is helpful for illustrating overall dynamics but appears to be ill-suited for understanding the possible drivers behind these transformations. For instance, the vast majority of the countries experienced an increase in the share of Service and Sales workers, particularly Personal and

protective service workers in the 2003-2010 period and Personal care workers in 2011-2018. These occupations fall into the 1st or 2nd quintile based on earnings ranking (lowest paid), some occupations from the MG7 of Crafts and trades related workers, MG9 of Elementary occupations and MG6 of Skilled agricultural and Fishery professionals. Since the employment share of the latter has undergone a strong and continuous decline, the dynamics of the low-paid quintiles resulted in being negative, despite the growth among Service and Sales workers. Thus, analysing occupational change through quintiles provides a more general picture of occupational change but underestimates important dynamics of specific occupational groups.

Another important aspect that remains overlooked when the analysis is focused on a difference in employment structure between the beginning and the end of a period through quintiles or occupational groups is the relative importance of some occupations compared to others and employment in a specific occupation in absolute terms. Knowing that some occupations gained/lost do not provide a full picture unless we know how many people are employed in these occupations in relative or absolute terms. For instance, if we look at the relative employment share at the level of ISCO MG through 2003-2018, we can clearly notice that the group of Service and sales workers is, on average, between the 2nd and 4th largest in terms of its relative employment share. This means that the occupational structure in a more "static" picture might be already polarized, especially in those countries where occupations from this group of workers are falling into the lowest-paid quintile.

Assessing the dynamics of change in occupational structure through the entire period allows, additionally, to detect longer time trends hidden in analysis simply comparing the difference between the beginning and the end of the period. In line with literature on occupational change, the vast majority of countries experienced a steady expansion of high-skilled occupations (Professionals and Technicians and Associate Professionals). Employment share of Service and Sales workers largely gradually increased, even though there were variations across countries. There was an overall trend of steady decline among medium-skilled occupations accelerated by the economic crisis and recession. This finding supports the hypothesis of Jaimovich and Siu, who suggested that employment in these occupations tends to fall most during economic downturns, leading to "jobless" recoveries due to contraction among middle-skilled workers (Autor, 2010; Jaimovich & Siu, 2012). But what explains the growth

dynamics in some occupations and decline in others? Is it driven by routinization, as suggested by the proponents of the RBTC theory?

In order to understand whether the task content and task intensity are helpful for understanding changes in occupational dynamics, the present analysis used direct information from workers provided in EWCS surveys. Task indexes specific to European countries were constructed separately for ISCO88 and ISCO08 occupational classifications. What emerged with respect to task content of occupations is a strong positive relation between routine and manual tasks, strong negative relations between routine/manual and cognitive tasks, moderately positive correlation between cognitive and interactive tasks and moderately negative between routine/manual and interactive tasks. In other words, the share of cognitive and interactive tasks declined, going down the occupational classification, whereas the share of routine and manual increased. Only some occupations were the exception to the rule: Customer services clerks, Personal services and Personal care workers with higher than average share of routine and very high share of interactive tasks. The dimension of interactivity might, thus, be very important in explaining the dynamics of occupational change in these groups and overall, since “interactivity” is a “bottleneck”, making occupations less susceptible to automation.

Pointing out at pervasive polarization of occupational structure in the US, UK and European countries, the proponents of RBTC suggested that routine-intense occupations were situated in the middle of the wage distribution (Autor et al.,2003; Goos & Manning, 2007; Goos & Manning, 2009). Some scholars consequently pointed out that it was a rather strong assumption taking into consideration substantial institutional diversity in European countries, which were likely to play an important role in the organization of wage hierarchy (Fernandez-Macias & Hurley, 2017; Oesch, 2013). The study that tested this assumption by Fernandez-Macias and Hurley (2017), in fact, demonstrated that most routine occupations in Europe were low paid, contradicting previous findings and suggesting that routinization is likely, then, to result in upgrading. Despite this important contribution, the study of Fernandez-Macias and Hurley (2017) did not consider the diversity of wage distributions across countries, which was likely to play an important role in explaining differences in employment trends based on where most-routine occupations fall on the wage hierarchy. The present analysis, thus, addressed this problem.

Overall, there were almost no differences regarding the high-skilled non-routine occupations being high-paid (including Managers, Professionals and Technicians and Associate Professionals). There were larger differences with respect to mildly-routine and most-routine occupations. Whereas in studies adopting task indexes from the US DOT, Service and sales occupations were defined as non-routine manual, here, following the analysis using EWCS data, they were classified as mildly routine. Consequently, an increase in these occupations was not expected to contribute to greater polarization when both routine intensity and occupations' placement on earnings ranking were taken into account.

Similarly, the composition of the most routine group of occupations also differed. As in Fernandez-Macias and Hurley (2017), the group of most routine occupations included Elementary occupations that were low-paid and declining across countries. Along with Elementary occupations, it also included a number of industrial occupations, particularly Plant and Machine Operators and Assemblers, which in many countries were found not at the bottom of the wage distribution but in the middle. Therefore, since routine intensity is negatively associated with earnings, expansion of non-routine high-skilled occupations is expected to lead to upgrading. In contrast, polarization is determined to a large extent by whether the most routine occupations are low or middle paid. It seems, therefore, that RBTC and SBTC do not preclude each other. Instead of arguing in support of SBTC and upgrading, rejecting RBTC and polarization, this analysis suggests that routinization is taking place and is compatible with both upgrading and polarization depending on the placement of most routine occupations in earning hierarchy.

Finally, the analysis clearly illustrated that while there were important cross-country differences, it was more evident for some groups of occupations rather than others. Mildly to high routine-intense medium-skilled industrial occupations have undergone through almost universal decline. Nevertheless, a high rate of unionisation and collective bargaining in the manufacturing sector played a crucial role in preventing wage decline, which was also true for generally low unionised CEE countries. Similarly, the job quality in these occupations was rather high, especially with regard to contractual stability. While these occupations declined in relative and absolute terms, the regression analysis demonstrated that stronger employment protection legislation for regular contracts as well as collective dismissals were able to impede the "hollowing

out" of what is considered the "middle". Despite the technological bias that reduced the demand for these occupations, a number of recent studies pointed out the limited impact of robots on employment and wages in Europe, likely mediated by the role of labour market institutions, as illustrated in this analysis. Nevertheless, considering that implementation of new technologies is likely to continue, the issue of training and re-training becomes particularly important to ensure complementarity of technologies rather than substitution.

The relative share of jobs in low skilled occupations, as well as their absolute number, have increased in the vast majority of European countries. While it is not often visible when the analysis is based on quintiles, it was more clear from the analysis at ISCO 1 or 2- digits. What emerged in the former case is a picture of occupational upgrading that, however, hides an important growth in the occupations that are not only low paid but also precarious in terms of employment, having a higher percentage of workers with involuntary temporary and part-time contracts. Moreover, the workers employed in Service and sales occupations intense in interactive tasks and, hence, less likely to be automated or substituted by AI often possess secondary or tertiary education, making them overeducated for the type of job.

The growth in these jobs is likely to be driven by the development of the "care economy", as suggested by Dwyer (2013), and taking into consideration population ageing, it is expected to continue. Labour market institutions seem to play a certain role in impeding the growth in low paid occupations, most so in Nordic countries and, in part, in the countries from the Conservative group. Southern European countries, instead, experienced a substantial increase in relative employment share in these occupations despite the strictness of EPL in Greece and Portugal, or high level of bargaining coverage and moderate strictness of EPL in Italy or Spain. The high share of low educated and low investments in R&D and education and training might be relevant for explaining such a pattern as well, impeding upskilling. The situation is similar for CEE countries, where with the exception of Poland, the pattern was that of slight to strong polarization or straight downgrading.

Substantial expansion of high skilled and high paid jobs driving in many countries occupational upgrading is a reason for optimism, but what is somehow disturbing is a pattern of slow down during the second period of analysis in some

countries and even decline in others. Demand and supply factors appear to have a crucial role in the expansion of these occupations. We have seen that the countries that managed to upgrade their occupational structure most were the ones with a higher share of investments in R&D and education and training, including adult training.

This Chapter made several contributions to the literature concerned with how technological change affected the labour market while trying to explain the causes of cross-country variations. It provided somehow lacking comparative perspective extending the number of countries as well as the period of the analysis. Most importantly, in line with previous studies by economic sociologists, it rejects the hypothesis of “pervasive” polarization. It rather points out at coexistence of processes of SBTC and RBTC, suggesting that RBTC does not inevitably lead to polarization once the role of institutional differences is taken into account and an alternative definition of occupational task content is employed.

The analysis in this Chapter largely supports upgrading of occupational structure across European countries, whether the indicator of interest is hourly earnings or educational level. What is, in part, concerning is the increasing share of higher-skilled workers pushing out the lower-skilled, meaning that upgrading might be taking place along with an increasing incidence of overeducation, more for some educational groups than others. The specifics of educational supply, qualification mismatch and occupational change will be the focus of the analysis of the next chapter. While educational supply appears to be crucial for occupational upgrading, the pattern of occupational structure and its change are likely to impact qualification match substantially. Therefore, analysing the link between the two is important for understanding how the matching can be improved for supporting occupational upgrading.

Chapter 4. Occupational change and overeducation in Europe

4.1. Introduction

As discussed in previous chapters, technological developments and changes in the supply of educated labour, or educational expansion, affected occupational structures across the countries. As illustrated in a previous chapter, this impact was partly mediated by the labour market institutions and consequently led to differential patterns of occupational change across countries, namely polarization or upgrading. Focusing on technological change as a main explanation on the demand side, previous literature found strong support for the polarization scenario in the US (Acemoglu & Autor, 2011; Autor et al., 2003; Autor et al., 2006) and the UK (Goos and Manning, 2007), whereas the findings for European countries were more mixed, depending on the method of assessing occupational change, as well as time periods, as illustrated by previous analysis.

In fact, along with variation across countries, there have also been differences in the patterns of occupational change between the two periods (2003-2010 and 2011-2018). During the first period comprising economic crisis, more countries have experienced a more polarized pattern of occupational change compared to the second period. While the cross-country differences were mostly related to the dynamics at the bottom of the occupational structure and, to a lesser extent, at the top, the decline among middle-skilled occupations was universal. The scholars who employed a task-based approach to explaining the impact of technological change on employment sustained that this decline in the middle resulted from diminishing demand for routine-intensive jobs found in the middle of the occupational distribution (Autor et al., 2003; Goos & Manning, 2007). Non-routine analytical and non-routine manual jobs, which at present are difficult to automate, are concentrated at the two opposite ends of the occupational distribution when measured by earnings, and the growth at both ends is expected to cause a polarization. Previous analysis in this study confirms this finding, illustrating expansion among the least routine and most complex jobs, followed by mildly routine and mildly complex jobs, and, instead, close to universal decline among highly routine jobs.

Independently on which approach is used to assess occupational change – skill-biased based on earnings or education level as an indicator for ranking or task-based

focused on the task content of occupations – during the past decades, job expansion has been taking place among high-skilled occupations, mainly professional and technicians and associate professionals. As discussed in the literature review, educational expansion has been an important factor contributing to occupational upgrading, and it is at the centre of SBTC theory proponents. However, the increase in the supply of educated labour that has been taking place across developed countries for decades has not always been accompanied by a commensurate growth in high-skilled jobs, leading to an increased incidence of overeducation (Freeman, 1975; Quintini et al., 2011).

As discussed in the literature review, literature on overeducation has paid significant attention to how specific individual characteristics affect the probability of qualification mismatch, its consequences and, to a lesser extent, the effect of the labour market and educational institutions on the incidence of overeducation.

This Chapter brings the two strands of literature – on occupational change and overeducation – together in order to assess whether there is a link between the two and whether occupational change can provide additional explanation for the incidence of overeducation. It aims at assessing the association between occupational change and over-education, trying to understand how workforce skill composition matches the demand posed by technological change.

Only a few studies have discussed the interaction between technological change, educational supply and changes in occupational structure (Oesch, 2013; Spitz-Oener, 2006). The issue of whether the overeducation incidence is affected by the occupational structure has been even more scarcely investigated (Zago, 2015). First, empirical analysis investigates the dynamics of over-education incidence across skill and task-based categories, allowing for a better understanding of the link between technological change and overeducation. It considers not only the skill level of jobs that have been declining or expanding but also their task content, which is particularly relevant, taking into consideration routinization. The second part of the empirical analysis tries to answer the question about the association between occupational change and overeducation over time, the issue that has been left aside by the literature on overeducation.

4.2. Research question and hypothesis

Individual factors, employment and contextual characteristics were found to be relevant for explaining the risks and dynamics of overeducation. At the individual level, female workers are more likely to be overeducated compared to male workers, being restricted in their labour market choices by family responsibilities (Dolton, 2001). Young workers entering the labour market have a higher risk of being overeducated than senior workers, compensating for their lack of experience by education (Dolton, 2001; Allen et al., 2013). Migrants are similarly found to have a higher probability of being overeducated compared to natives (Green, 2007; Munoz de Bustillo et al., 2012). With regard to the job characteristics, the risk of overeducation is higher for the workers with part-time and temporary contracts and in unskilled occupations (Borgna et al. 2019).

During the past decades, skilled workers have become more and more important for the creation and expansion of new industries and occupations driven by technological change (Berman & Machin, 2000; Goldin & Katz, 2008). This development introduced by economists has been known as a Skill-Biased Technological change. In the "race between technology and education," educational expansion has been considered a result of labour demand.

Sociologists, on the other hand, suggested alternative theories for educational expansion. Collins (1971) considered educational expansion as a result of conflict and competition, where education became a mean for ensuring the attainment of social status for specific social groups, leading to credential inflation.

Schofer and Meyer (2005) suggested that following World War II, a new model of society has developed. It was facilitated by a number of institutional changes legitimizing educational expansion: 1) democratization, liberalization and expansion of human rights, fuelling the "education for all" movement; 2) "scientization" of society, enhancing the importance of schooling; 3) the rise of national development logics, with educational expansion seen as a mean for progress; 4) diffusion of pro-educational cultural models and discourses globally.

Therefore, economics and sociology have suggested different mechanisms driving educational expansion with its divergent implications for the labour force. If educational expansion is not driven by demand, as suggested by economists, it is likely

to result in a mismatch between high-skilled labour supply and demand. Taking into consideration the changes in occupational structure appears, thus, to be very important and relevant, as it allows to understand the results of interaction between the demand and supply factors.

In one of the most cited works on job polarization, Goos and Manning (2007) suggested that there might be a link between job polarization and qualification mismatch since the decline of employment in middle-skilled occupations is likely to result in higher educated workers being forced to accept lower-skilled jobs. However, this issue has been left unexplored despite enormous attention to the authors' work. We can quite naturally expect that economic growth and development are facilitated by the high level of educational achievement and human capital accumulation, fostering innovation and technological development. Conversely, the lack of educated and matched workers is likely to have a negative impact on economic growth and especially when it is driven by technological change requiring upskilling. Therefore, a mismatch between the demand and supply represents the most obvious explanation of overeducation. We might, thus, expect occupational change – driven by technological change and supported by educational expansion – to be linked to the dynamics of overeducation.

Analysing the US labour market over the Great Recession period, Zago (2015) finds that stronger state-level polarization was associated with a stronger downward mismatch during the recovery. High-skilled workers were forced to move to routine jobs, middle-skilled to manual or, along with low-skilled, out of the labour market, whereas the skill requirements across all the occupations increased.

Focusing on overeducation among tertiary graduates, Croce and Ghinoni (2012) suggested that higher relative wage of university graduates (compared to secondary educated) – interpreted as a confirmation of the job assignment hypothesis, possibly driven by skill-biased technological change – resulted in a decrease in the incidence of overeducation. According to the authors, an increase in the supply of high-skilled alone cannot be considered as a major factor driving the incidence of overeducation. Finally, the authors point out at countercyclical behaviour of overeducation, suggesting its possible role as a short-term adjustment mechanism. In fact, several studies suggest overeducation is a cyclical phenomenon, rising following

the economic crisis of 2008 and declining in most countries after the 2010s (Croce & Ghignoni, 2012; Verhaest & Van der Velden, 2013; McGuinness et al., 2017).

The discussed evidence, linking specifically the incidence of overeducation and occupational change, while being limited, suggests that there might be a specific relation between overeducation and the patterns of occupational change. And, taking into consideration previous literature findings on the micro-determinants of overeducation, it is likely to play out differently for different occupational and educational groups. This chapter aims to understand *whether the occupational change leads to a higher incidence of overeducation and for which groups of workers*.

The vast majority of studies on overeducation focus on tertiary graduates in specific countries or, in some cases, country groups. This study does not exclude any educational groups since they are likely to be affected differently by transformations in occupational structure. In particular, the routine-biased technological change is likely to cause a displacement in occupational structure and increase the incidence of overeducation for middle-skilled workers (*Hypothesis 1*).

Along with a decline in routine intense jobs in the middle of occupational structure, technological change leads to the expansion of non-routine service jobs that can be frequently found at the bottom quintiles of employment distribution based on earnings but not the skill distribution. The rise of these low-skilled mildly routine occupations is expected then lead to an increasing incidence of overeducation for middle-skilled and high-skilled, especially when there is no commensurate expansion of high-skilled occupations *(Hypothesis 2*).

This Chapter, therefore, aims to analyse the variation in the incidence of overeducation, its trends and factors explaining cross-national differences. Building on the previous literature, relevant individual (e.g. age, gender, migration status), employment (contract type and duration), and macro characteristics (e.g. share of specific employment groups, education supply, GDP growth) are included in the analysis reflecting both demand and supply-side factors that might affect the risk of overeducation. Moreover, taking into consideration the findings on the cyclical character of overeducation, the analysis is conducted for the pre-crisis and crisis period (2003-2010) and the post-crisis period (2011-2018) separately.

4.3. Data and methods

The analysis of this Chapter is based on data from the European Labour Force Survey for the years 2003-to 2018. While the descriptive statistics are based on the entire sample, the data for regression analysis for the first period includes 1090444 individuals from the EU countries (excluding Malta), Switzerland and UK, and 1354019 for the second. As in a previous analysis, the sample is restricted to 20-64 years old workers.

The *dependent* variable of the analysis is a continuous variable indicating the probability of the worker being overeducated. Considering the information available in the dataset and the absence of any direct question with respect to the required educational level, the variable of qualification mismatch is constructed following realized matches or a statistical approach. The required level of education is defined at ISCO 2-digit level following the assessment of educational distribution. The worker is considered to be overeducated if their level of education is higher than one standard deviation from the modal level of education in occupation in a specific country and year. Three levels of education are considered: ISCED 0-2 (up to lower secondary), ISCED 3-4 (upper secondary and post-secondary non-tertiary), and ISCED 5-6 (tertiary). These calculations are implemented separately for both periods since, as discussed previously, there has been a substantial change in ISCO classification in 2011 and ignoring this change using crosswalks would have resulted in a loss of information.

The descriptive part of the analysis provides information on the incidence of qualification mismatch and its change within and between different time periods and across countries. The frequency of overeducation is then assessed with respect to demographic characteristics and levels of education. Finally, the share of overeducated workers is calculated across occupational skill groups and occupational groups based on task content integrated from the previous analysis.

The second part of the empirical analysis focuses on investigating how the probability of overeducation varies across countries and years, taking into consideration individual characteristics, occupational change and specific country-level characteristics. The main *independent* variable at the individual level is the level of education introduced as a dummy (primary, secondary and tertiary). Other individual

characteristics relevant to the outcome are also included in the analysis as *controls*: gender, age group (20-29, 30-49, 50-64), migration status, and job characteristics (working full or part-time and having permanent or temporary contract).

At the country level, two main *independent* variables are considered: 1) the share of middle-skilled employment and 2) the share of employment in mildly routine occupations, both integrated from the previous analysis of occupational change as a percentage of total employment. In line with previous literature, middle-skilled occupations include workers from the ISCO MG 4 (Clerks), MG 7 (Craft and trades related workers), and MG 8 (Machine operators and Assemblers). Following the previous analysis, mildly routine occupations include occupations with moderate routine intensity with, particularly, a high share of interactive tasks, which makes them difficult to substitute by automation at present.

Controls at the country level include the share of upper-secondary students enrolled in firm-based vocational training and the share of the tertiary-educated population, which can also be considered a supply measure. Business cycle effects are controlled through the inclusion of the GDP growth variable.

The mixed-effects linear probability model is used for estimating the effect of country-level variables on the probability of being overeducated, allowing to discern between-country differences and control for within individual-level compositional effects. The model, thus, has three levels: countries, years, and individuals.

4.4. Empirical results

4.4.1. What explains overeducation's incidence? Individual-level determinants, educational supply and skill and task content of occupations.

Before presenting the regression results, this section provides descriptive evidence on how educational supply evolved in different countries and how the incidence of qualification mismatch and overeducation varied across countries and occupations.

As it follows from previously discussed theories on the impact of technological change, the latter is expected to raise the demand for higher-skilled workers causing

a related increase on the supply side. As previous analysis demonstrated, there had been a clear upgrading of occupational structure whether the ranking of occupations is based on earnings or mean skill level. Figures C.1 and C.2 demonstrate the educational composition of ISCO MG of occupations for the 2003-2010 and 2011-2018 periods.

The share of low-skilled workers across all occupations declined during both periods, especially among Crafts and trades related workers (ISCO MG 7) and Plant and machine operators and assemblers (ISCO MG 8). The share of low-skilled workers was lowest in CEE countries and highest in Southern Europe. During the first period, lower educated workers from ISCO MG 5 Service and Sales workers and MG 9 Elementary occupations were largely substituted by workers with a secondary level of education. During the same period, the share of tertiary-educated workers slightly increased in Clerical occupations (MG 4), squeezing out both low- and secondary educated. Between 2011-2018, the displacement of low skilled workers accelerated and was driven by the increasing share of secondary and tertiary educated in these occupations, possibly giving rise to qualification mismatch. Overall, there has been a tendency of the increasing share of workers with a secondary level of education in manufacturing occupations (ISCO MG 7, 8), and to a lesser extent in Elementary occupations (MG 9); and that of tertiary educated in Clerical occupations and Service and Sales occupations (in addition to high skilled occupation in MG 1-3).

This evidence, indeed, support the thesis of educational upgrading. It further suggests the significant disadvantage for low-educated workers and the possibility of educational upgrading occurring at the cost of the rising incidence of overeducation. Whether it was the case will be discussed in the following.

The incidence of overeducation by country and period is presented in Figures C.3 and C.4, illustrating significant variation across countries. As for the first sub-period (Figure C.3), the estimated level of overeducation was lowest (<10%) in CEE countries, Nordic countries (Finland, Sweden and Norway), Luxemburg and Austria; and highest in Southern countries exceeding 20% (except Portugal), Switzerland, and Ireland (around 20%). The vast majority of countries experience an increase in the incidence of overeducation (red dots), and only in 9 countries it decreased (blue dots). It increased by 4% and more in Spain, Sweden, Ireland, Luxemburg and Poland; 2-4%

in Switzerland, Greece, Portugal, Latvia, Cyprus, Netherlands and Slovakia, and less than 2% in Austria, Denmark, Estonia, Slovenia and Finland. Incidence of overeducation declined most in Belgium and UK and remained relatively stable in Germany and France.

Between 2011-2018 (Figure C.4), more countries experienced a decline in overeducation incidence. The highest increase of 4 % and above occurred in Austria, Portugal, Slovakia and Sweden. Despite these changes, the share of overeducated workers remained highest in Southern Europe (around 20%) and lowest in CEE countries (10% or less). Two exceptions from the case were Slovakia in the first group and Denmark in the latter, with a higher than 10% share of overeducated workers. Comparing the two periods, there is clear evidence of a decreasing and more stable overeducation incidence during 2011-2018 compared to the previous period. Along with analysis of the distribution of overeducation by countries, assessing specific worker's characteristics might offer further insights for understanding whether it was driven by specific groups.

Numerous studies demonstrated that a higher incidence of overeducation is particularly driven by the group of tertiary graduates. As Figures C.5 and C.6 demonstrate, the incidence of overeducation in this group exceeded 20%, and in most countries, it was well above the 30% threshold. As with general rates of overeducation, it visibly decreased between 2011-2018 compared to the previous period, even though in half of the countries, it remained above 30%. While the incidence of overall overeducation was particularly high in Southern countries, these figures illustrate that it was not driven by the group of tertiary graduates, but, instead, a higher than average level of overeducation among medium-skilled workers, particularly high in Spain and Portugal, and slightly lower in Italy and Greece.

In contrast, CEE countries with remarkably low overall overeducation rates were less immune to overeducation among tertiary graduates, whereas it remained close to zero for secondary educated workers. Among Baltic countries, Lithuania stood out as one of the countries with the lowest share of tertiary educated graduates (below 20%), whereas Estonia and Latvia were close to average. Incidence of overeducation was among the highest in Austria, Switzerland and Germany, around average in France, Ireland and Netherlands and among the lowest in Belgium, Luxemburg, and the UK.

Within the Nordic countries, Finland and Norway exhibited the lowest rate of overeducation for tertiary graduates. In contrast, it was close to average and increasing in Denmark and above average for Sweden.

After having assessed the incidence of overeducation across countries and its change in time, it might be useful to assess how it varied by workers' characteristics. Figure C.7 illustrates the incidence of overeducation among tertiary graduates across age groups. Overall, in line with many studies, the incidence of overeducation decreased with age, the trend became even clearer during the second period. The countries of Southern Europe, Bulgaria, France, Ireland, Netherlands, Norway and Poland were characterized by the largest gap in overeducation incidence between young people and the 50+ years old age group. There was less variation across age groups in the countries of Continental Europe, CEE countries during the first period, Finland and Denmark. Between 2011-2018 the gap between the two groups instead increased in Austria and CEE countries, with increasing overeducation incidence among young people.

As for individuals with upper-secondary and post-secondary non-tertiary levels of education (Figure C.8), apart from the generally low risk of their overeducation, there was almost no difference in the incidence of overeducation across age groups. This might be linked to a strong vocational focus of secondary level educational programmes, ensuring a better match for younger workers and allowing for retraining of older workers (Shavit & Müller, 1998). The exception from the case were the countries of Southern Europe with not only a high risk of overeducation among secondary educated workers but also a larger gap between younger and older workers, which was the case in Spain, Italy and Portugal (Brzinsky-Fay, 2007).

In most countries, highly skilled men were more likely to be overeducated than women (Figure C.9). The opposite was the case only in Luxemburg, Cyprus, Germany, UK and Italy. The pattern was similar for medium-skilled workers, even though around a third of the countries experienced an increasing incidence of overeducation for women and, thus, a larger gap between the two genders (Figure C.10).

What explains these dynamics? Educational expansion has been considered one of the main "suspects" in driving the incidence of education up. Indeed, we might naturally expect the rise in the overeducation of tertiary graduates if the supply of

individuals with this level of education increases. As it is evident from Table 1 below, the population with tertiary level of education expanded in all the countries, with stronger growth during 2011-2018. Between 2003-2018, the share of tertiary educated increased by more than 15% in Luxemburg, Ireland, Lithuania, Switzerland, Poland, Sweden, Cyprus and Latvia. In Croatia, Netherlands, Hungary, Italy, Romania, Denmark, Bulgaria and Germany, the growth was lower, below 10%.

TABLE 1. Share of population with tertiary education

GEO/TIME	2004	2010	Difference 2003-2010	2011	2018	Difference 2011-2018
Finland	34,0	38,1	4,1	39,3	44,5	5,2
Denmark	32,4	33,0	0,6	33,7	39,4	5,7
Norway	32,0	36,9	4,9	37,6	43,7	6,1
Estonia	31,5	35,5	4,0	36,9	41,2	4,3
Belgium	29,8	35,0	5,2	34,6	40,6	6,0
Cyprus	29,4	35,7	6,3	37,7	44,1	6,4
Netherlands	29,3	32,0	2,7	32,1	38,3	6,2
United Kingdom	29,2	35,1	5,9	36,9	43,2	6,3
Ireland	28,3	38,7	10,4	39,2	46,9	7,7
Sweden	28,1	33,9	5,8	34,8	43,2	8,4
Switzerland	28,1	33,9	5,8	34,0	43,7	9,7
Spain	26,7	31,0	4,3	31,9	37,3	5,4
Germany	24,9	26,7	1,8	27,7	29,1	1,4
Lithuania	24,5	32,4	7,9	33,5	41,7	8,2
France	24,3	28,9	4,6	29,7	36,9	7,2
Luxembourg	23,7	35,5	11,8	37,0	44,1	7,1
European Union - 28 countries (2013-2020)	21,7	25,9	4,2	26,8	32,3	5,5
Bulgaria	21,4	23,3	1,9	23,6	28,2	4,6
Greece	20,7	24,0	3,3	25,4	31,7	6,3
Latvia	19,2	26,9	7,7	27,7	33,9	6,2
Slovenia	18,8	23,7	4,9	25,1	32,5	7,4
Austria	18,4	19,1	0,7	19,2	32,7	13,5
Hungary	16,6	20,0	3,4	21,0	25,1	4,1
Croatia	16,2	18,6	2,4	18,0	25,4	7,4
Poland	15,3	22,5	7,2	23,3	30,9	7,6
Slovakia	12,8	17,3	4,5	18,6	24,6	6,0
Portugal	12,6	15,5	2,9	17,2	25,0	7,8
Czechia	12,3	16,8	4,5	18,2	24,3	6,1
Italy	11,4	14,8	3,4	15,0	19,3	4,3
Romania	10,4	13,6	3,2	14,6	17,8	3,2
Source: Eurostat [edat_lfse_03]						

The share of the medium-skilled population (upper secondary and post-secondary non-tertiary education) has been declining in most countries (Table 2 below).

TABLE 2. Share of population with upper-secondary and post-secondary non-tertiary education

GEO/TIME	2004	2010	Difference 2003-2010	2011	2018	Difference 2011-2018
Czechia	76,7	75,2	-1,5	74,1	69,6	-4,5
Slovakia	73,9	73,6	-0,3	72,6	67,1	-5,5
Poland	68,1	66,0	-2,1	65,6	61,5	-4,1
Romania	60,7	60,2	-0,5	59,9	60,7	0,8
Hungary	58,5	61,1	2,6	60,4	59,8	-0,6
Croatia	55,2	58,7	3,5	60,3	59,7	-0,6
Germany	59,0	59,4	0,4	59,0	57,5	-1,5
Latvia	64,2	61,7	-2,5	60,2	56,7	-3,5
Slovenia	60,5	59,6	-0,9	59,4	55,7	-3,7
Bulgaria	50,2	55,8	5,6	56,5	54,4	-2,1
Lithuania	62,2	59,5	-2,7	59,4	53,1	-6,3
Austria	61,2	63,2	2,0	63,2	52,6	-10,6
Estonia	57,2	53,8	-3,4	52,1	48,1	-4,0
European Union - 28 countries (2013-2020)	46,4	46,8	0,4	46,6	45,8	-0,8
Finland	43,6	44,8	1,2	44,4	44,7	0,3
Switzerland	54,4	51,2	-3,2	50,8	44,7	-6,1
France	41,5	41,8	0,3	41,9	42,4	0,5
Italy	36,8	40,3	3,5	41,0	42,4	1,4
Sweden	54,8	47,3	-7,5	46,8	42,4	-4,4
Greece	38,2	38,7	0,5	39,1	41,8	2,7
Denmark	49,0	42,3	-6,7	43,1	41,6	-1,5
Netherlands	41,5	40,4	-1,1	40,3	40,7	0,4
Norway	55,3	44,0	-11,3	43,7	39,3	-4,4
Cyprus	34,9	38,4	3,5	37,4	38,1	0,7
Belgium	33,9	35,5	1,6	36,7	37,6	0,9
United Kingdom	41,3	41,0	-0,3	39,4	37,1	-2,3
Ireland	34,7	34,3	-0,4	34,7	36,2	1,5
Luxembourg	39,6	42,2	2,6	40,2	34,5	-5,7
Portugal	12,5	16,2	3,7	17,4	24,8	7,4
Spain	18,6	21,9	3,3	22,1	22,9	0,8
Source: Eurostat [edat_lfse_03]						

CEE and Baltic countries, along with Germany and Austria, had the highest share of workers with this educational level. In fact, in the two first country groups, secondary educational attainment level is almost universal, a heritage of socialist systems of the past where VET was prioritised over general education. This also explains a relatively low level of the population with tertiary education in the region, except Estonia, where it is one of the highest and comparable to that of the Nordic countries. We should also keep in mind that these countries experienced very strong emigration after the accession to the EU, especially of young and tertiary-educated individuals, which might explain the lower incidence of overeducation across occupations.

Austria, Germany and Switzerland represent another group of countries with extensive systems of VET, countries with so-called collective skill formation systems, especially at the upper-secondary level (Busemeyer & Trampusch, 2012). All three countries exhibited different patterns of tertiary education expansion: it was lowest in Germany, grew very slightly in Austria during the first period and jumped by 13% during the second period, expanded by more than 15% in Switzerland over 2003-2018. Recalling the result of the previous analysis, there has been a visible increase in the incidence of overeducation in Austria and Switzerland and a very slight in Germany. VET continued to play an important role in these countries, but considering the extent of routinization and automation driven by technological change and threatening mainly medium-skilled workforce, whether the system will be able to adapt to these challenges remains an open question.

Southern European countries were for a long time “laggards” with respect to both secondary and tertiary education attainment levels. Instead, the share of low-educated remained until now the highest in Europe, especially among the older population. Educational expansion occurred mostly among tertiary-educated rather than secondary educated. Share of tertiary-educated expanded most in Spain, where it exceeded the European average and was close to the average in Greece. Portugal and Italy were lagging behind. While Portugal was catching up between 2011-2018, the growth remained very limited in Italy. Incidence of overeducating among medium-skilled workers was the highest in these four countries. However, with respect to tertiary educated, a high incidence of overeducation was registered only in Italy – the

country with the slowest growth in the share of tertiary educated. In contrast, it was slightly above average in Greece and largely below average in Portugal and Spain.

While we can clearly see some relation between the supply of educated workers and the increase in the incidence of overeducation, it is not always the case. Educational expansion alone cannot explain the dynamics of overeducation, especially if we consider the second sub-period with a significant increase in the share of tertiary-educated individuals and prevalently declining incidence of mismatch.

While this evidence might be considered as support to overeducation being a temporary phenomenon taking into consideration its particular increase during 2003-2010 – the period that comprises economic crisis – and decline afterwards, there is still a noticeable persistence which is more evident in some countries than others, and especially among tertiary-educated individuals.

Since educational expansion does not seem to suffice in explaining qualification mismatch dynamics, we investigate whether there is an association between overeducation and occupational change.

One of the main contributions of this thesis is to analyse whether there is a link between the incidence of overeducation and employment change. Goos and Manning (2009) were the first to suggest that polarization would cause a rise in overeducation: a decline in middle-skilled jobs driven by routinization would push workers with higher education to accept jobs requiring low skills. They, however, did not investigate the issue in their work, nor have other scholars thoroughly followed it up.

Figure C.11 illustrates how the incidence of overeducation varied across occupational groups based on their skill level. The incidence of overeducation was lowest among Managers, professionals and technicians, which is largely due to the composition of this quintile with a high share of high-skilled workers for whom a tertiary level of education is necessary to access and do the job, resulting in the lowest incidence of mismatch in it. Overeducation in this group was the highest in a number of CEE and Continental Europe countries where there is still a large proportion of medium-skilled workers in these occupations (excluding the group of Professionals with the tertiary level mode of education everywhere). While the secondary non-tertiary level of education prevailed among workers in these occupations, educational expansion led to the growing number of younger tertiary-educated workers entering

these occupations. The high incidence of overeducation in this group was mostly driven by Physical and Engineering science associate professionals and Other associate professionals.

Incidence of overeducation across countries varied much more for the next two occupational groups. Within the group of Clerks, Craft and Trades workers and Machine Operators and Assemblers, it was generally low in CEE countries, particularly during 2003-2010, which was due to the prevalence of workers with medium skills in these occupations and overall. The countries with strong VET systems also exhibited a lower incidence of overeducation in this skill group. The opposite was true for Southern European countries where the level of workers' education was prevalently low, but the flow of workers with secondary education increased, driving up the incidence of overeducation for medium-skilled workers. This tendency was somehow weaker in Portugal, where the share of low educated prevailed with very little supply from other educational groups. The incidence of overeducation in this group was, thus, lower in the countries with a better match in industrial occupations and a larger share of workers with secondary education.

While between the two periods, the incidence of overeducation generally tended to decrease in the first group of highly skilled workers, to a lesser extent and with more mixed dynamics in the middle, the trend was different for the group of low skilled workers. There appeared to be a persistent trend of increasing overeducation incidence within the two periods. The incidence of overeducation in this group reached 15% and more in two-thirds of the countries in 2011-2018 compared to less than half in the previous period. While it is difficult to detect a geographical pattern, it tended to be high in the countries of Southern Europe, the UK and Ireland and lowest, even though increasing in CEE countries. Among the countries of Continental Europe share of overeducated workers in this group was above the average in Switzerland and Netherlands during both periods, close to average and increasing in Austria and Luxemburg and slightly declining in France and Belgium. Germany was, thus, the only country where the share of overeducated workers remained below the average and stable between the two periods. There was also a tendency of increasing rates of overeducation within the two periods in Nordic countries, even though comparing the two periods, it remained close to the 15% threshold.

After having analysed the variation of overeducation's incidence across the skill groups of occupations, assessing the relation between task complexity of occupations and overeducation might provide further insights. Why is it relevant? Because routinization hypothesis became one of the major explanations for changes in occupational structure, driving, in particular, the decline of routine intense occupations, which do not necessarily, as previous analysis demonstrated, overlap with skill levels of occupations. Understanding the content and nature of the jobs that decline/expand might be, thus, more informative if we want to take into greater consideration the role of demand-side factors and technological change in particular.

As Figure C.12 illustrates, the incidence of overeducation was, on average, lowest across the group of occupations least intense in routine and manual tasks and most in cognitive and interactive. This group was largely composed of high-skilled occupations, excluding Life science and Health Associate Professionals (32) and General managers (13) in the first period, Science and engineering associate professionals (31) and Health associate professionals (32) in the second period.

It was higher among the occupations intense in routine and manual tasks with very weak cognitive and interactive intensity. This group includes most of the industrial occupations (except Metal, machinery and related workers (72), Electrical and Electronic trades workers, and Handicraft and printing workers) and Elementary occupations. In many of the countries, workers in these industrial occupations were comparatively well-matched, which was especially the case in the countries with strong vocational specificity. Those were the countries where the secondary level of education prevailed among industrial as well as Elementary occupations – most routine intense occupations – reducing the incidence of mismatch, such as CEE countries. The incidence of overeducation was higher in the countries with an increasing share of secondary educated workers in low skilled-occupations. The high incidence of overeducation in Southern countries, Luxemburg and, in part, the Netherlands, was a result of an increasing share of medium-educated workers entering industrial occupations and, to a lesser extent, Elementary occupations. In Austria, Belgium, Ireland and the UK, it was largely due to the increase of medium-skilled workers, and in the case of the last two countries, the high-skilled in Elementary occupations. While it can be considered a sign of upskilling, the growing share of secondary or even

tertiary educated in Elementary occupations appears to be problematic as it is likely the case that worker skills become underutilized.

Regarding mildly routine occupations, the incidence of overeducation in these occupations mostly increased within countries and between the two periods. Only several countries had, on average, less than 15% of overeducated workers in these occupations in 2011-2018, which were the countries of CEE, Germany, Finland and Luxemburg. This group is largely composed of Clerks and Service and sales workers, which rank close to average on routine intensity but require a high degree of interactivity. A number of occupations from the MG7 are also in this group, namely Metal, machinery and related trades workers (72), Handicraft and Printing workers (73) and Electrical and electronic trades workers (74), which are characterised by the combination of higher than average intensity in routine, cognitive and manual tasks. The high incidence of overeducation in this group is driven by an increasing share of secondary and, to a lesser extent, tertiary-educated workers in the MG 5 of Personal and Protective service workers and tertiary-educated workers in the MG 4 Clerks. While there is some degree of cross-country variation in the incidence of mismatch in this group, it is much less significant compared to the least and most-complex occupations. This finding is somehow worrying, taking into consideration that the employment shares of personal and protective service workers, being less susceptible to automation, has been growing and is expected to continue this trend. It is, therefore, important to understand which occupations have been expanding/declining and how these processes affected the incidence of overeducation itself.

As it has been previously discussed, the routine intensity of occupations is one of the most important factors in determining the chances of “survival” of occupation in the context of technological change. In fact, employment share in these routine-intense industrial occupations has been declining across the vast majority of the EU countries, accelerated by the economic crisis. In most countries, this group is composed of well-paid, medium-skilled, and well-matched workers, who being susceptible to automation and hit severely by the economic crisis, have been losing their jobs. Considering routinization and “hollowing out” of the middle, we could expect a larger share of medium-skilled workers to enter lower-paid occupations, thus causing overeducation to increase. This scenario could be aggravated if the share of low-skilled workers increases, as in the case of polarization of occupational structure. Suppose the supply

of tertiary-educated workers outstrips the demand or does not match it. In that case, we might, similarly, expect them to enter lower-skilled occupations competing with individuals with medium skills. These changes in occupational structure can, thus, be expected to have a differential risk for individuals with different levels of education, as well as vary across countries and time.

While so far, only one-to-one association between the incidence of overeducation and occupation characteristics was assessed, further analysis taking into consideration individual and country-level characteristics simultaneously is needed to discern between the effects of various factors on the outcome. Therefore, the main aim of the next section is to assess whether the occupational change or changes in the share of middle-skilled and mildly routine occupations affects the incidence of mismatch among workers with different levels of educational attainment.

4.4.2. Incidence of overeducation and occupational change: assessing the role of labour market institutions and educational system

Table 3 presents the results of the mixed-effects linear probability model on the probability of being overeducated during the first period. The first (empty) model suggests that the probability of overeducation varies across countries, but most variation occurs within countries. Around 12% of variation lies between countries, 3% within countries between years and 85% between individuals, according to the Variance Partitioning Coefficient (VPC). There appear to be, thus, a moderate variation across countries, with most of the variation in the probability of being overeducated lying at the individual level. The ICC of the empty model for year and country is 0.02. Hence, the variance at both levels is quite small in relation to the total variance, and the similarity between individuals from the same countries and years is rather weak. While looking at VPC and ICC, the clustering reveals to be relatively low, the three-level model provides a better fit compared to the single-level model according to the LR test (Prob > chi2 = 0.0000).

TABLE 3: Probability of being overeducated and change in the employment share of MIDDLE-SKILLED and MILDLY-ROUTINE occupations (2003-2010)

	EMPTY MODELS			MODELS ON SKILL LEVELS					MODELS ON TASK CONTENTS		
	1	2	3	4	5	6	7	8	9	10	11
Individual-level variables											
30-49				-0.0388***	-0.0381***	-0.0381***	-0.0367***	-0.0367***	-0.0381***	-0.0358***	-0.0358***
				(-42.76)	(-42.25)	(-42.23)	(-40.98)	(-40.98)	(-42.25)	(-39.92)	(-39.91)
50-64				-0.0584***	-0.0558***	-0.0557***	-0.0558***	-0.0558***	-0.0558***	-0.0541***	-0.0541***
				(-56.42)	(-54.21)	(-54.17)	(-54.54)	(-54.53)	(-54.20)	(-52.79)	(-52.76)
female				-0.0249***	-0.0111***	-0.0111***	-0.0101***	-0.0101***	-0.0111***	-0.0122***	-0.0122***
				(-36.87)	(-15.70)	(-15.71)	(-14.31)	(-14.32)	(-15.70)	(-17.22)	(-17.22)
Secondary level of education (ISCED 3-4)				0.143***	0.188***	0.188***	-0.304***	-0.304***	0.188***	-1.095***	-1.094***
				(154.72)	(202.92)	(202.94)	(-41.63)	(-41.63)	(202.92)	(-75.01)	(-75.01)
Tertiary level (ISCED 5-6)				0.412***	0.495***	0.495***	-0.292***	-0.292***	0.495***	-0.417***	-0.417***
				(399.72)	(457.31)	(457.33)	(-36.02)	(-36.02)	(457.32)	(-25.77)	(-25.75)
National				-0.104***	-0.0766***	-0.0767***	-0.0749***	-0.0749***	-0.0767***	-0.0769***	-0.0770***
				(-65.97)	(-49.66)	(-49.70)	(-48.78)	(-48.80)	(-49.68)	(-50.07)	(-50.10)
Temporary contract					0.00982***	0.00982***	0.0116***	0.0116***	0.00983***	0.0109***	0.0109***
					(8.21)	(8.21)	(9.78)	(9.78)	(8.22)	(9.14)	(9.14)
Unskilled occupation					0.166***	0.166***	0.169***	0.169***	0.166***	0.166***	0.166***
					(183.63)	(183.63)	(188.65)	(188.65)	(183.63)	(185.34)	(185.34)
Part-time contract					0.0232***	0.0232***	0.0235***	0.0235***	0.0232***	0.0231***	0.0232***
					(21.23)	(21.24)	(21.64)	(21.64)	(21.23)	(21.30)	(21.31)
Small firm					-0.0480***	-0.0480***	-0.0485***	-0.0485***	-0.0480***	-0.0485***	-0.0485***
					(-54.78)	(-54.77)	(-55.60)	(-55.59)	(-54.77)	(-55.57)	(-55.56)
Medium and large firm					-0.0586***	-0.0586***	-0.0587***	-0.0587***	-0.0586***	-0.0589***	-0.0589***
					(-69.18)	(-69.19)	(-69.72)	(-69.72)	(-69.19)	(-69.94)	(-69.95)
Industry sector					-0.0696***	-0.0696***	-0.0752***	-0.0752***	-0.0696***	-0.0640***	-0.0640***
					(-36.77)	(-36.79)	(-39.93)	(-39.93)	(-36.78)	(-33.93)	(-33.93)
Service sector					-0.106***	-0.106***	-0.115***	-0.115***	-0.106***	-0.103***	-0.103***

					(-57.61)	(-57.60)	(-62.32)	(-62.31)	(-57.61)	(-55.89)	(-55.87)
Country-year level variables											
Share of middle-skilled in employment						0.00422***	-0.0102***	-0.0122***			
						(5.26)	(-12.39)	(-10.06)			
2ry educ*MS share							0.0141***	0.0141***			
							(68.04)	(68.04)			
3ry educ*MS share							0.0228***	0.0228***			
							(98.07)	(98.07)			
Share of mildly-routine employment									0.00638***	-0.0165***	-0.0189***
									(4.78)	(-11.93)	(-12.86)
2ry educ*MdR share										0.0307***	0.0307***
										(88.10)	(88.10)
3ry educ*MdR share										0.0217***	0.0217***
										(55.99)	(55.98)
share of students in VET								-0.000273			-0.000305
								(-0.66)			(-0.75)
tetiary educated pop								-0.00217*			-0.00264***
								(-2.39)			(-3.90)
Trade balance								6.19e-08			6.71e-09
								(0.41)			(0.05)
ICC country	0.021		0.021	0.0421	0.047	0.0456	0.0515	0.051	0.0367	0.041	0.041
ICC year and country			0.0221	0.0445	0.0498	0.0479	0.0539	0.053	0.0393	0.0437	0.043
Var country	0.05		0.05	0.0654	0.068	0.0044	0.005	0.005	0.0035	0.0039	0.0038
Var year		0.0046	0.0132	0.0158	0.0165	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Residual	0.0344	0.348	0.344	0.311	0.3038	0.092	0.091	0.091	0.092	0.091	0.091
Constant	0.134***	0.142***	0.133***	0.0866***	0.0999***	-0.0453	0.461***	0.602***	-0.159**	0.795***	0.980***
	(14.15)	(79.81)	(14.00)	(6.91)	(7.65)	(-1.49)	(14.68)	(9.01)	(-2.87)	(13.87)	(13.20)
N	868224	868224	868224	868224	868224	868224	868224	868224	868224	868224	868224

Model 4 includes all individual-level variables, and Model 5 includes the latter and job characteristics. The effects of all the individual-level variables are significant. In line with previous literature, the probability of being overeducated declines with age: belonging to the 30-49 age group reduces the probability of being overeducated by 0.04 and the 50-64 age group by 0.06. Adding other individual-level predictors suggest that along with belonging to older age groups, being female and country national reduces the probability of being overeducated while having higher levels of education strongly increases this probability. Individuals with upper secondary and post-secondary non-tertiary education have a 0.14 higher probability of being overeducated, while for those with tertiary education, it increases up to 0.41. Adding these variables to the model increases the unexplained variance at the country level (16%) and slightly decreases the unexplained variance at the individual level (79%).

When all individual-level variables, including job characteristics, are added to the model (Model 5), the coefficients for individuals with upper secondary and post-secondary non-tertiary education and tertiary levels of education remain statistically significant and even increase: those from the former group are 19% and the latter 49% more likely to be overeducated. The effect of other individual-level variables remains significant and in the same direction, even though the effect of age, gender and nationality slightly weaken. In line with the literature, having temporary and part-time contracts increases the probability of overeducation by 1% for the workers with temporary contracts and 2% for part-time workers. Similarly, the probability of being overeducated decrease with increasing firm size, it is 5% less for small firms (11-49), and 6% less for medium and large firms (50<) compared to micro firms. The risk of overeducation is also lower for workers in Industry (-7%) and Service sectors (-10%) compared to Agricultural sector. Among the job characteristics, working in an unskilled occupation is a major determinant of overeducation; these workers are 17% more likely to be overeducated.

Model 6 adds the share of middle-skilled employment. Net of individual-level and job characteristics, the share of middle-skilled workers is significantly, slightly and positively associated with the probability of being overeducated: one percentage point increase in the share of middle-skilled workers is associated with a 0.4% percentage point increase in the probability of being overeducated. While it is not high in absolute terms, it is quite substantial in relative terms, taking into consideration that the share

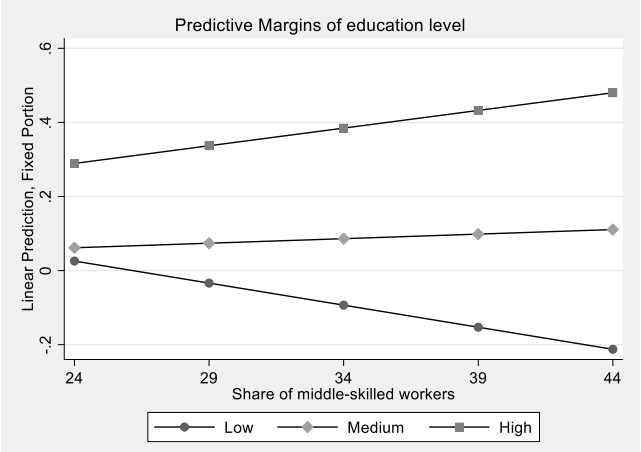
of middle-skilled employment is entered as a percentage of the total share. Including this country-level variable does not significantly alter the significance or magnitude of individual-level variables. Since we are particularly interested in whether the share of middle-skilled employment affects workers with different educational levels differently, Model 7 introduces interaction term between educational level and the share of middle-skilled employment. The final model suggests that 7% of the variance takes place between countries, whereas 93% can be attributed to the variance between individuals.

The level of middle-skilled employment appears to influence the probability of overeducation for the two groups differently. One percentage point increase in the share of middle-skilled workers is associated with a 1% percentage point increase in the probability of being overeducated for workers with an upper-secondary and post-secondary non-tertiary level of education, and 2% for tertiary-educated.

The share of students enrolled in upper-secondary vocational programmes is negatively associated with overeducation probability, but it is not significant. The association with the share of the population with tertiary education is, instead, negative and significant. Including these country-level variables does not alter the size of the effect or significance level of the main independent variables (educational level, share of middle-skilled employment, and their interaction).

Figure 1 below illustrates the marginal effect of the employment share of middle-skilled on the probability of being overeducated for different educational groups.

Figure 1. Predictive margins, probability of overeducation by the level of education as the share of middle-skilled jobs increases, 2003-2010

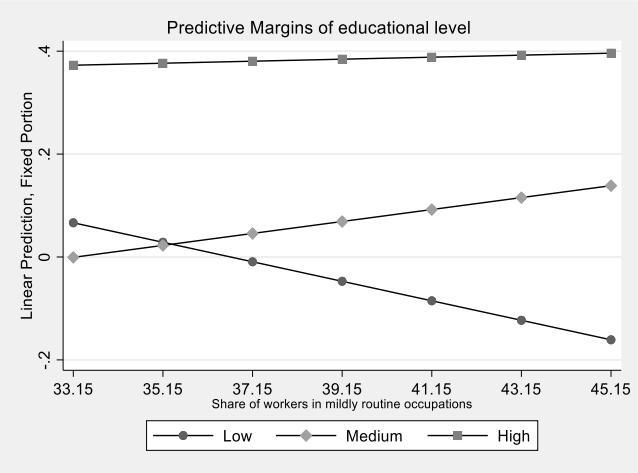


There is a more than 20 percentage point gap in the probability of being overeducated for the two groups. It increases as the share of employment in middle-skilled occupations increases. In short, the higher is the share of middle-skilled workers, the larger is the gap in the probability of overeducation between the groups of workers with an upper-secondary and post-secondary non-tertiary level of education and tertiary educated. Apart from being high, at around 30%, the predicted probability of overeducation increases much steeper for the group of tertiary educated and is very low for the workers with upper-secondary and post-secondary non-tertiary education, remaining below 10% when the share of middle-skilled employment reaches its maximum.

With regard to the share of mildly routine occupations, the effect of individual variables and employment characteristics on the probability of overeducation remain rather similar. Model 10 introduces an interaction between the share of mildly-routine intense occupations and the levels of education. It suggests that a one percentage point increase in the share of middle-routine occupations increases the chances of overeducation by 3% for individuals with an upper secondary and post-secondary non-tertiary level of education and by 2% for those with tertiary. Therefore, an increase in the share of mildly routine occupations seems more consequential for intermediate-educated workers.

Figure 2 below illustrates the marginal effect of the employment share of mildly routine occupations on the probability of being overeducated for different educational groups.

Figure 2. Predictive margins, probability of overeducation by the level of education as the share of mildly-routine jobs increases, 2003-2010



A very large gap between the probability of overeducation is visible when the share of employment in mildly-routine occupations is the lowest. However, with an increasing share of employment in these occupations, the probability of overeducation for individuals with an intermediate level of education increases steeply, while it remains basically stable for tertiary educated.

Comparing the relations between the share of employment in medium-skilled occupations and mildly-routine occupations and the probability of overeducation, it appears that individuals with a tertiary level of education face a higher probability of overeducation as the share of middle-skilled occupations expands. In contrast, its effect on medium-skilled is weaker even though positive. Medium-skilled workers face, instead, a sharply increasing probability of being overeducated with the growth of mildly-routine occupations, compared to tertiary educated, even though the risk of overeducation in absolute terms is higher for the latter. These findings might suggest a substitution effect when tertiary skilled workers substitute those with medium skilled, and the latter lower-skilled in mildly-routine intense occupations.

Considering differences in ISCO classification and variations in the patterns of occupational change discussed in the previous chapter and continuing educational expansion, it might be interesting to assess whether the risks of overeducation for different educational groups were altered in 2011-2018. Descriptive evidence presented earlier suggested that the rates of overeducation declined compared to the

previous period, but it was more visible for the workers with an intermediate level of education rather than tertiary graduates.

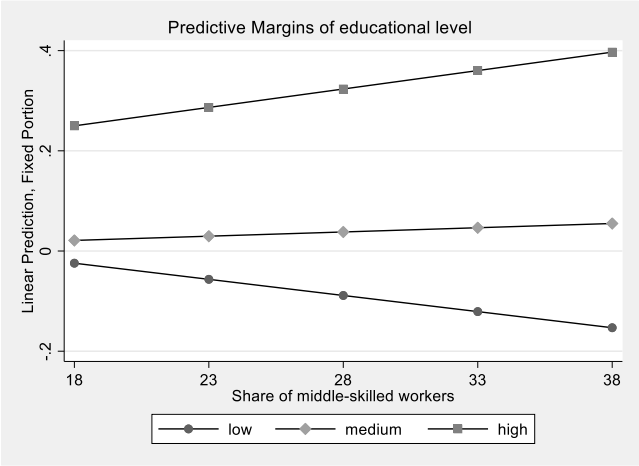
Table 4 below presents the result of the mixed-effects model for the 2011-2018 period. The effects of individual variables remained largely similar. The relative disadvantage of individuals with intermediate and tertiary levels of education declined by 0.5% compared to the 2003-2010 period holding the rest of the variables constant.

TABLE 4: Probability of being overeducated and change in the employment share of MIDDLE-SKILLED and MILDLY-ROUTINE occupations (2011-2018)											
	EMPTY MODELS			MODELS ON SKILL LEVELS					MODELS ON TASK CONTENTS		
	1	2	3	4	5	6	7	8	9	10	11
Individual-level variables											
30-49				-0.0446***	-0.0393***	-0.0393***	-0.0389***	-0.0388***	-0.0393***	-0.0400***	-0.0400***
				(-52.66)	(-46.13)	(-46.14)	(-45.72)	(-45.60)	(-46.14)	(-47.03)	(-46.89)
50-64				-0.0602***	-0.0534***	-0.0534***	-0.0545***	-0.0544***	-0.0534***	-0.0549***	-0.0549***
				(-65.94)	(-57.87)	(-57.86)	(-59.16)	(-59.03)	(-57.87)	(-59.62)	(-59.46)
female				-0.0119***	-0.00299***	-0.00300***	-0.00235***	-0.00237***	-0.00300***	-0.00256***	-0.00257***
				(-20.29)	(-4.82)	(-4.83)	(-3.79)	(-3.81)	(-4.83)	(-4.12)	(-4.14)
Secondary level of education (ISCED 3-4)				0.104***	0.144***	0.144***	-0.101***	-0.100***	0.144***	-0.216***	-0.214***
				(118.39)	(163.30)	(163.31)	(-19.48)	(-19.23)	(163.30)	(-29.78)	(-29.53)
Tertiary level (ISCED 5-6)				0.362***	0.437***	0.437***	0.0234***	0.0257***	0.437***	-0.0725***	-0.0694***
				(386.94)	(442.66)	(442.69)	(4.25)	(4.64)	(442.68)	(-9.34)	(-8.93)
National				-0.0978***	-0.0747***	-0.0747***	-0.0745***	-0.0744***	-0.0747***	-0.0792***	-0.0792***
				(-78.64)	(-60.75)	(-60.76)	(-60.72)	(-60.61)	(-60.77)	(-64.44)	(-64.33)
Temporary contract					0.0237***	0.0237***	0.0255***	0.0256***	0.0237***	0.0230***	0.0230***
					(23.75)	(23.76)	(25.72)	(25.72)	(23.75)	(23.13)	(23.15)
Unskilled occupation					0.139***	0.139***	0.142***	0.142***	0.139***	0.138***	0.139***
					(167.12)	(167.11)	(171.35)	(171.27)	(167.13)	(166.62)	(166.58)
Part-time contract					0.0289***	0.0289***	0.0290***	0.0290***	0.0289***	0.0289***	0.0289***
					(31.81)	(31.83)	(32.00)	(31.93)	(31.81)	(31.88)	(31.81)
Small firm					-0.0411***	-0.0411***	-0.0408***	-0.0408***	-0.0410***	-0.0406***	-0.0405***
					(-52.30)	(-52.31)	(-52.18)	(-52.05)	(-52.30)	(-51.78)	(-51.66)
Medium and large firm					-0.0560***	-0.0559***	-0.0554***	-0.0553***	-0.0559***	-0.0555***	-0.0555***
					(-74.77)	(-74.77)	(-74.23)	(-74.01)	(-74.76)	(-74.37)	(-74.16)
Industry sector					-0.0827***	-0.0827***	-0.0888***	-0.0888***	-0.0827***	-0.0781***	-0.0782***
					(-46.76)	(-46.77)	(-50.30)	(-50.29)	(-46.77)	(-44.26)	(-44.28)
Service sector					-0.121***	-0.121***	-0.128***	-0.128***	-0.121***	-0.116***	-0.116***
					(-70.19)	(-70.19)	(-74.53)	(-74.47)	(-70.20)	(-67.38)	(-67.36)

Country-year level variables											
Share of middle-skilled in employment						0.00512***	-0.00407***	-0.00645***			
						(5.70)	(-4.54)	(-6.09)			
2ry educ*MS share							0.00815***	0.00812***			
							(48.37)	(48.06)			
3ry educ*MS share							0.0139***	0.0138***			
							(76.48)	(75.89)			
Share of mildly-routine employment								-0.000171	0.00590***	-0.00360***	-0.00478***
								(-0.77)	(6.27)	(-3.87)	(-4.82)
2ry educ*MdR share										0.00914***	0.00911***
								-0.00161***		(49.86)	(49.61)
3ry educ*MdR share								(-3.49)		0.0131***	0.0130***
										(66.22)	(65.78)
share of students in VET								-0.000171			-0.000229
								(-0.77)			(-1.07)
tetiary educated pop								-0.00162***			-0.00143***
								(-3.52)			(-3.44)
Trade balance								-0.000000174			-0.000000215*
								(-1.81)			(-2.35)
ICC country	0.0146		0.0143	0.0307	0.0336	0.039	0.0398	0.0329	0.0269	0.0265	0.0225
ICC year and country			0.0159	0.0331	0.0361	0.041	0.0412	0.0348	0.0291	0.0285	0.0244
Var country	0.04		0.0404	0.0546	0.0562	0.0037	0.0037	0.003	0.0025	0.0025	0.0021
Var year		0.0041	0.0134	0.0153	0.0153	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Residual	0.3358	0.3384	0.3356	0.0306	0.3006	0.0904	0.0899	0.0899	0.09	0.09	0.09
Constant	0.124***	0.132***	0.124***	0.0827***	0.00965	-0.144***	0.132***	0.266***			
	(16.33)	(88.92)	(16.37)	(8.02)	(0.81)	(-4.84)	(4.43)	(5.91)	-0.0995**	0.273***	0.378***
	0.3358	0.3384	0.3356	0.0306	0.3006	0.0904	0.0899	0.0899	(-2.77)	(7.69)	(8.27)
N	1098692	1098692	1098692	1098692	1098692	1098692	1098692	1098692	1098692	1098692	1098692

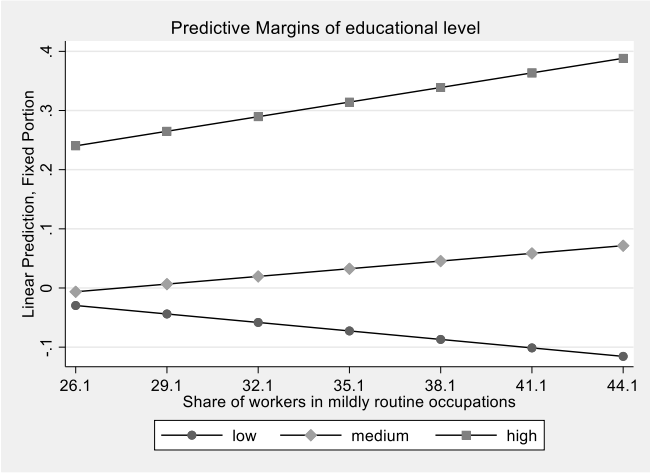
The effect of macro variables preserved the same direction, but the magnitude slightly decreased. The most visible changes between the two periods emerge when comparing the models with interaction terms. As Figure 3 below demonstrates, the gap in the predicted probability of overeducation for individuals with intermediate and tertiary education levels widened compared to the 2003-2010 period, rising from approximately 2.5 to around 4 when reaching the highest share of middle-skilled occupations. As in 2003-2010, the slope remains steeper for the workers with tertiary education.

Figure 3. Predictive margins, probability of overeducation by the level of education as the share of middle-skilled jobs increases, 2011-2018



More substantial differences between the two periods arose when assessing the interaction between the share of mildly-routine occupations and different educational levels on individuals' probability of overeducation (Figure 4 below).

Figure 4. Predictive margins, probability of overeducation by the level of education as the share of mildly-routine jobs increases, 2011-2018



In the 2003-2010 period, the gap in the probability of being overeducated was narrowing for the intermediary and tertiary educated, from around 4 to 2 points. This resulted from a steeply increasing probability of being overeducated for the former group and a slight decline for the latter with an increasing employment share of mildly-routine occupations. In 2011-2018, the gap between the two widened: the predicted probability of overeducation for intermediary-educated workers remained very low and almost unchanged at different levels of employment share of mildly-routine occupations, whereas that of tertiary-educated increased, and increased rather steeply. These findings suggest that the relative disadvantage in terms of overeducation of workers with tertiary level of overeducation persisted and that it is rather sensitive to the changes in occupational structure and the growth in mildly routine occupations.

4.5. Conclusions

This Chapter investigated the change in the incidence of overeducation and how it is linked to occupational change. While a significant number of studies analysed how the risk of overeducation varies depending on individual determinants and macro determinants, very few scholars tried to assess the association between occupational

change and overeducation. Filling this gap was one of the main contributions of this Chapter.

Using the data from the European Labour Force Survey, this paper first analysed how the incidence of overeducation has changed in a more recent period from a cross-country perspective. The findings suggest that the overall incidence of overeducation decreased during the second period of observation compared to 2003-2010. It might be considered as support to the hypothesis of overeducation as a temporary phenomenon triggered by the economic crisis and recession. However, despite the overall decline, there has been a noticeable persistence in overeducation incidence, more visible in some countries and specific groups of individuals than in others.

During both periods, overeducation rates have been the highest in Southern European countries (to a lesser extent Greece), driven to a larger extent by the group of workers with an intermediary level of education. Overall, the incidence of overeducation was lowest in CEE countries, resulting from almost no overeducation among workers with an intermediary level of education and a rather high incidence of overeducation among tertiary graduates, especially so in Slovakia, Hungary and the Czech Republic. This peculiarity of CEE and Baltic countries might be due to a very high share of the population with an upper-secondary and post-secondary non-tertiary level of educational attainment inherited from the past socialist system. Overall, the incidence of overeducation was highest among tertiary graduates and lowest among individuals with an intermediary level of education. Moreover, there was very little to no variation across different age groups among the letter, which is likely to be a positive result of vocational education systems, more responsive to the demand through training of young and retraining of older workers.

Observing comparatively high overeducation rates among tertiary graduates, scholars suggested educational expansion to be the main cause driving this trend. However, the present analysis illustrates that the share of tertiary graduates continued to increase during 2011-2018, whereas the incidence of overeducation tended to decline, which contradicts the former hypothesis. Acknowledging the limited power of educational expansion explanation, this analysis suggested that there might be a link

between occupational change and incidence of overeducation since occupational change describes an impact of demand factors.

Descriptive evidence across occupational groups suggested that the incidence of overeducation was higher among the occupational groups of Clerks (MG4), Plant and machine operators and Assemblers (MG8) and Service and sales workers and Elementary occupations (MG5 and 9). However, whereas there was a general tendency of declining incidence of overeducation among medium-skilled occupations, it instead increased among low-skilled occupations, and more so between 2011-2018. Similarly, when the incidence of overeducation was assessed across groups of occupations based on their routine intensity, the decline was visible for the group of least routine occupations, dynamics were mixed among most-routine occupations with a general tendency towards decline, whereas it was high and continued to increase over both periods in the group of mildly-routine occupations.

As the analysis of the previous chapter on occupational change demonstrated, almost all of the countries have experienced an expansion of high-skilled, high-paid non-routine occupations, with a generally lower incidence of overeducation in this group. The share of middle-skilled and generally middle-paid workers, with high intensity in routine tasks and overall lower incidence of overeducation, mostly declined. Finally, the employment shares of low-paid occupations with high routine intensity have declined, whereas that of low-paid and mildly routine occupations have increased. Following this process of “hollowing out”, we expected the increasing substitution of workers with different skills going down the occupational ladder and squeezing out low skilled. The risk of overeducation across educational groups was expected, thus, to be different depending not only on individual characteristics but also on the nature of occupations that decline and expand.

The results of the regression analysis of this Chapter, indeed, support this hypothesis. The effect of individual-level variables confirmed the previous finding from the literature with a higher risk of overeducation for men compared to women, foreigners compared to nationals and younger compared to older workers. The risk of overeducation was also higher for workers with temporary and part-time contracts, which is also in line with the evidence. The risk of overeducation was increasing the

higher is the level of education, which is rather predictable, but its effects differed when the occupational change was taken into account.

First of all, there was a significant gap in the probability of overeducation for the workers with intermediate and tertiary levels of education. The effect of an increasing share of middle-skilled on the probability of overeducation was almost parallel for the two groups. The gap in the predicted probability between the two was quite constant, around 30 pp.

Second, the pattern for the two groups was rather different when we analysed its connection to the expansion of mildly-routine occupations. During 2003-2010, an increasing share of these occupations was driving rather steeply an increase in the probability of overeducation for the workers with upper-secondary and post-secondary non-tertiary education. The predicted probability of overeducation for tertiary-educated was higher in absolute terms but decreasing. The gap was narrowing; the stronger was the expansion of mildly-routine occupations.

During 2011-2018, the predicted probability of overeducation for intermediary educated was below 10%, with almost no change despite an increase in the share of mildly routine occupations. However, the previous trend of the decline in the predicted probability of overeducation for tertiary-educated reversed and was increased along with an expansion of mildly-routine occupations.

The presented evidence, very importantly, suggests that the relative disadvantage of tertiary-educated workers persisted and even increased. Considering that the share of middle-skilled occupations is declining everywhere, the workers with intermediate skills and tertiary graduates (especially during the second period) seem to have been squeezing out lower-skilled workers in mildly-routine occupations. Moreover, what is particularly worrying, is that along with upgrading of occupational structure and general upskilling, the incidence of overeducation remains rather high, especially among tertiary educated. It is also likely to remain high, taking into consideration the expansion of mildly-routine occupations.

Therefore, routine-biased technological change seems to be responsible not only for the decline of the jobs in the middle but also for its adverse effect on workers' productivity, pushing them to enter occupations that require a lower level of education

than they possess. Considering occupational change and its bias towards routine jobs, providing workers with skills that complement technology becomes fundamental.

Conclusions

This dissertation explored the issues of occupational change and overeducation, trying to establish whether there is a connection between the two. Each topic was addressed by taking into consideration the previous contributions from different disciplinary fields – primarily sociology, economic sociology and labour economics, using and combining various sources of data and employing relevant to answering the research questions methods. Thus, a number of interesting results contributing to the existing literature on these two topics emerged from this research and are discussed below.

First of all, the dissertation assessed changes in occupational structure using different indicators of job quality, occupational task content and addressing the issue from a multidisciplinary perspective. Independently from the indicators used, there has been strong growth among high-skilled, high-paid and non-routine jobs, which, however, were frequently around the average when employment quality and work-life balance were assessed. While many studies interpreted this result with strong growth at the top as supporting the SBTC hypothesis and upgrading rejecting RBTC, the picture that emerges from this dissertation is more nuanced.

Comparing the results using different indicators, it appears that technological change leads to increasing demand for high-skilled workers with high intensity in cognitive and cognitive-interactive tasks and decreasing for highly routine and routine manual tasks. Whereas the former cluster at the top of skill and earning distribution, the latter are found in the middle and at the bottom. Hence, whether a polarization pattern emerges depends on where these latter occupations fall in the wage distribution, implying that RBTC can result not only in polarisation but, as SBTC, in upgrading. This finding questions the assumptions of Goos and Manning (2009), indicating that most routine-intense occupations are not necessarily found in the middle of the earnings distribution. On the other hand, it casts doubt on the suggestion of Fernandez-Macias and Hurley (2017), who concluded that RBTC in European countries led to upgrading. Routinization, in this research, appears not to preclude neither upgrading nor SBTC while allowing for better distinction between tasks and skills.

It is important to point out that these nuances are impossible to identify if the occupational change is assessed using quintiles of occupational distribution, as merging occupations hides dynamics in specific occupations and prevents from detecting possible drivers behind it. Analysis at the level of ISCO MG and ISCO 2-digit suggest that in line with the routinization and hollowing-out hypothesis, there has been a continuous decline among routine-intense industrial occupations in the middle of the earnings distribution with an above-average index in terms of employment quality and work-life balance. This trend took place across all the European countries being especially strong during the 2003-2010 period. A slight exception from the case were the CEE countries with a still comparatively high share of employment in industrial occupations. Overall, regression analysis demonstrated that among wage setting and labour market institutions, the strictness of employment protection legislation and collective dismissals regulation were the only institutions associated with the mitigating impact of technological change on the employment share of middle-skilled occupations. These results align with more recent findings on the limited impact of robots on employment and wages in Europe, which are likely mediated by the role of labour market institutions and prevents both from further declining (Graetz & Michaels, 2018).

At the same time, there has been an expansion among Service and Sales occupations with a mildly routine and strong interactive intensity, which fall in most countries in the bottom quintiles. If occupational change is analysed focusing exclusively on quintiles, this trend is hidden due to the mixed dynamics among lowest-paid occupations: decline in the employment share of Elementary occupations and growth in Services and sales occupations. While Elementary occupations resulted in being most routine, Service and Sales occupations are average in terms of routine intensity with a high share of interactive tasks. These features impede automation, suggesting that the task content of occupations remains crucial for understanding the dynamics of occupational change. Moreover, due to these different dynamics across occupations, conclusions with respect to upgrading based on quintiles analysis might be unduly positive as a considerable share of “good” jobs continue to decline, while the share of low-paid service and sales occupations remains high and is likely to continue to grow accompanying the expansion at the top.

The expansion among high-skilled and high pad jobs occurred in the vast majority of the countries, with the exception of Greece, Hungary, Romania and Slovakia, with a downgrading trend. Comparatively, the strongest growth in these occupations occurred in the countries with a strong supply of tertiary educated and the highest share of investments in R&D, education, and training, including adult training. However, while the supply of educated labour continued to grow, the expansion at the top slightly slowed down during the 2011-2018 period. Moreover, looking at the educational composition of occupations and the overall trend of upskilling, one trend becomes rather visible: the share of higher-skilled workers tended to increase across all the occupations, squeezing out the lower-skilled. This evidence suggested that there might be a relation between overeducation and occupational change and that upskilling might be taking place at the cost of rising overeducation.

The empirical analysis of the change in the incidence of overeducation suggested that, overall, it tended to increase during the 2003-2010 period and decline during 2011-2018. While this finding might be considered as a confirmation of the hypothesis of overeducation being a temporary phenomenon driven by the economic crisis, there has been a noticeable persistence of overeducation, particularly so among tertiary educated. Considering vast literature discussing individual and, to a lesser extent, macro determinants of overeducation, this research pursued the objective of filling the gap in the literature assessing the association between occupational change and overeducation.

Results from the descriptive analysis suggest that overeducation was higher among workers from medium-skilled occupations and highest among the low-skilled. With respect to task content of occupations, overeducation incidence was highest among mildly-routine occupations and, in some countries, most routine occupations. Lower incidence of overeducation in the middle and among most-routine occupations was registered in the countries with strong VET systems, with, moreover, very little variation in the incidence across age and gender groups. It was similarly the case in CEE and Baltic countries with almost universal attainment of secondary level of education.

While there has been a decline in the incidence of overeducation among medium-skilled occupations, it has, instead, increased among lower-skilled mildly-

routine occupations. Linking this observation to the patterns of occupational change, we expected “hollowing out” in the middle to result in substituting workers down the occupational ladder, squeezing out lower-skilled. The evidence suggests that, considering the decline in the middle, the countries with stronger expansion among lower-skilled mildly-routine groups of occupations experienced a persistently high incidence of overeducation. This implies that a more polarized pattern of occupational change with growth among mildly-routine occupations is associated with a higher incidence of overeducation, especially for tertiary educated.

Indeed, the empirical analysis demonstrated that there was a significant gap in the risk of overeducation among educational groups, with tertiary-educated being persistently disadvantaged. Between 2003-2010, the risk of overeducation for medium-skilled workers was slightly increasing the higher was the share of middle-skilled occupations and steeply increasing the higher was the share of mildly-routine occupations. As for tertiary-educated, the predicted probability of overeducation was on average 20% or higher compared to the medium-skilled, but while it was positively associated with employment in middle-skilled occupations, it was slightly negatively associated with employment share in mildly-routine occupations.

The picture has changed during the 2011-2018 period: the risk of overeducation for medium-skilled declined compared to the previous period and was below 10%. It, instead, increased for tertiary-educated, whose predicted probability of overeducation was rising the higher was the share of employment in the middle-skilled, and, in contrast to the previous period, in mildly-routine occupations as well. This evidence suggests that the relative disadvantage of workers with tertiary education not only persisted but has even increased with the expansion of employment in lower-paid, lower-skilled, mildly routine occupations. Moreover, since the share of middle-skilled occupations has been declining, workers with upper-secondary and post-secondary non-tertiary levels of education as well as tertiary-educated appeared to squeeze out lower-skilled workers in mildly routine low-skilled occupations. Whereas during the first period it was driven by an increasing share of medium-skilled, during the second period it was a combination of the latter and tertiary-skilled. These findings suggest a substitution effect when tertiary skilled workers substitute those with medium-skilled and the latter lower-skilled in mildly-routine intense occupations. Following the results of this analysis and considering the persistence of overeducation, we might conclude

that human capital theory alone cannot explain the dynamics and that the findings are more in line with what is predicted by signalling theory. Moreover, while educational expansion has been considered an important driver of the incidence of overeducation, this analysis doesn't seem to confirm it. The educational expansion has taken place during the entire 2003-2018 period, but the overall incidence of overeducation, overall, slightly decreased by the end of the period.

Taking into consideration the presented evidence, a number of observations emerge. First, while there has not been pervasive and strong polarization, there has been a widespread continuous tendency of "hollowing out" in the middle. Most importantly, the decline occurred among relatively well-paid jobs with good employment quality being mitigated, to some extent, by hiring and firing regulations. This finding suggests that considering continuous technological change, providing workers with skills able to complement technology while encouraging firms to retain workers and provide training is fundamental for not leaving them behind. Otherwise, there might be a risk of going over what happened following the Industrial revolution with massive unrest, where the middle class is fated to repeat the experience of middle-income artisans. More generally, we see that technological optimism is often counterbalanced with a more pessimistic view pointing out the substituting effect of technology and, as a result, the declining middle class, who appear to be more prone to support far-right parties. Supporting and encouraging training and re-training, thus, appear to be of utmost importance in order to mitigate the impact of technological disruption on the labour market and social cohesion in general. While the current research focused at the macro level and on the role of labour market institutions, in particular, future research might be interested in assessing the trajectory of employees in middle-skilled routine intense occupations, namely on what determines whether the employee remains employed or exits the occupation, and what is the role of training in re-training practices in retaining these workers.

Second, along with the decline in the middle, most of the countries experienced an increase in the share of lower-paid service and sales workers. In this context, the increasing supply of tertiary-educated has apparently forced medium and high-skilled workers to enter lower-skilled jobs. These occupations, especially personal service and personal care workers, are unlikely to be substituted by technology in the nearest future. Moreover, some scholars suggest that they might further expand due to

increasing demand for service and a “caring economy” (Dwyer, 2013). Taking into consideration that these low paid and more often than not precarious jobs are likely to expand, more attention should be devoted to improving their quality.

Altogether, these findings suggest that supply might not match the demand properly, suggesting that policymakers should pay more attention to providing skills and education which are relevant to the demand and are in line with changes in the processes of production and technology. Fostering public and private investments in research and development as well as human capital appear to be equally important for creating high skilled jobs and absorbing the labour supply. While the expansion of tertiary education has been of extreme importance for upgrading of occupational structure as well as improved social and economic well-being, the tertiary-educated remain relatively more disadvantaged in terms of overeducation risks. The results of the analysis would have probably been even worse if we used the required level of education instead of the mode of educational level in occupation. Unfortunately, no such indicator allowing for a long-term analysis is currently available. To expand the evidence further on which factors determine the risk of overeducation in the context of occupational change, future research could analyse how the risk of overeducation is linked to the fields of education and how it varies across occupational groups and tasks categories. This would allow reaching a more fine-grained picture of how well the demand matches the supply and what fields of education guarantee a better placement in the context of skill- and task-biased technological change.

Appendix A

Appendix to Chapter 1

Summary and conclusion of the main studies on occupational change					
Author	**Work**	**Findings on occupational change**	**Countries**	**Source and period**	**Method**
Acemoglu D., Autor D. 2010	Skills, Tasks and Technologies: Implications for Employment and Earnings	**Polarization** of occupational structure prevail: monotonic growth 1979-1989; strong growth at highest percentiles, decline in the middle and modest growth at the bottom 1989-1999; employment growth concentrated in lowest percentiles, middle share declined and highest remained practically unchanged 1999-2007. **Polarization** of employment assessing task composition: employment growth in non-routine cognitive and non-routine manual and decline in routine jobs.	US	CPS (1963-2008); Census of Populations (1960, 1970, 1980,1990,2000); American Community Survey (2008).	For occupational structure change: ranking 318 occupations by skill level, occupation-skill ranking approximated by average wage for creating occupational percentiles. Changes in occupational task composition are assessed assigning task groups (Non-routine cognitive, Routine cognitive, Routine manual, and Non-routine manual) to broad occupational categories estimating their intensity for each category.
Asplund R., Barth E., Lundborg P., Nilsen K. 2011	Polarization of the Nordic Labour Markets	At 2-digit job and wage **polarization** for Norway, Sweden and US and **upgrading** for Finland. At 3-digit Finland also demonstrated **polarisation**.	Finland, Norway, Sweden, US	LFS Finland (1999, 2001,2005), Wage Statistics Norway 1997, 2000,2006) Statistics Sweden (1997, 2001, 2006)	Estimate occupational growth, employment share through ranking 2-digit occupational categories by deciles by their median wage. Separate analysis of wage dispersion and change in occupational wages

Autor D., Dorn D. 2013	The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market	**Polarization** during the whole period with largest employment and wage growth in the top, modest at the bottom, and weak in the middle. Polarization is particularly linked to the expansion of low skilled service sector and change in labour specialization.	US	Census IPUM (1950,1970,1980,1990,2000); American Community Survey (2005); DOT.	Assess changes in employment share ranking occupations by skill level approximated by mean log wage in each occupation. Create RTI index matching occupation and job task requirements, obtaining routine, manual and abstract job classification. Construct routine employment share measure for commuting zones to test the link between the level of routine intensity of employment and wage polarization through OLS.
Autor D., Katz L., Kerney M. 2006	The Polarization of the U.S. Labor Market	**Polarization.** Analysing wage inequality: substantial increase in upper (90/10) and lower (50/10) wage inequality between 1979-1987, then diverging with continuous growth in the upper half and contraction in lower in 1987-2004. Analysing skill content: declining employment for lower skilled and monotonic growth moving up the education level distribution for 1980s. Afterwards polarized pattern: rapid growth of high-skilled jobs, moderate in low skilled and slow in the middle. Analysing task content: computerization leads to substitution of routine jobs	US	CPS 1973-2004;	Assess changes in employment shares (hours worked) sorting 3-digit occupations by mean years of schooling into deciles. To examine the impact of computerization on task content, divide occupations into 1)routine; 2) manual; and 3) abstract tasks.

Autor D., Levy F., Murnane R. 2003	The Skill Content of Recent Technological Change: an Empirical Exploration	**Polarization**: share of labour force engaged into nonroutine analytical and nonroutine interactive increased since 1960s, while those employed in routine cognitive, nonroutine manual and routine manual decreased.	US	Census Integrated Public Micro samples (IPUMS 1960, 1970, 1980, 1990);CPS (1980,1990, 1998); data from the Dictionary of Occupational Titles (1977,1991)	Append DOT occupation characteristics to IPUMS for measuring changes in task requirements. Propose task model including the following categories: routine manual, routine cognitive, non-routine analytical, non-routine interactive and non-routine manual. Estimate relation between computerization and tasks through OLS
Berman E., Bound J., Machin S. 1998	Implications of Skill Biased Technological Change: International Evidence	**Upgrading,** Skill biased Technological Change: Decline in manufacturing employment, especially among less-skilled. Increased percentage of non-productive workers in manufacturing employment in 1970-1980, slower growth in 1980-1990. Relative wage of nonproduction workers typically declined in the 1970s and increased in the 1980s	US, Norway, Luxemburg, Sweden, Australia, Japan, Denmark, West Germany, Austria, UK, Belgium	United Nations General Industrial Statistics Database 1970-1980, 1980-1990	Assess the change in aggregate proportions of workers within industries.
Cirillo V. 2018	Job Polarization in European Industries	Smooth **polarization** when analysing changes in employment by occupational groups in Germany, Spain and Italy; while growth in high skilled occupations in France and the UK. **Reduced polarization** in manufacturing due to the decline of the low-skilled jobs; **strong** polarization in services due to the decline of jobs in the middle.	Germany, France, Italy, Spain and UK	EU LFS, Sectoral Innovation Database 1999-2011	Assess changes employment share and wages by macro-occupational groups and macro sectors
Dwyer R., Wright E. 2003	The Patterns of Job Expansions in the United States: a comparison of the 1960s and 1990s	**Upgrading i**n 1960s followed by rather even job growth in 1970-1980s. Asymmetrical **polarization** of the employment structure since 1990s: very strong growth in the top, moderately strong at the bottom, and weak growth in the middle.	US	CPS 1963-1980, 1983-2000	Jobs approach: classify jobs by economic sector and 2-digit occupation rank-ordering them on the basis of hourly median earnings and form 5 even job quality quintiles.

Dwyer R., Wright E. 2019	Low-Wage Job Growth, Polarization, and the Limits and Opportunities of the Service Economy	Study by periods: higher job growth in upper and lower quintiles rather than middle during expansion; during recessions stronger decline in the middle. Low wage job growth concentrated overwhelmingly in service sectors.	US	CPS 1983-2017,Outgoing Rotation Group Earner Study	Analyse occupational change by terciles, ranking jobs (combining sector and occupation) according to median hourly wage.
Fernandez Macias E., Hurley J. 2016	Routine-biased technical change and job polarization in Europe	Descriptive and decomposition analysis shows structural **upgrading** with mild polarization. Close to **polarization**/clear polarization in France, Germany and UK; upgrading Finland and Spain. Routine tasks are spread across middle as well as low-skilled occupations.	EU 15	EU LFS 1995-2007, for task content analysis EWCS, trade intensity index from World Input-Output database	Create routine, cognitive and social interaction indexes (EWCS) applying their averaged value to individuals and jobs (combination of occupation at 2-digits and sector). Analyse correlations among indexes, wage and education with job creation intensity index.
Fernandez-Macias E. 2012	Job polarization in Europe? Changes in the Employment Structure and Job Quality, 1995-2007.	**Polarization** in the Netherlands; France and Germany with stronger growth in high paid jobs; Belgium with no growth in the 1st quintiles, but the 2nd.	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.	EU LFS 1995-2007, EU SES, EU SILC	Combine information on occupation and sector to create jobs. Job quality measures (median earnings and education) are assigned to each job, which are ranked for creating job quality quintiles.
Firpo S., Fortin N., Lemieux T. 2013	Occupational Tasks and Changes in the Wage Structure	Changes in the returns to occupational tasks have contributed to **polarization** in wage distribution. Technological change and deunionization were its drivers in the 1980s and 1990s, while offshorability from the 1990s onwards.	US	Current Population Survey (CPS) 1976-1990, 1990-2002, 2003-2004; O*NET	Estimate returns to occupational tasks creating five task indexes to classify jobs (information content, automation, face-to-face, on-site job, decision-making), indexes of technological change and offshorablility.

Fonseca T., Lima F., Pereiraz S. 2018	Job polarization, technological change and routinization: evidence for Portugal	Wage **polarization** from mid 1990s, preceeded by period of large inequalities with substantial wage growth among high wage earners and moderate among middle and bottom earners (SBTC). Confirmed by shift-share decomposition mostly within industries (especially in 1995-2007). Wage premium increased for abstract tasks, while declined for routine-manual. Employment in routine-cognitive slightly declined but with increasing wage premium due to the expansion of service sector.	Portugal	Quadros de Pessoal, matched employee employer dataset (1986-2007)	Shift share decomposition (between and within industry). Task measures (abstract, routine cognitive, routine manual and manual), are constructed matching O*NET with occupations.
Goos M., Manning A., Salomon A. 2009	Job Polarization in Europe	**Polarization** with growing employment shares at the bottom and the top. Employment share in the bottom relative to the middle increases in all the countries. Higher paying occupations expand relative to the middle in all the countries except Portugal.	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.	EU LFS 1993-2006	Assess changes of employment share (hours worked weekly) by ranking occupations at 2-digits by mean wage (UK mean wage applied to all the countries) and obtaining the difference within period. Task measures are created using O*NET and include: abstract, service and routine tasks.
Goos M., Manning A., Salomon A. 2014	Explaining Job Polarization: Routine-Biased Technological Change and Offshoring	**Polarization** is confirmed analysing the change in employment shares across European countries. Regression analysis support penalization of occupations with higher RTI demonstrating shift in relative demand away from occupations that are more routine and offshorable	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom	EU LFS 1993-2010, OECD STAN 1993-2010	Occupations are ranked by their mean wage for accessing change in employment shares. Create RTI index mapping it to european occupations and offshoring index. Regression is used to assess the impact of RTI and offshoring on employment share change (hours worked)

Gualtieri V., Guarascio D., Quaranta R. 2018	Does routinization affect occupation dynamics? Evidence from the 'Italian O*Net' data	Analysing employment change by occupation skill groups (high, medium, low): soft **upgrading** within 2005-2010 period, with a moderate increase of medium and high-skill jobs and a contraction of low skilled. **Polarization** during 2011-2016 with shrinking share of medium-skilled workers. Occupations ranked high on RTI tend to be penalized in both periods but stronger in the latter and particularly in service sector.	Italy	Survey on Italian Occupations (Indagine Campionaria sulle Professioni 2005-2016	Rank occupations at 4-digit by RTI index. Routine Task Index include following categories: routine cognitive, routine manual, analytical, interpersonal, non-routine manual, interpersonal adaptability. Analysis of employment dynamics by quintiles of the RTI distribution.
Guy Michaels, Ashwini Natraj, and John Van Reenen	Has ICT Polarized Skill Demand? Evidence from Eleven Countries Over Twenty Five Years	**Polarization**: wage bill of middle skilled rose from 1980-1986 and declined afterwards, while that of low-skilled continued to decline but at slower rate. High skilled wage bill share grew, especially fast in UK, Finland and US.	Austria, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Spain, the United Kingdom, and the United States	EU KLEMS 1980-2004	Estimate changes in industry-level wage bill share of workers grouping occupations on the basis of educational level (low, middle and high) establishing its relation with ICT capital and non-ICT capital across industries.
M.Goos and A.Manning 2003	Lousy and Lovely Jobs: The Rising Polarization of Work in Britain	**Polarization**: overall increase in non-routine cognitive and interactive tasks together with a decrease in routine tasks (especially cognitive ones) and a smaller decrease in non-routine manual tasks	UK	New Earnings Survey; LFS 1975-1999; UK Social change and Economic Life Initiative (1986)	Assess occupational change creating job quality deciles (combination of occupation and sector) and median wage. Assess changes in job tasks composition assigning each occupation tasks from DOT.
Machin S., Van Reenen J. 1998	Technology and Changes in Skill Structure: Evidence from Seven OECD Countries	**Upgrading**: wage bill share of non-production workers grew in all the countries with the largest increase in the UK and the US, and smallest in Sweden and Japan. Skill upgrading occurred within industries and mostly R&D intensive ones.	France, Germany, Japan, UK, US, Sweden, Denmark	Standardized analytical database, Business enterprise and R&D database	Estimate changes in worker wage bill shares between 1973-1989 and assess the level of between/within industry changes using occupation and education as a proxy for skills. Use regression and cost-share-based models to check complementarity between R&D intensity and skill upgrading, and computer usage and skill upgrading.

Oesch D., Rodriguez-Menes J. 2011	Upgrading or polarization? Occupational change in Britain, Germany, Spain and Switzerland, 1990–2008	Overall tendency towards **upgrading** in Germany, Spain and Switzerland: decline in agricultural, industrial and clerical employment and growth in business and welfare service jobs. Slightly **more polarized** pattern in UK with job growth in the bottom. Strongest growth in high-paid occupation in all four countries accompanied by decline in middling jobs in the UK and Switzerland, and low-skilled jobs in Germany and Spain. Routinization better describes employment evolution in UK and Spain, while SBTC in Germany and Switzerland.	Britain, Germany, Spain and Switzerland	LFS 1991-2008 (UK); SOEP 1990-2007 (Germany), EPA 1990-2008 (Spain); SAKE 1991-2008 (Switzerland)	Jobs approach: rank order 4 digit (Germany and Switzerland), and 3-digit occupations (Spain and UK) by median earnings calculated for each occupation to create quintiles. Analyse change in employment share by skill (high, middle, low) and task groups (non-routine service and manual tasks, routine cognitive and manual tasks and non-routine analytical and interactive tasks.
Oesch D., Piccito G. 2019	The Polarization Myth: Occupational Upgrading in Germany, Spain, Sweden, and the UK, 1992–2015	**Upgrading** in all the countries independently of the job quality indicator used. The UK is exception if job quality is measured by earnings. Analysis by periods (1992–2000, 2000–2008, and 2008–2015) demonstrates job decline at the bottom in all the countries, and overall continued upgrading with little variation over the business cycles.	Germany, Spain, Sweden, and the UK	EU LFS (1992–2015), for Sweden (1997-2015); ESS (2006, 2010, 2012); SES 2002.	Rank order occupations at 3-digit by median hourly gross wage, average education level, prestige and job satisfaction level and form job quality quintiles.
Oesch D., Murphy E. 2017	Is employment polarisation inevitable? Occupational change in Ireland and Switzerland, 1970–2010	**Polarization** during 1980s, **upgrading** from 1990 continued in 2000s	Ireland and Switzerland	Census data 1970-2010 for Switzerland; 1971-2006 for Ireland	Rank jobs using occupation and sector information. To analyse change creating even job quality quintiles using hourly median wage and education.

Peugny C. 2019	The decline in middle-skilled employment in 12 European countries: New evidence for job polarisation	**Strong polarization** in France, Sweden and Austria. Polarization in Germany, Italy, Greece and Spain with growth in low and high skilled, decline in industrial skilled employees but not clerical ones. **Relative polarisation** in Finland, Denmark, Netherlands, Portugal and UK with decline in middling jobs without growth at the bottom.	Austria, Denmark, Greece, Finland, France, Germany, Italy, Netherlands, Sweden, Portugal, Spain, the United Kingdom	EU LFS 1993-2013	Constructs skill groups using European Socio-economic Groups Classification (ESeG): high skilled, less skilled industrial employees, clerical workers in administration and service sectors, less skilled.
Piccito G. 2019	Qualificazione o polarizzazione? Il mutamento della struttura occupazionale in Italia, 1992-2015.	Different patterns before/after crisis. Strong **upgrading** characterized occupational change before the crisis (1992-2008) according to all the indicators with exception of job quality. In 2008-2015 **polarization** trend emerges if measuring job quality with earnings, prestige score and ISEI.	Italy	EU LFS 1992-2015	Rank order occupations at 3-digit by median hourly gross wage, average education level, prestige and job satisfaction level and form job quality quintiles.
Salvatori 2015	The Anatomy of Job Polarisation in the UK	**Polarization** through the whole period with stronger job growth on the top. Non-graduates account for declining middle due to the reduction of their numbers and shift towards the bottom of the distribution. Employment loss concentrated among less educated. Immigrants contributed to the growth of all segments but stronger at the top and bottom.	UK	LFS 1979-2012, New Earnings Survey, Annual Survey on Hours and Earnings	To access changes in occupational structure: 1) shift-share analysis based on education level and median wage information; 2) shift share decomposition of changes within and between demographic groups; 3) shift-share analysis for routine and non-routine occupations assessed through RTI index, direct information from survey and using occupations as proxies for job tasks; 4) changes in hourly median wages by deciles and decades.

Sebastian R. 2018	Explaining job polarisation in Spain from a task perspective	**Polarization** as for evolution of employment shares, but not for wages. Strongest decline in the middle of employment share distribution (routine jobs), while growth at the bottom (manual) and the top (abstract).	Spain	LFS (1994-2014); Structure of Earnings Survey; European Working Conditions Survey.	Changes in employment share: rank 2-digit occupation and 1-digit sector into five quintiles based on mean wage. For testing routinization: develop task indexes from direct survey (abstract, manual, routine) and routine task intensity index (RTI) and measure them for each occupation.
Spitz-Oener A. 2006	Technical Change, Job Tasks, and Rising Educational Demands: Looking outside the Wage Structure	Employment **polarization** during 1979-1999. Substantial shift towards employment in nonroutine cognitive tasks and decline in manual and cognitive routine tasks. Most of task change occurred within occupation and, specifically those with higher computer use.	Germany	Qualification and Career Survey 1979, 1985/86, 1991/92, and 1998/99,	Task based approach: nonroutine analytical tasks; nonroutine interactive tasks; routine cognitive tasks; routine manual tasks; and nonroutine manual tasks. Analysis of employment change through creation of skill index deciles.

Appendix B

Appendix to Chapter 3

Table 1: Correlations and reliability tests for the Task dimensions

ROUTINE

Please tell me, does your job involve short repetitive tasks of less than ... ? 1 minute

Please tell me, does your job involve short repetitive tasks of less than ... ? 10 minute

Generally, does your main paid job involve - Monotonous tasks?

	Repetitive of <1	Repetitive of <10 min	Monotonous tasks
Repetitive of <1	1		
Repetitive of <10 min	0,46	1	
Monotonous tasks	0,21	0,20	1

Item	Observations	Sign	item-test correlation	item rest correlation	average inter-item correlation	
Repetitive of <1 min	24237	+	0,77	0,43	0,20	0,33
Repetitive of <10 min	24237	+	0,76	0,43	0,21	0,35
Monotonous tasks	24237	+	0,65	0,24	0,46	0,63
Test scale					0,29	0,61

COGNITIVE

Please tell me, using the same scale, does your main paid job involve ...?
Working with computers: PCs, network, mainframe

Generally, does your main paid job involve ... ?
solving unforeseen problems on your own

Generally, does your main paid job involve ... ?
complex tasks

	Learning	Solving unforeseen problems	Complex tasks	Working with computers etc
Learning	1			
Solving unforeseen problems	0,30	1		
Complex tasks	0,42	0,28	1	
Working with computers etc	0,29	0,18	0,25	1

Generally, does your main paid job involve ... ? learning new things

Item	Observations	Sign	item-test correlation	item-rest correlation	average interitem correlation	alpha
Learning	24237	+	0,74	0,48	0,24	0,48
Solving unforeseen problems	24237	+	0,65	0,35	0,32	0,59
Complex tasks	24237	+	0,72	0,45	0,26	0,51
Working with computers etc	24237	+	0,63	0,32	0,34	0,60
Test scale					0,29	0,62

MANUAL

Please tell me, using the same scale, does your main paid job involve ...?
- Tiring or painful positions
- Carrying or moving heavy loads
- Repetitive hand or arm movements

	Heavy loads	Tiring positions	Repetitive hand movements
Heavy loads	1		
Tiring positions	0,47	1	
Repetitive hand movements	0,41	0,30	1

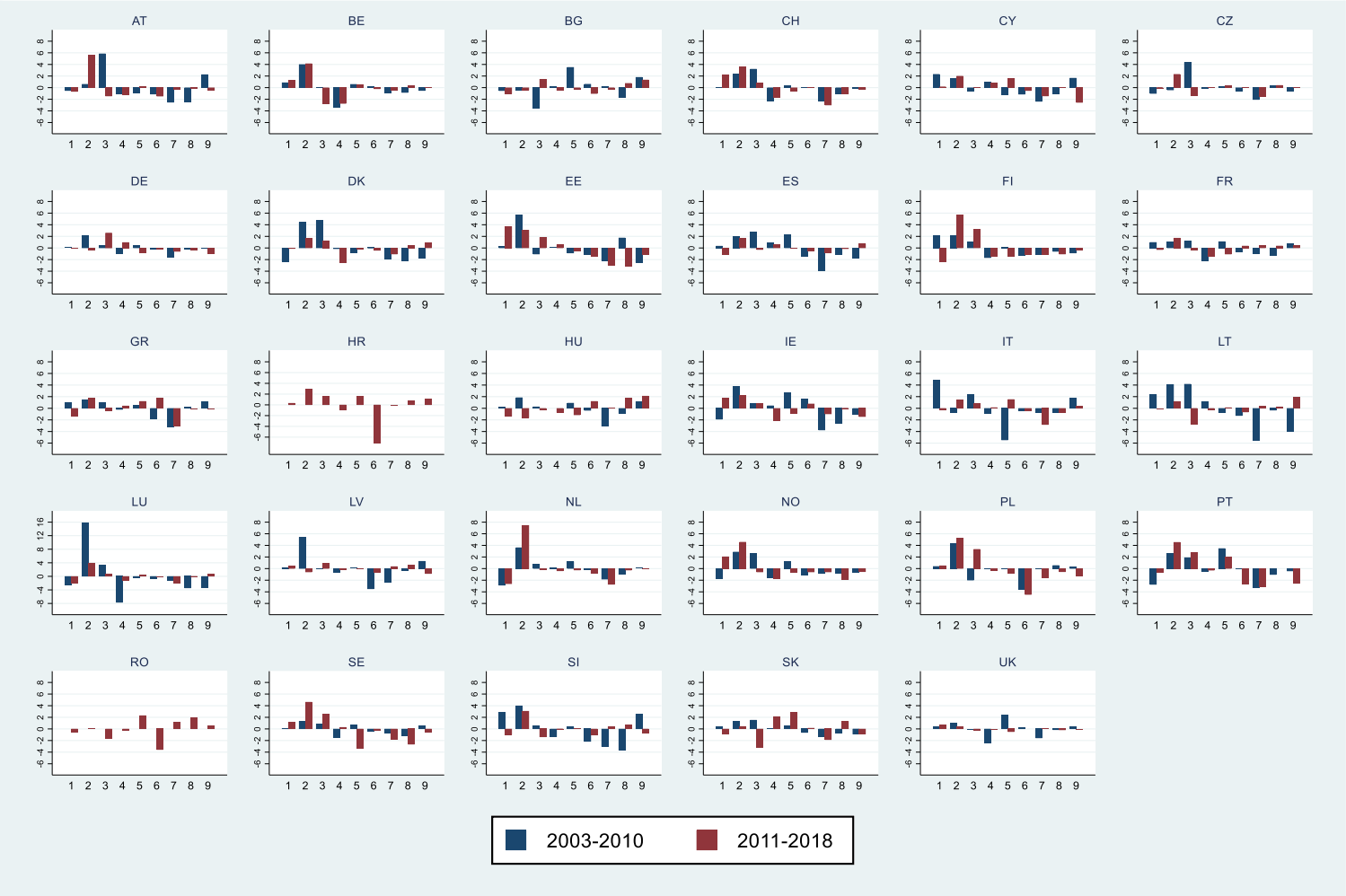
Item	Obs	Sign	item-test correlation	item-rest	average interitem correlation	alpha
Heavy loads	24237	+	0,81	0,54	0,30	0,47
Tiring positions	24237	+	0,77	0,46	0,41	0,58
Repetitive hand movements	24237	+	0,74	0,42	0,47	0,64
Test scale					0,39	0,66

INTERACTIVE

Please tell me, using the same scale, does your main paid job involve ...?
Dealing directly with people who are not employees at your workplace such as customers, passengers, pupils, patients, etc
Is your pace of work dependent on - Direct demands from people such as customers

	Dealing with indirect contacts	Pace of work dependent on customers
Dealing with indirect contacts	1	
Pace of work dependent on customers	0.4215	1

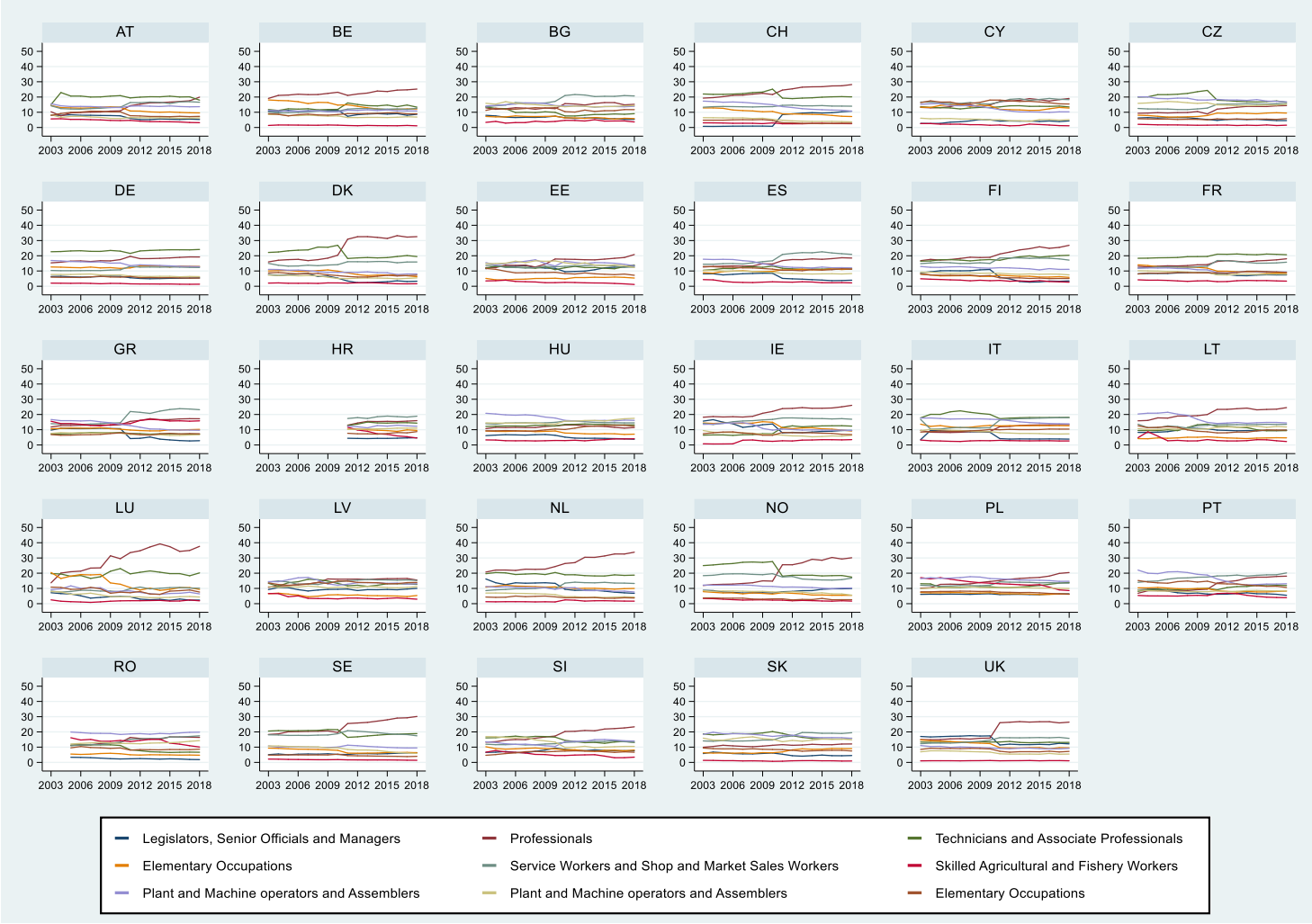
Figure B.1: Changes in Employment by Major ISCO Occupations (difference)



ISCO1 Legislators, Senior Officials and Managers; ISCO 2 Professionals; ISCO3 Technicians and Associate Professionals; ISCO4 Clerks; ISCO5 Service Workers and Shop and Market Sales Workers; ISCO6 Skilled Agricultural and Fishery Workers; ISCO7 Craft and Related Trade Workers; ISCO8 Plant and Machine operators and Assemblers; ISCO9 Elementary Occupations.

Source: EU Labour Force Survey 2003-2018

Figure B.2: Change in employment by ISCO 1-digit occupation over 2003-2018

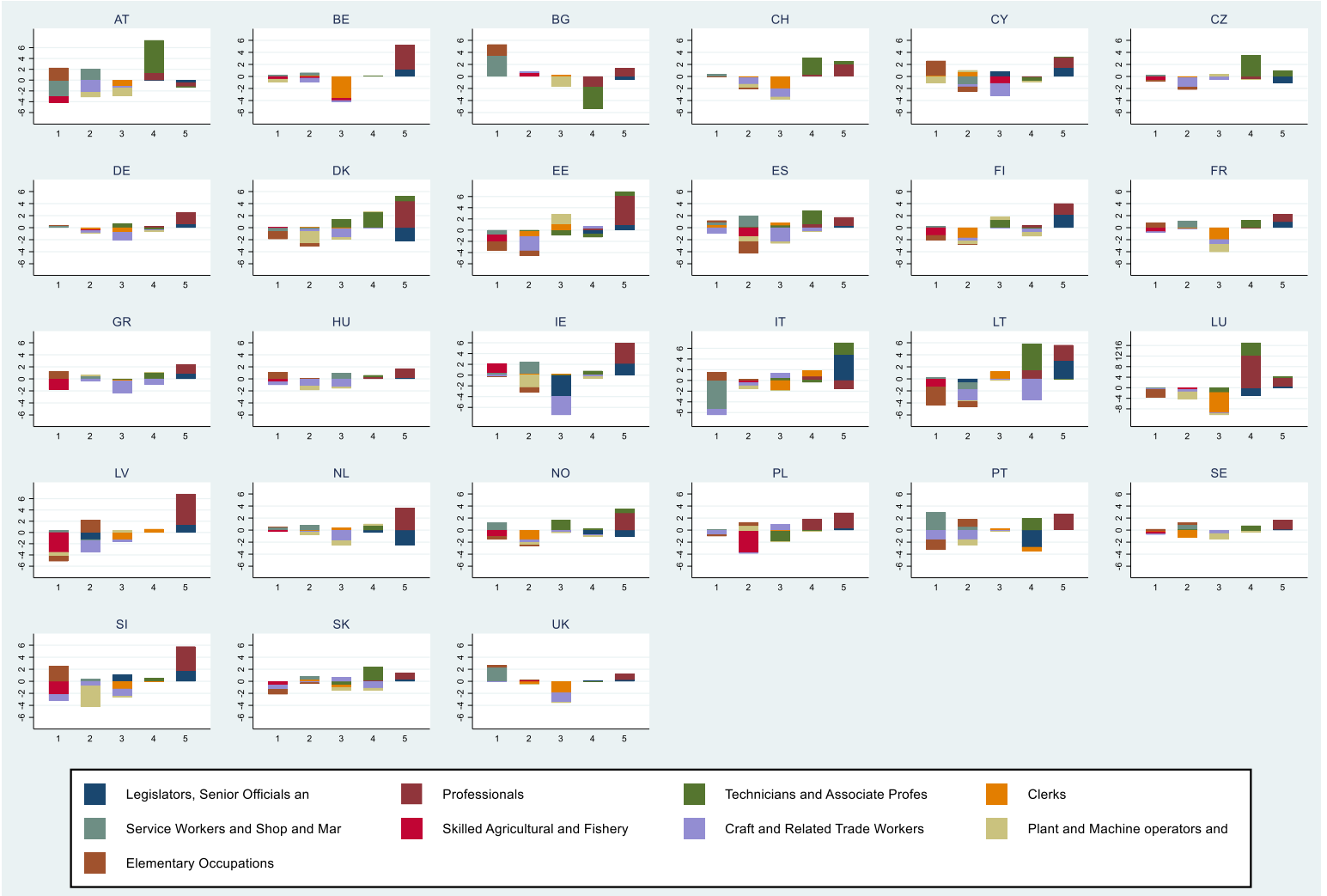


Source:EU Labour Force Survey 2003-2018

Figure B.3: Employment change by ISCO 1 digit 2003-2018

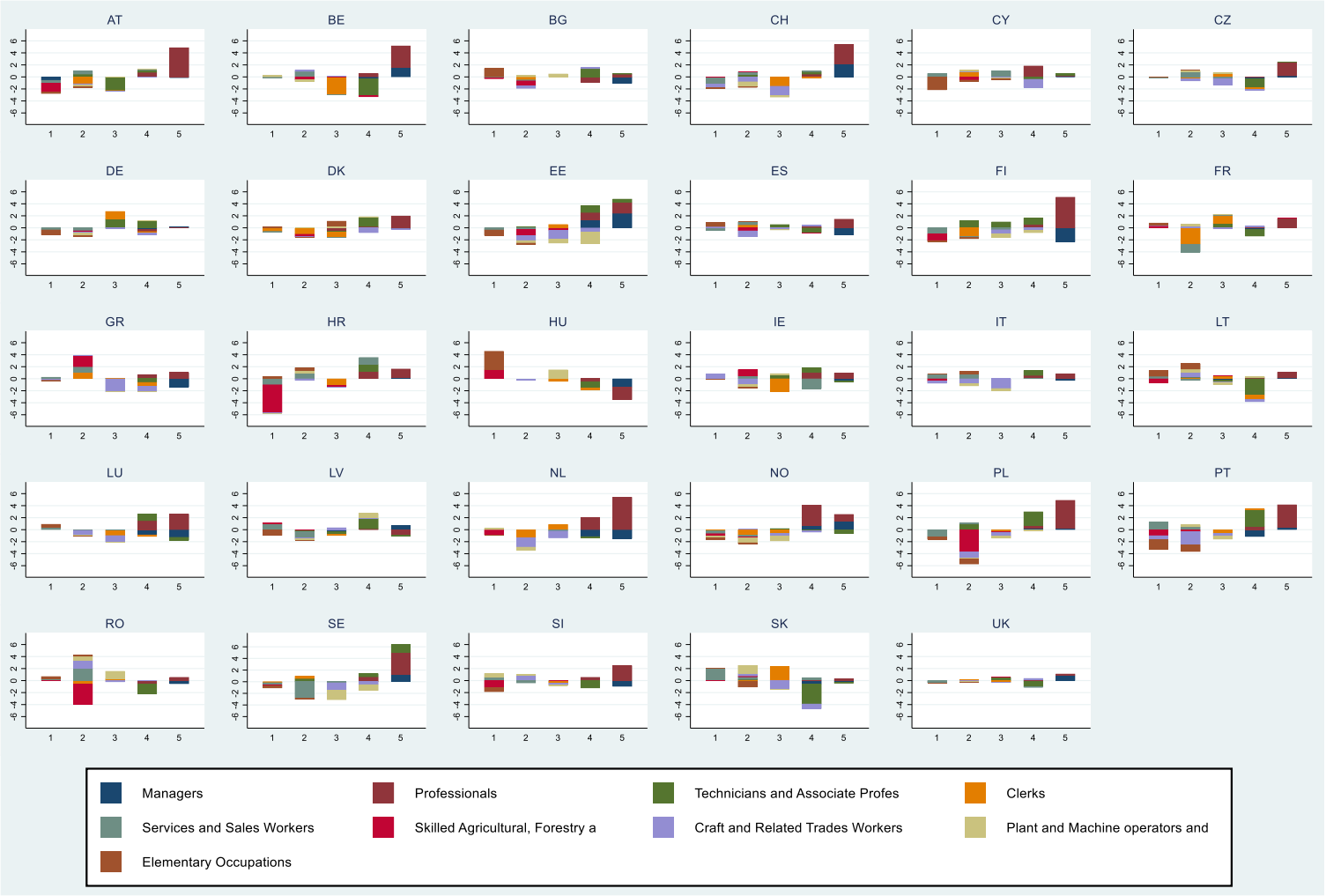
Data source: EU LFS 2003-2018 and EU SES, occupations ranked by median hourly earnings at 1-ISCO digit level

Figure B.4: Employment change by occupational quality (earnings) 2003-2010, disaggregated by ISCO Major groups



2-digit occupations are ranked by earnings and divided into quintiles with approximately 20% each,disaggregated at ISCO 1 digit
Data source: EU LFS 2003-2010 and EU SES(2006), from lowest-paid (1) to highest-paid (5).

Figure B.5: Employment change by occupational quality (earnings) 2011-2018, disaggregated by ISCO Major groups



2-digit occupations are ranked by earnings and divided into quintiles with approximately 20% each,disaggregated at ISCO 1 digit
Data source: EU LFS 2011-2018 and EU SES (2014), from lowest-paid (1) to highest-paid (5).

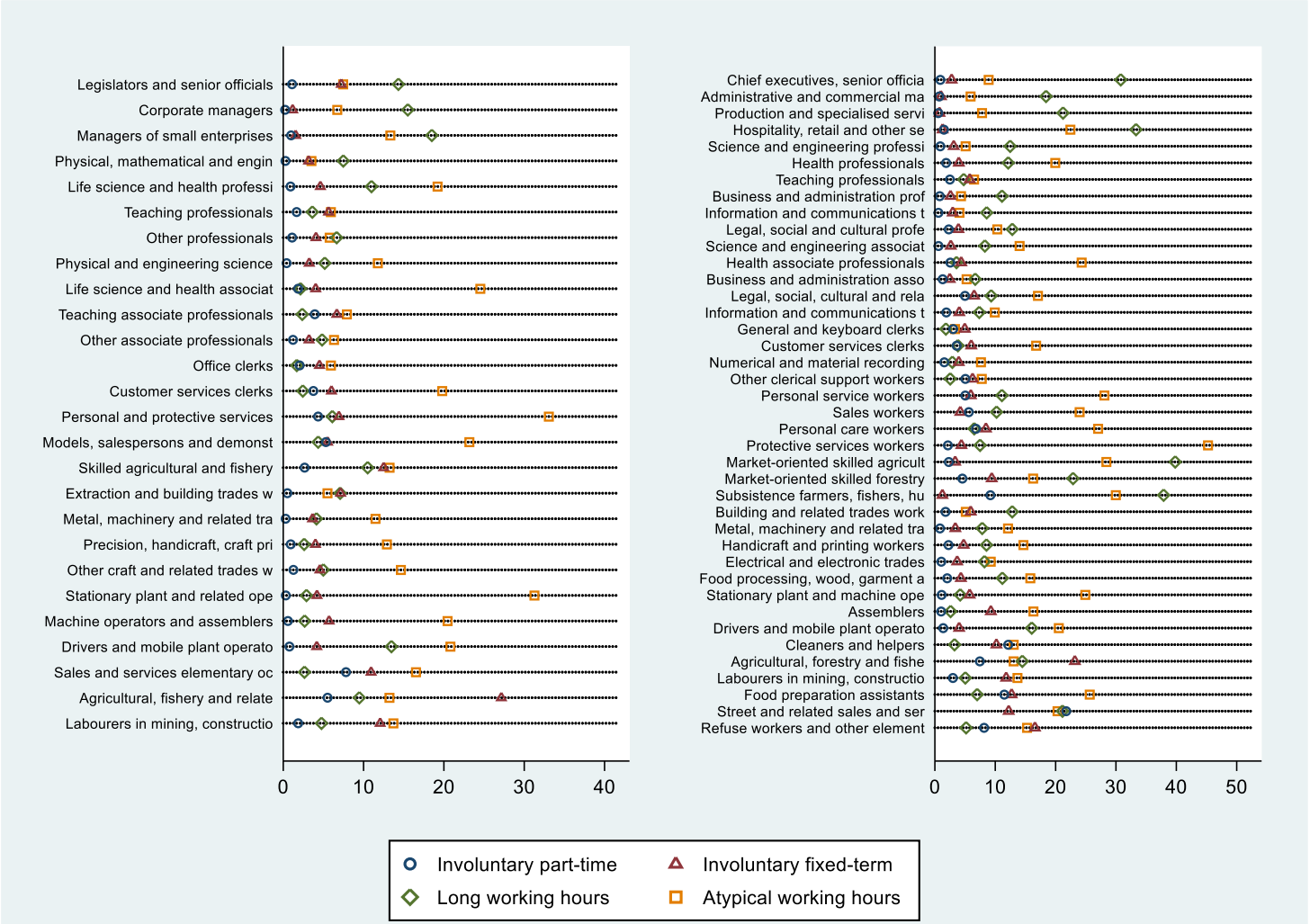
Figure B.6: Employment change by occupational quality (earnings), across quintiles 2003-2018

2-digit occupations are ranked by earnings and divided into quintiles with approximately 20% each. From lowest-paid (1) to highest-paid (5)
Data source: EU LFS 2003-2010, EU LFS 2011-2018

Figure B.7: Employment change by occupational quality (level of education), across quintiles 2003-2018

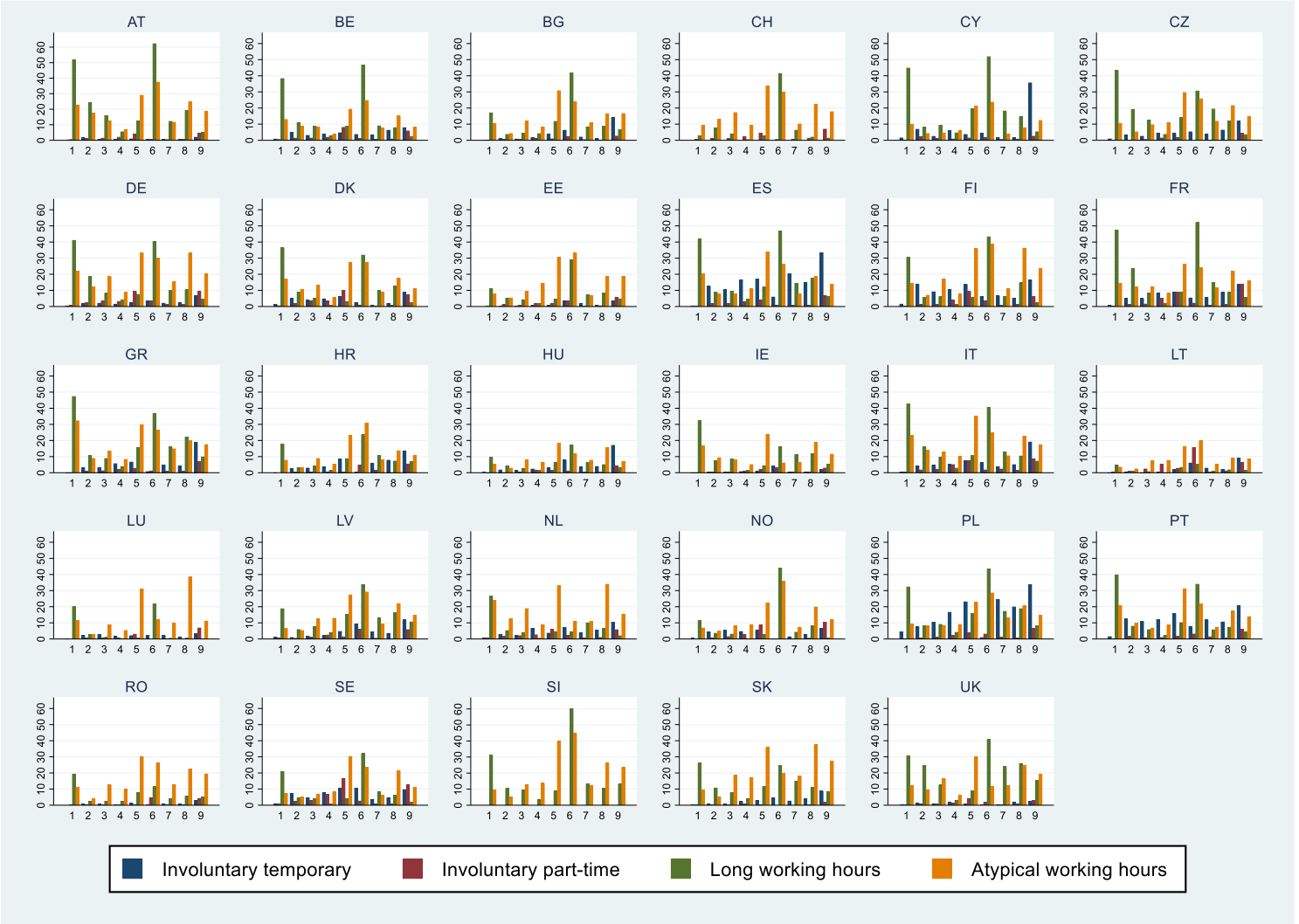
2-digit occupations are ranked by mean education level and divided into quintiles with approximately 20% each.
Data source: EU LFS 2003-2010, EU LFS 2011-2018

Figure B.8: Average Employment quality and work-life balance across occupations, ISCO 88 and ISCO08



Share of workers with specific working condition at 2-digit ISCO occupation level (%)
Data source: EU LFS 2005, EU LFS 2014

Figure B.9: Mean scores for different employment quality dimensions across ISCO Major groups (2005)



Percentage of workers reporting specific working condition
Source: EU LFS 2005

Figure B.10: Mean scores for different employment quality dimensions across ISCO Major groups (2011)

Percentage of workers reporting specific working condition
Source: EU LFS 2011

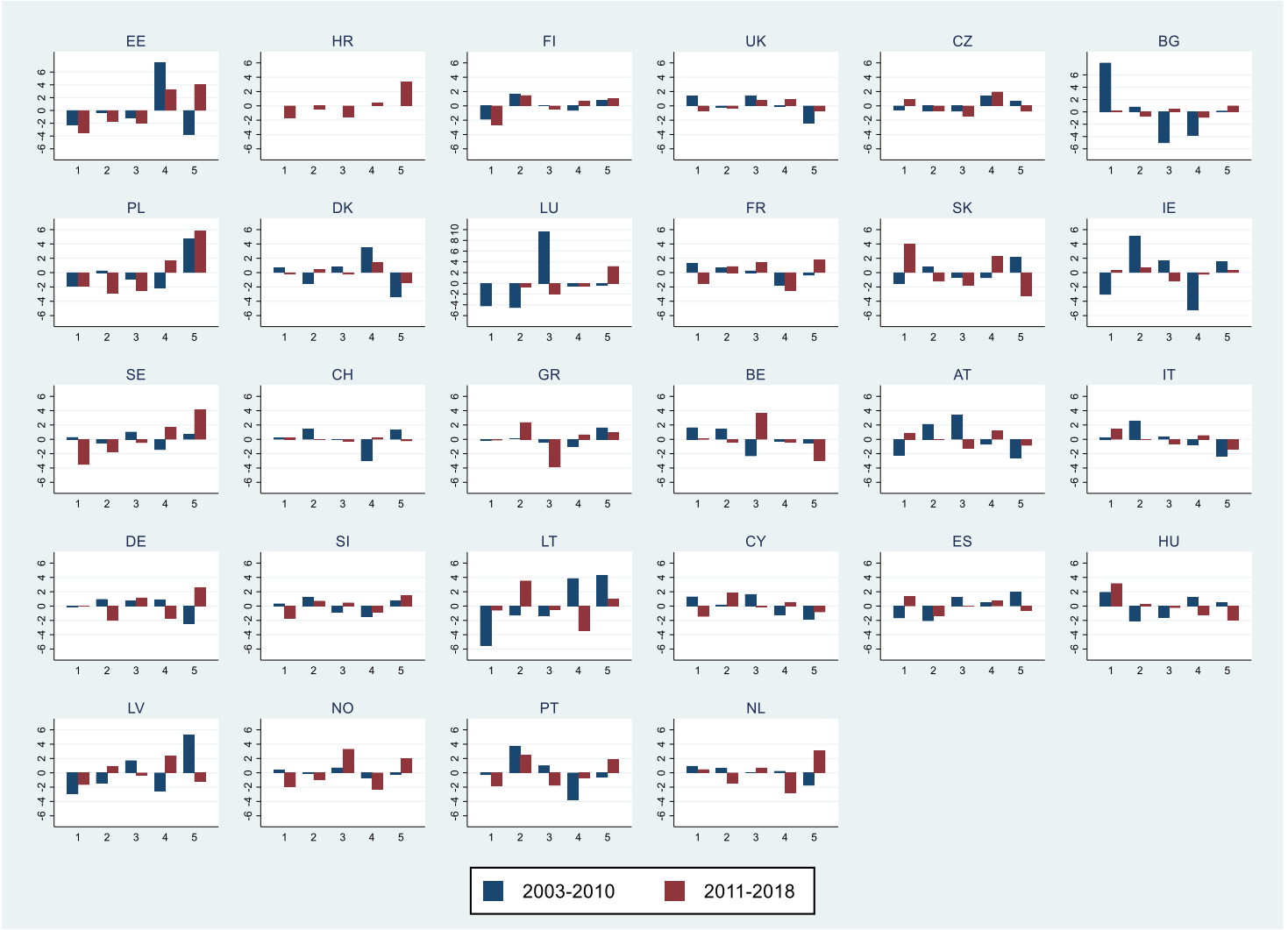
Figure B.11: Mean indexes of job quality at 1 digit ISCO 88

Source: EU LFS, year 2005

Figure B.12: Mean indexes of job quality at 1 digit ISCO 08

Source: EU LFS, year 2011

Figure B.13: Change in Employment share by Employment quality (2003-2018)

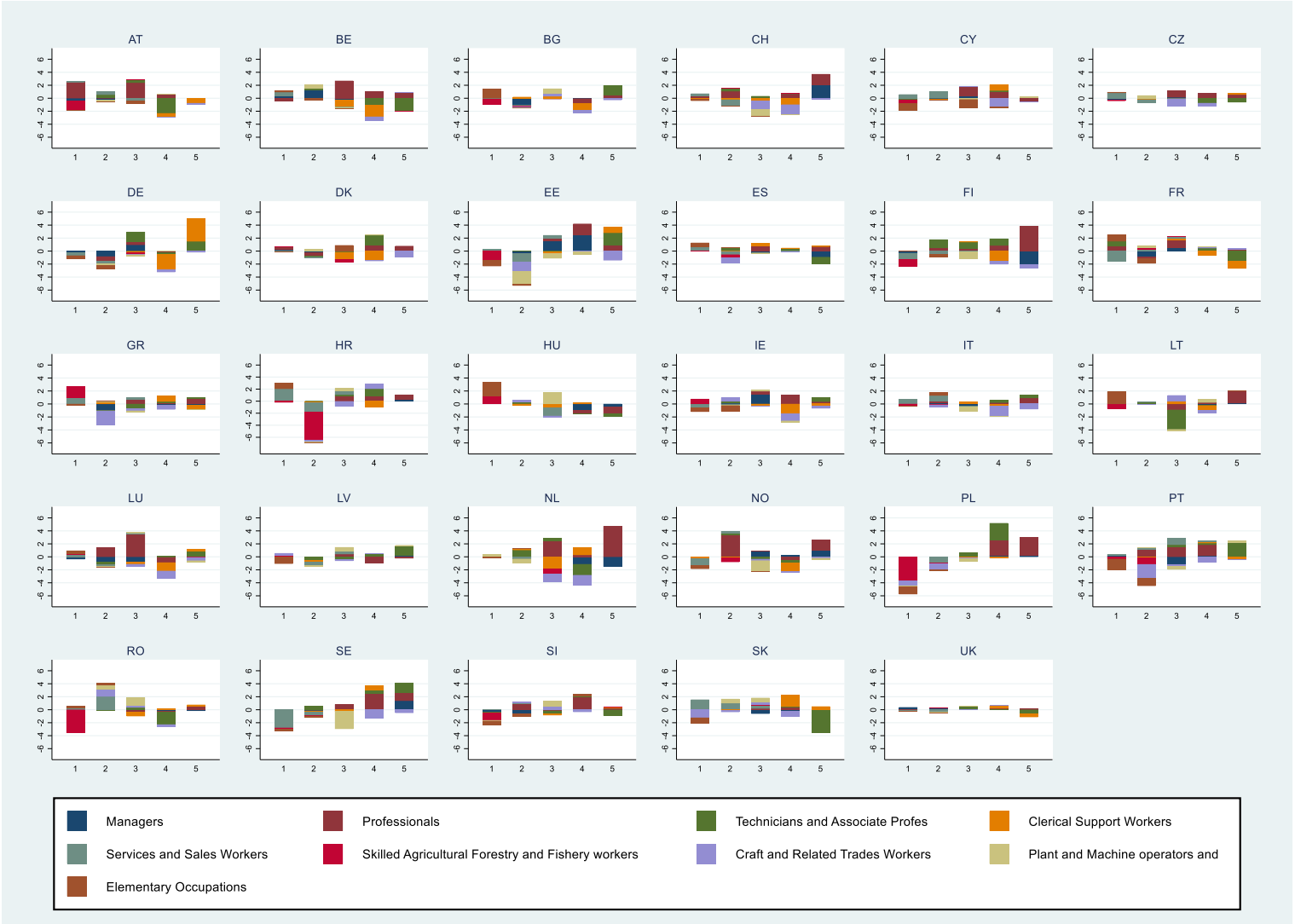


2-digit occupations are ranked by job quality index and divided into quintiles with approximately 20% each.
Source: EU LFS, 2003-2010 and 2011-2018, from lowest quality (1) to the highest (5)

Figure B.14: Change in Employment share by Employment quality (2003-2010)

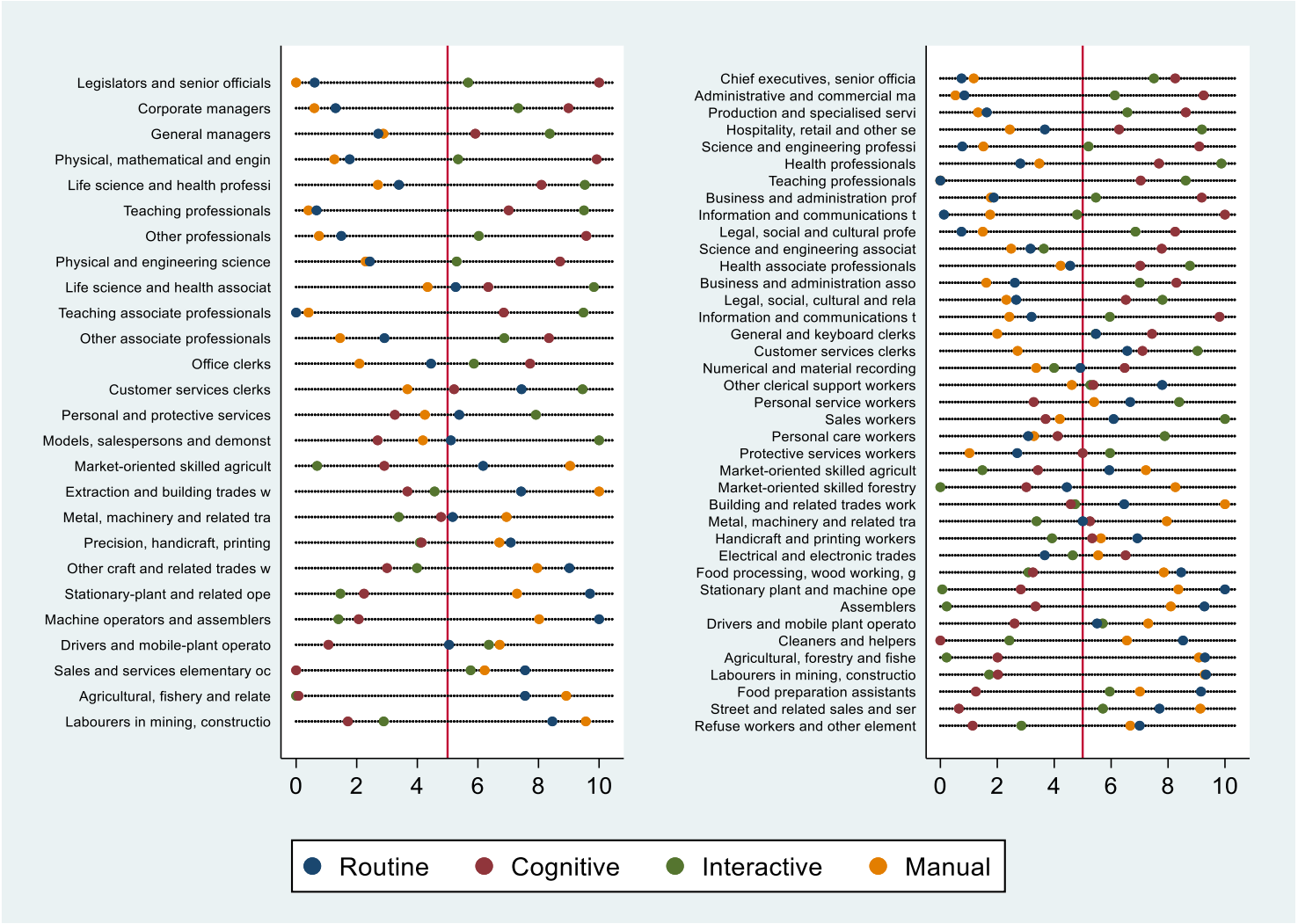
2-digit occupations are ranked by job quality index and divided into quintiles with approximately 20% each, disaggregated
Source: EU LFS (2003-2010), from lowest job quality (1) to the highest (5)

Figure B.15: Change in Employment share by Employment quality (2011-2018)



2-digit occupations are ranked by job quality index and divided into quintiles with approximately 20% each, disaggregated
Source: EU LFS (2011-2018)

Figure B.16: Task indexes of occupations for sub-major occupational groups, ISCO88 and ISCO08



Source: EWCS, 2005 for ISCO 88 and 2015 for ISCO 08

Figure B.17: Correlation among task dimensions

	Routine	Interactive	Manual	Cognitive
Routine	1			
Interactive	-0.53	1		
Manual	0.87	-0.67	1	
Cognitive	-0.78	0.47	-0.84	1

Source: EWCS 2005, 2-digit occupations ranked by each task index

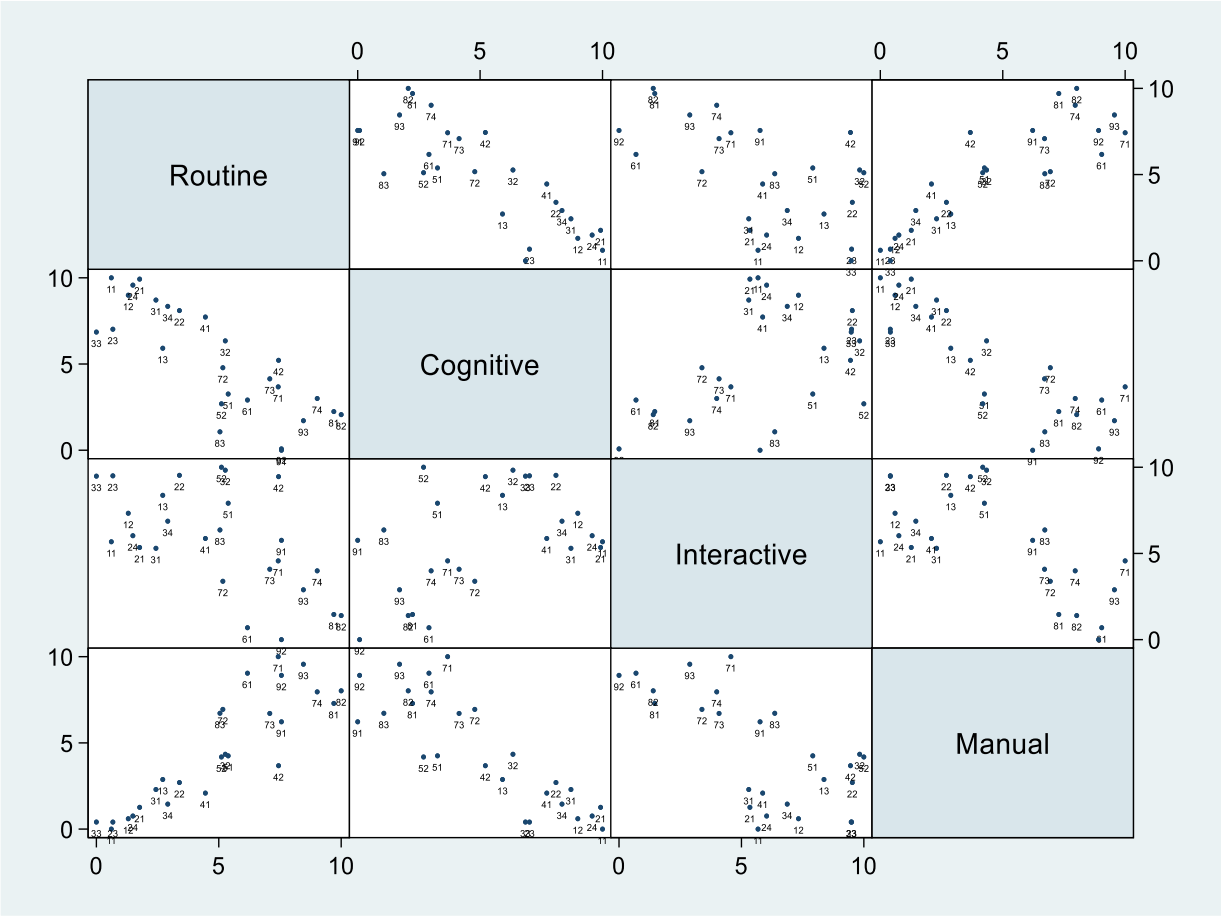


Figure B.18: Correlation among task dimensions

	Routine	Interactive	Manual	Cognitive
Routine	1			
Interactive	-0.53	1		
Manual	0.83	-0.63	1	
Cognitive	-0.82	0.49	-0.80	1

Source: EWCS 2015, 2-digit
occupations ranked by each task index

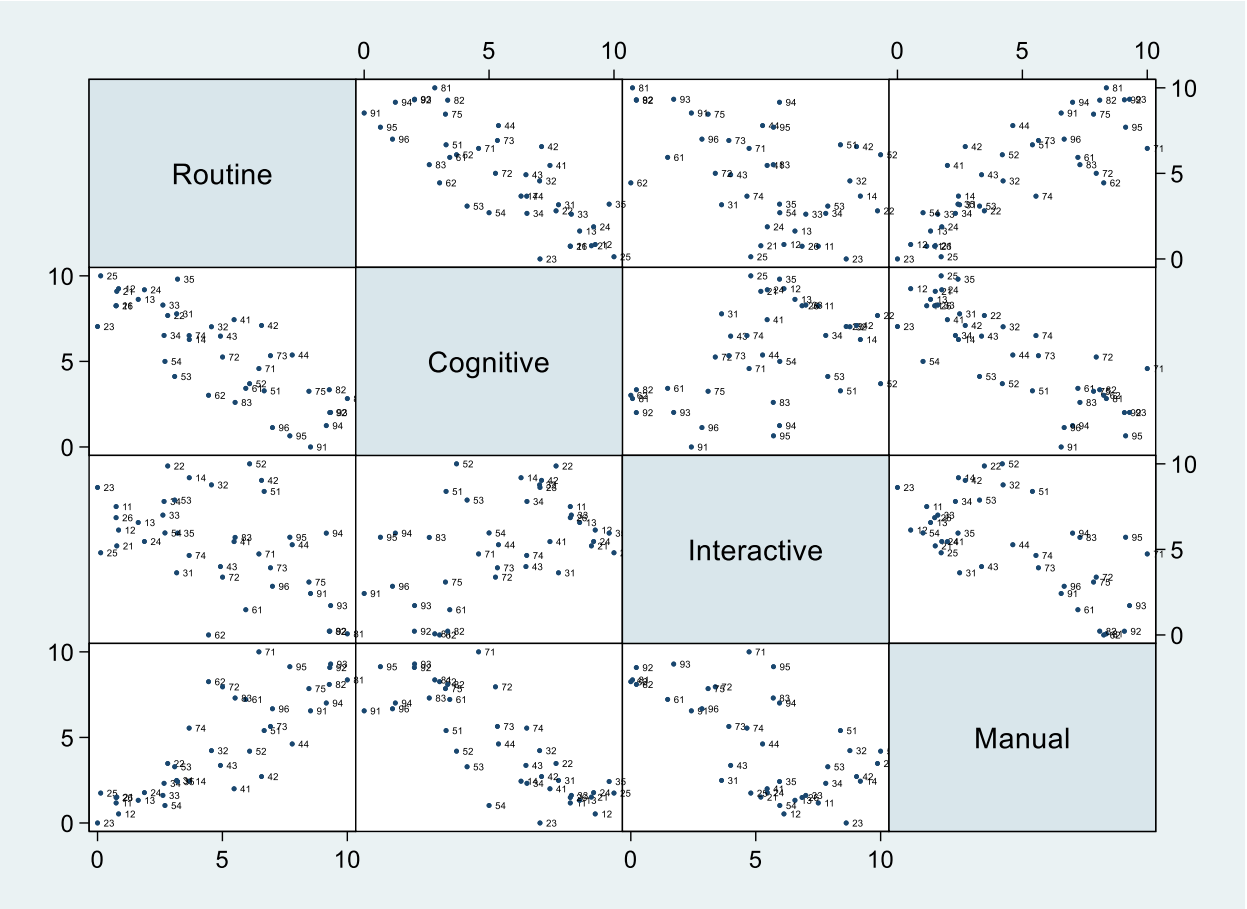
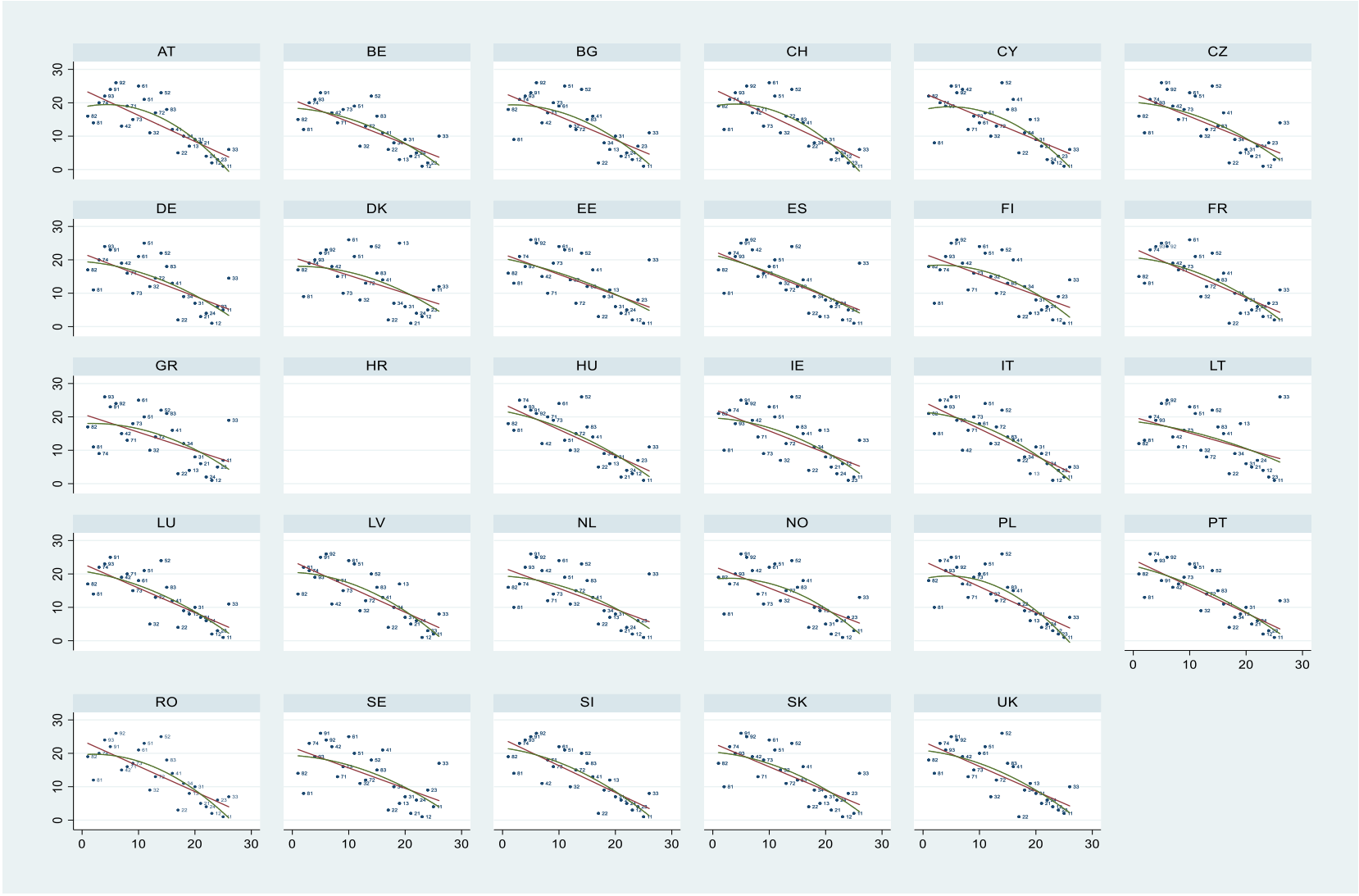
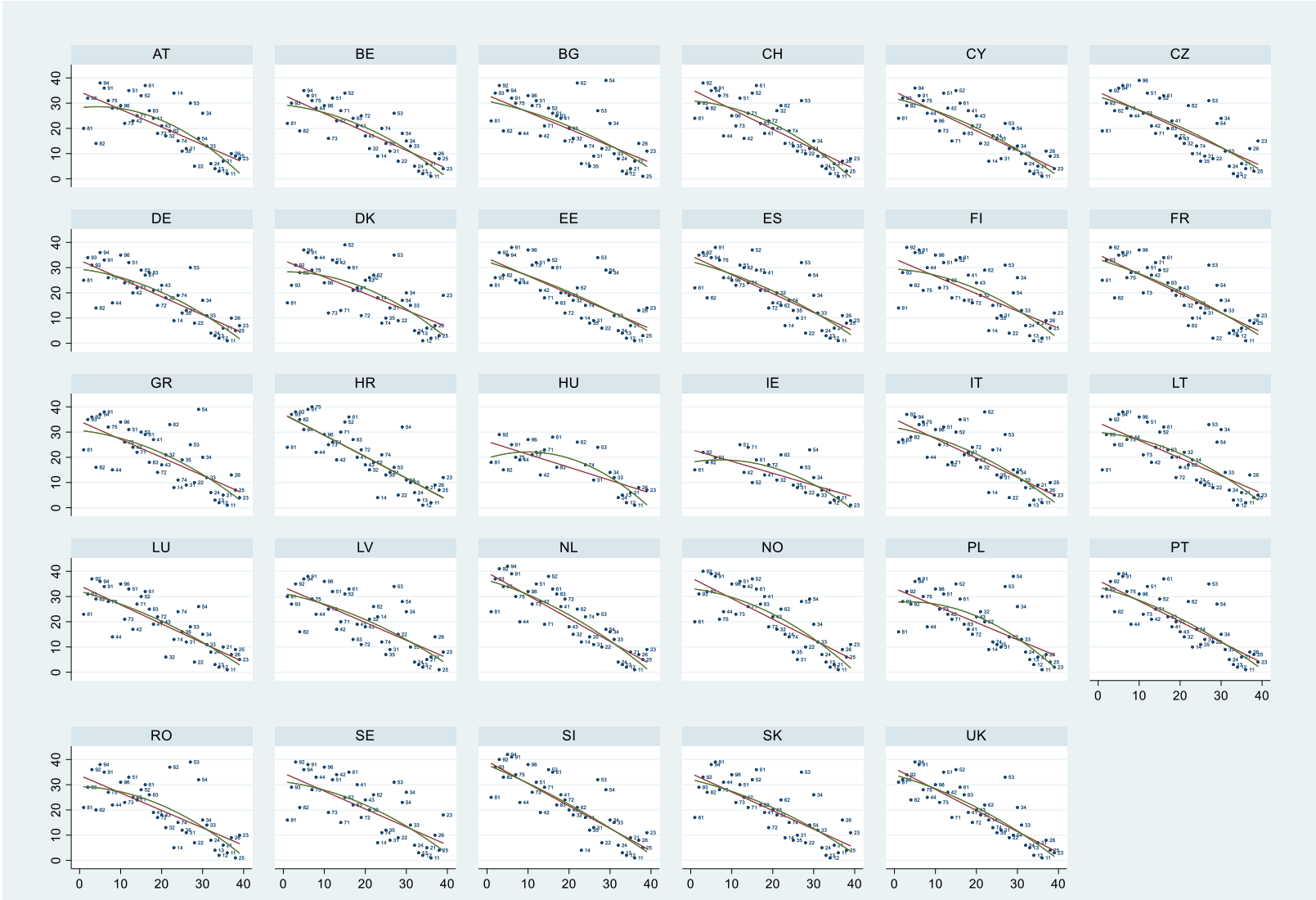


Figure B.19: Correlation between the ranks by routine index and earnings for ISCO 88



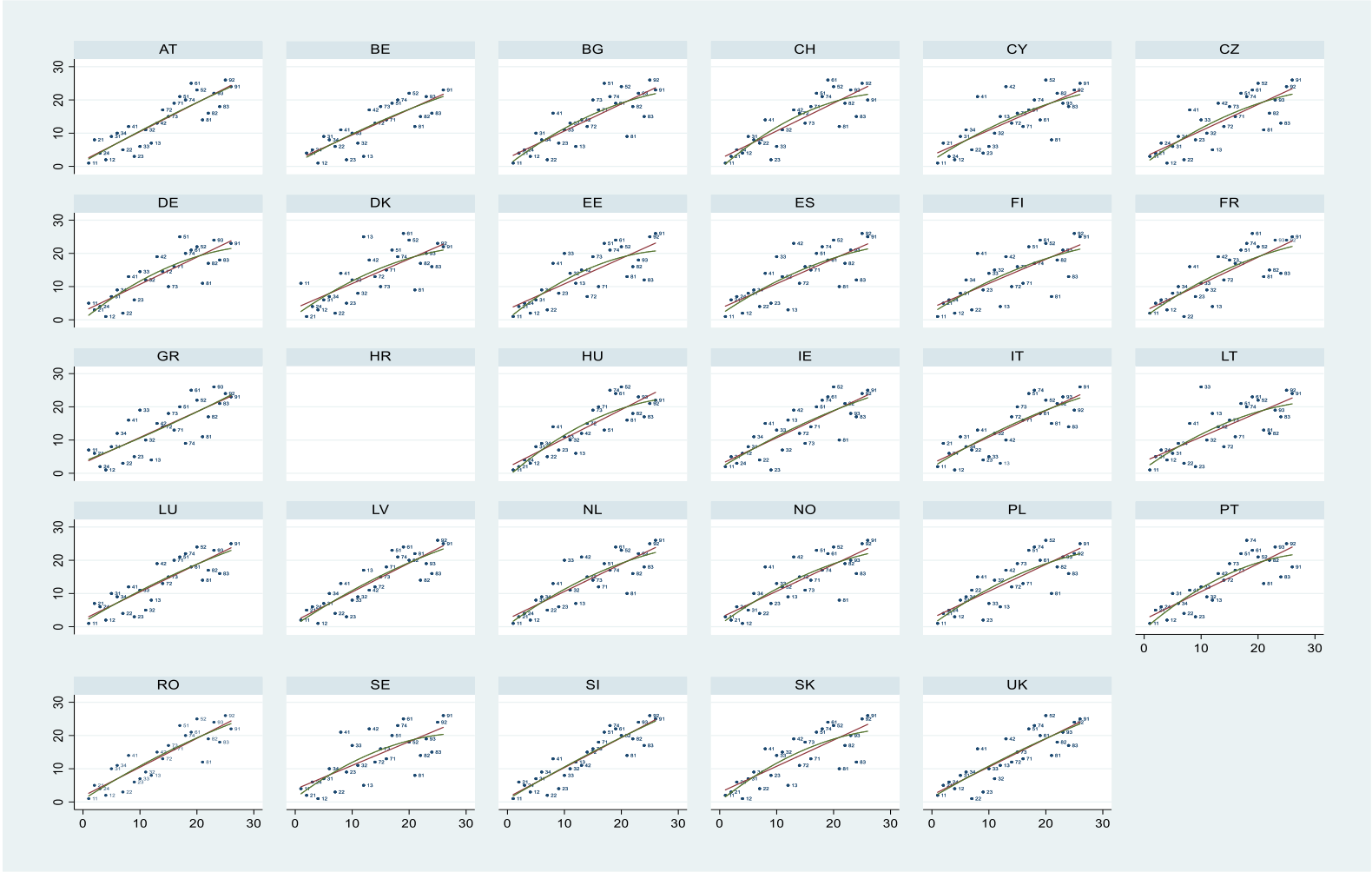
Source: EWCS 2005 and EU SES, 2-digit occupations ranked by routine intensity and earnings

Figure B.20: Correlation between the ranks by routine index and earnings ISCO 08



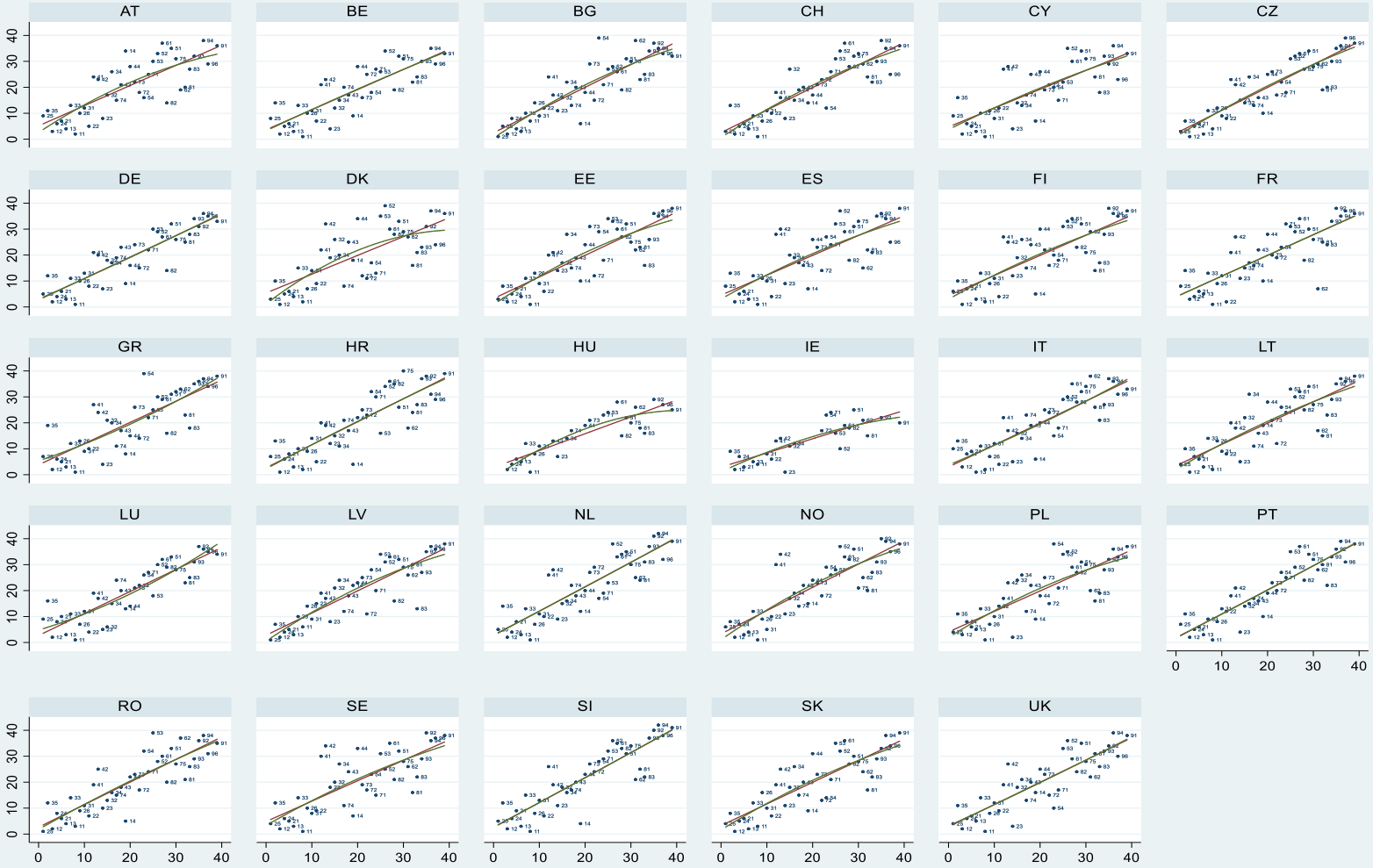
Source: EWCS 2015 and EU SES, 2-digit occupations ranked by routine intensity and earnings

Figure B.21: Correlations between the ranks by cognitive index and earnings ISCO88



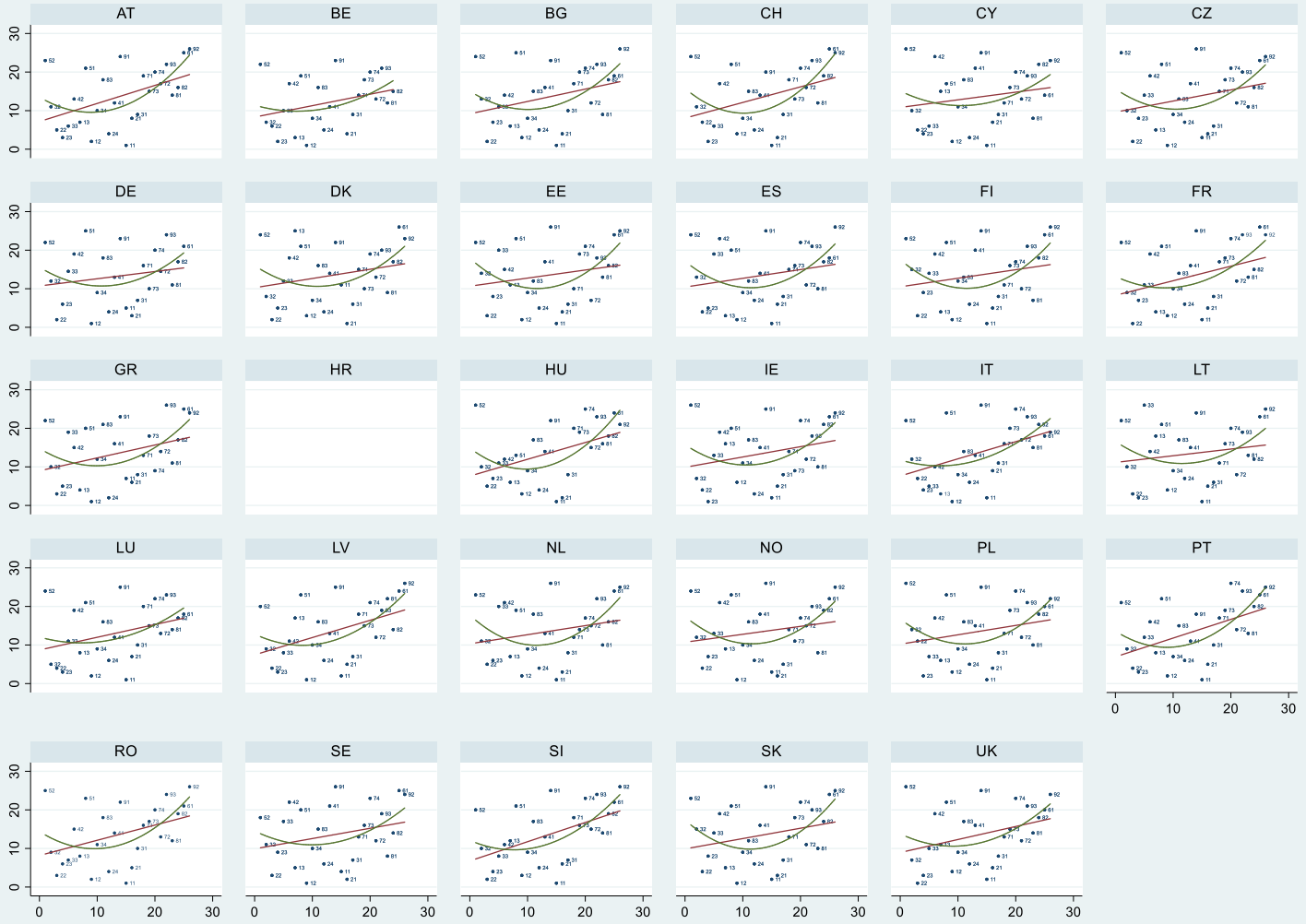
Source: EWCS 2005 and EU SES, 2-digit occupations ranked by cognitive intensity and earnings

Figure B.22: Correlations between the ranks by cognitive index and earnings ISCO08



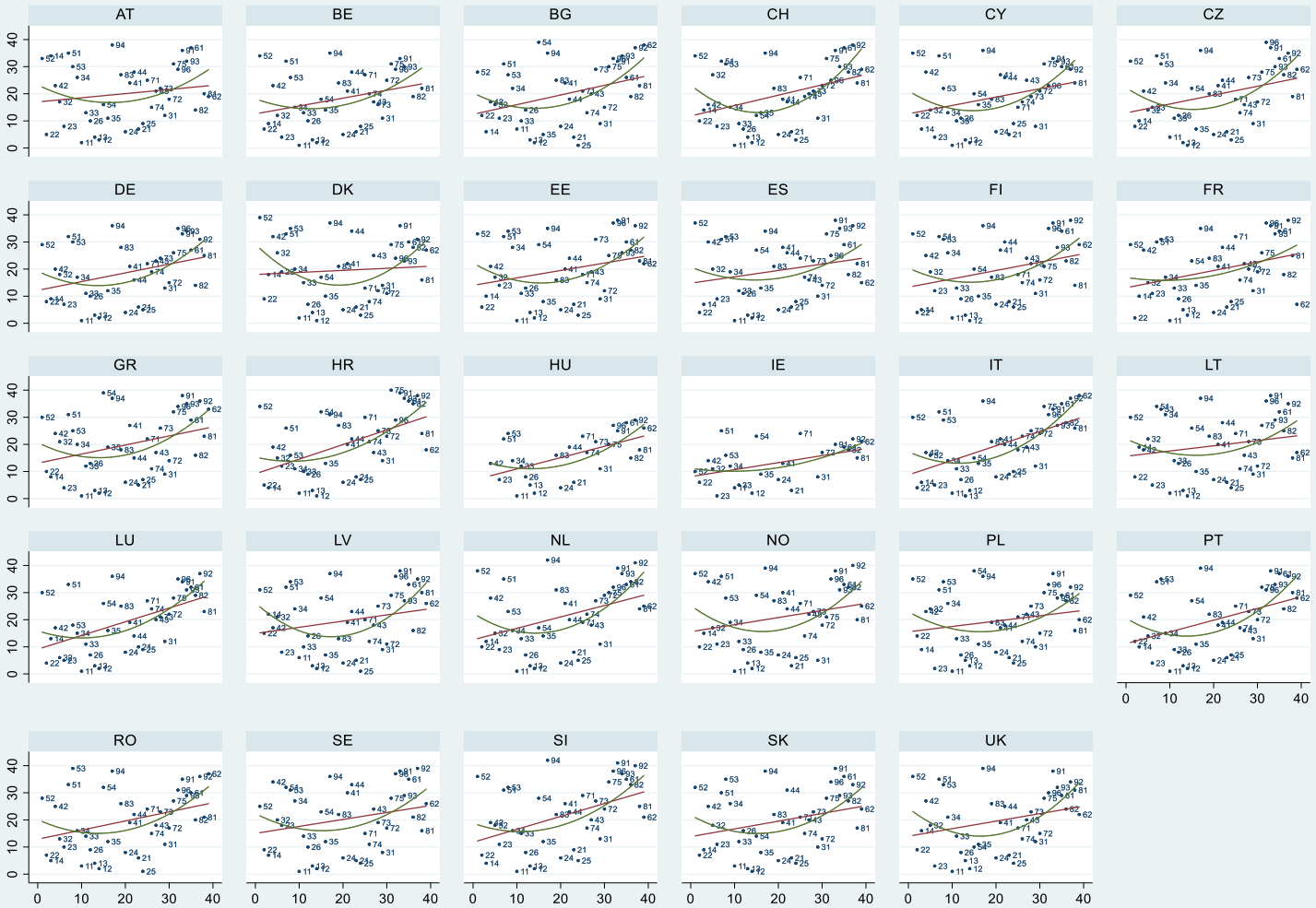
Source: EWCS 2015 and EU SES, 2-digit occupations ranked by cognitive intensity and earnings

Figure B.23: Correlations between the ranks by interactive index and earnings ISCO88



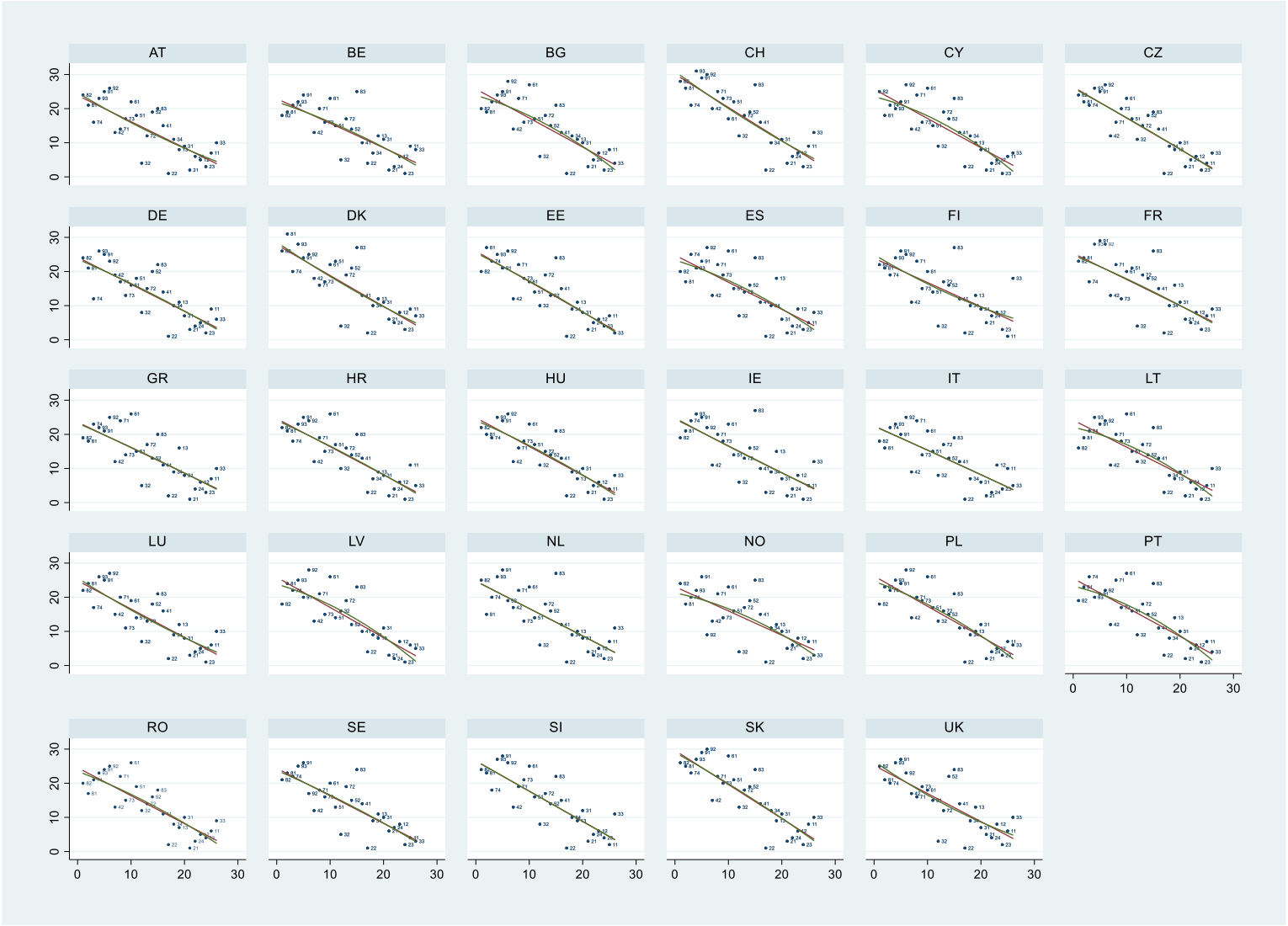
Source: EWCS 2005 and EU SES, 2-digit occupations ranked by interactive intensity and earnings

Figure B.24: Correlations between the ranks by interactive index and earnings ISCO08



Source: EWCS 2015 and EU SES, 2-digit occupations ranked by interactive intensity and earnings

Figure B.25: Correlations between the ranks by educational level and routine index ISCO88

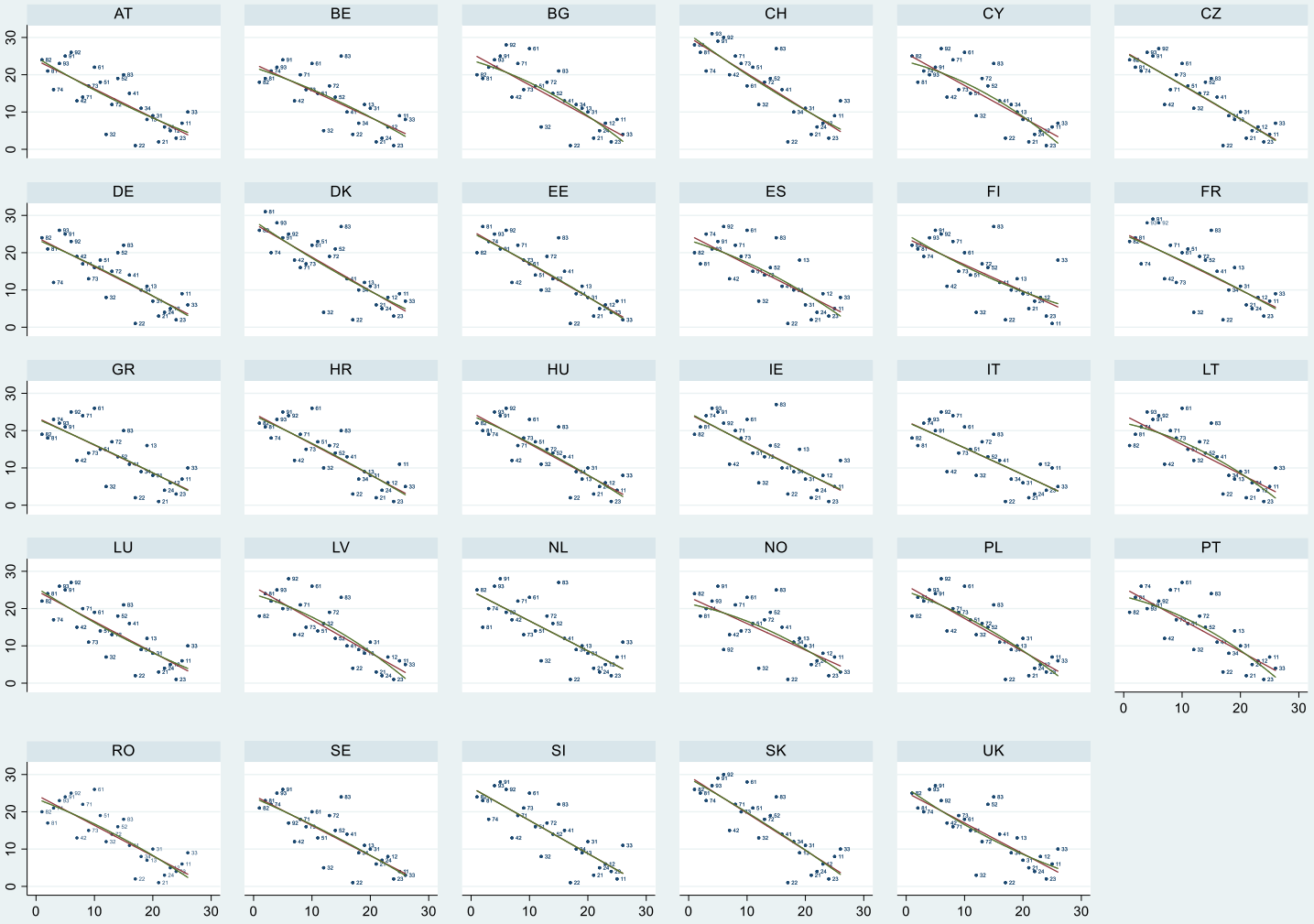


Source: EWCS 2005 and EU LFS, 2-digit occupations ranked by routine intensity and mean educational level

Figure B.26: Correlations between rank by educational level and cognitive index ISCO88

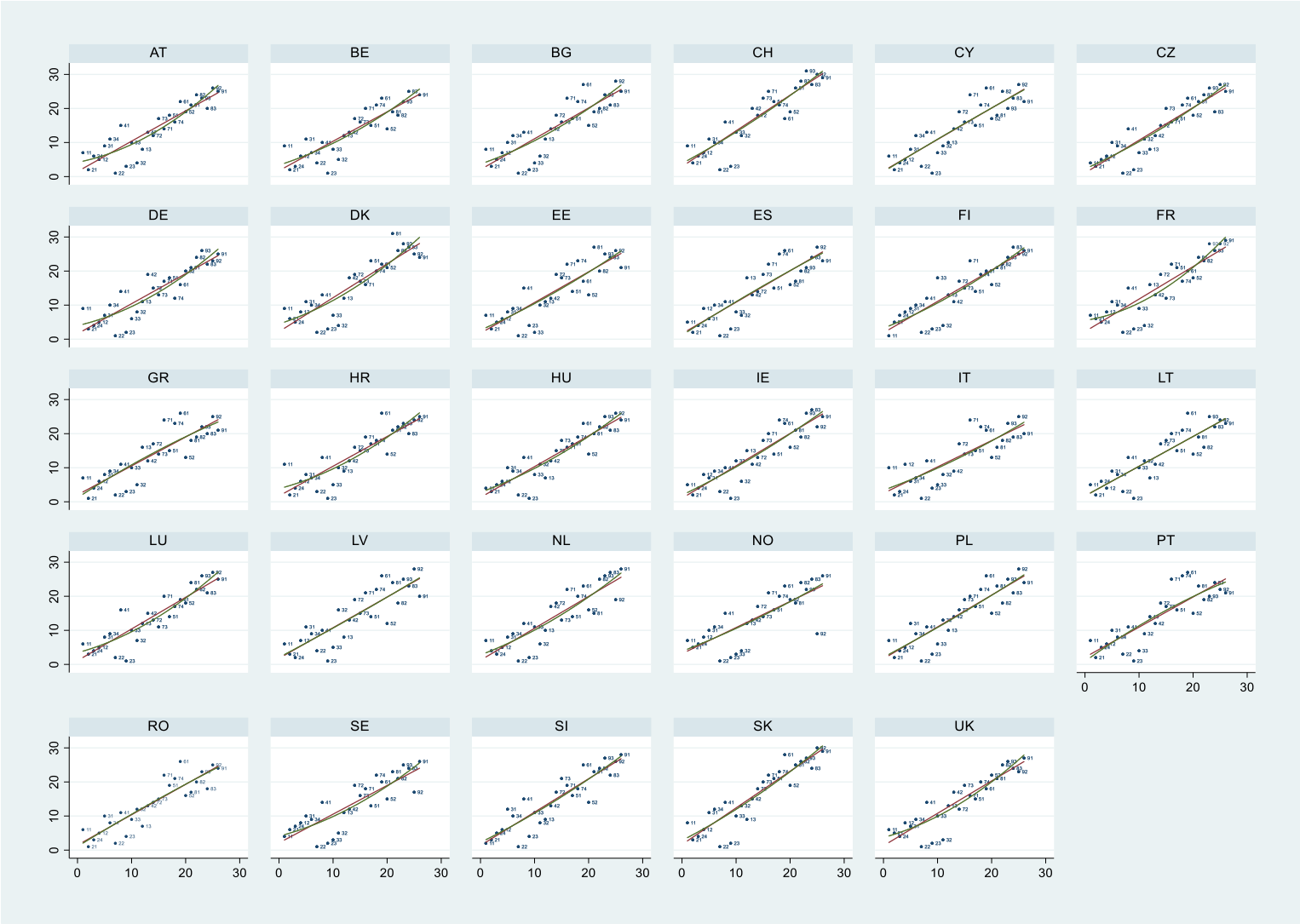
Source: EWCS 2015 and EU LFS, 2-digit occupations ranked by routine intensity and mean educational level

Figure B.27: Correlations between the ranks by educational level and manual index ISCO88



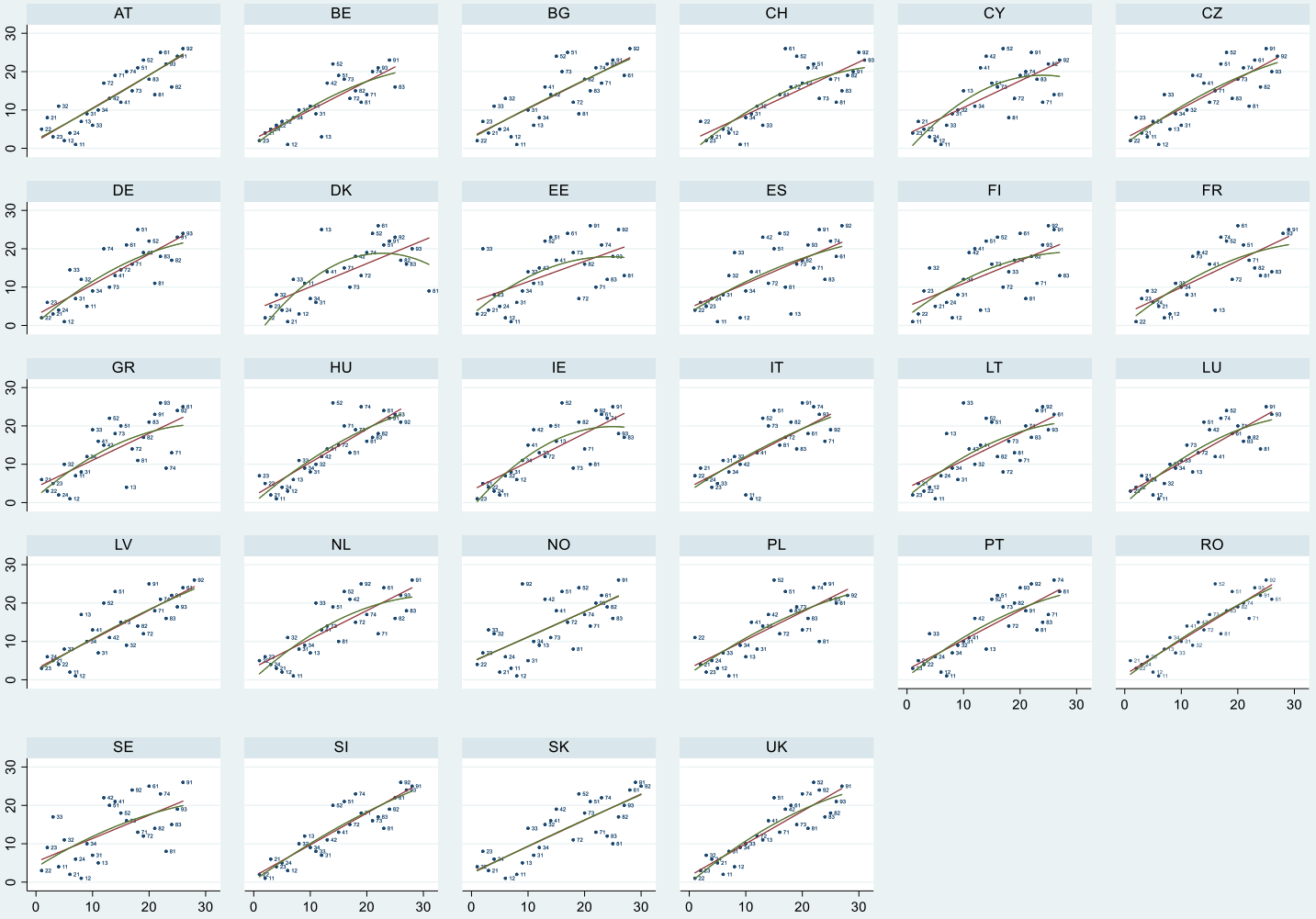
Source: EWCS 2005 and EU LFS, 2-digit occupations ranked by manual intensity and mean educational level

Figure B.28: Correlations between rank by educational level and interactive index ISCO88



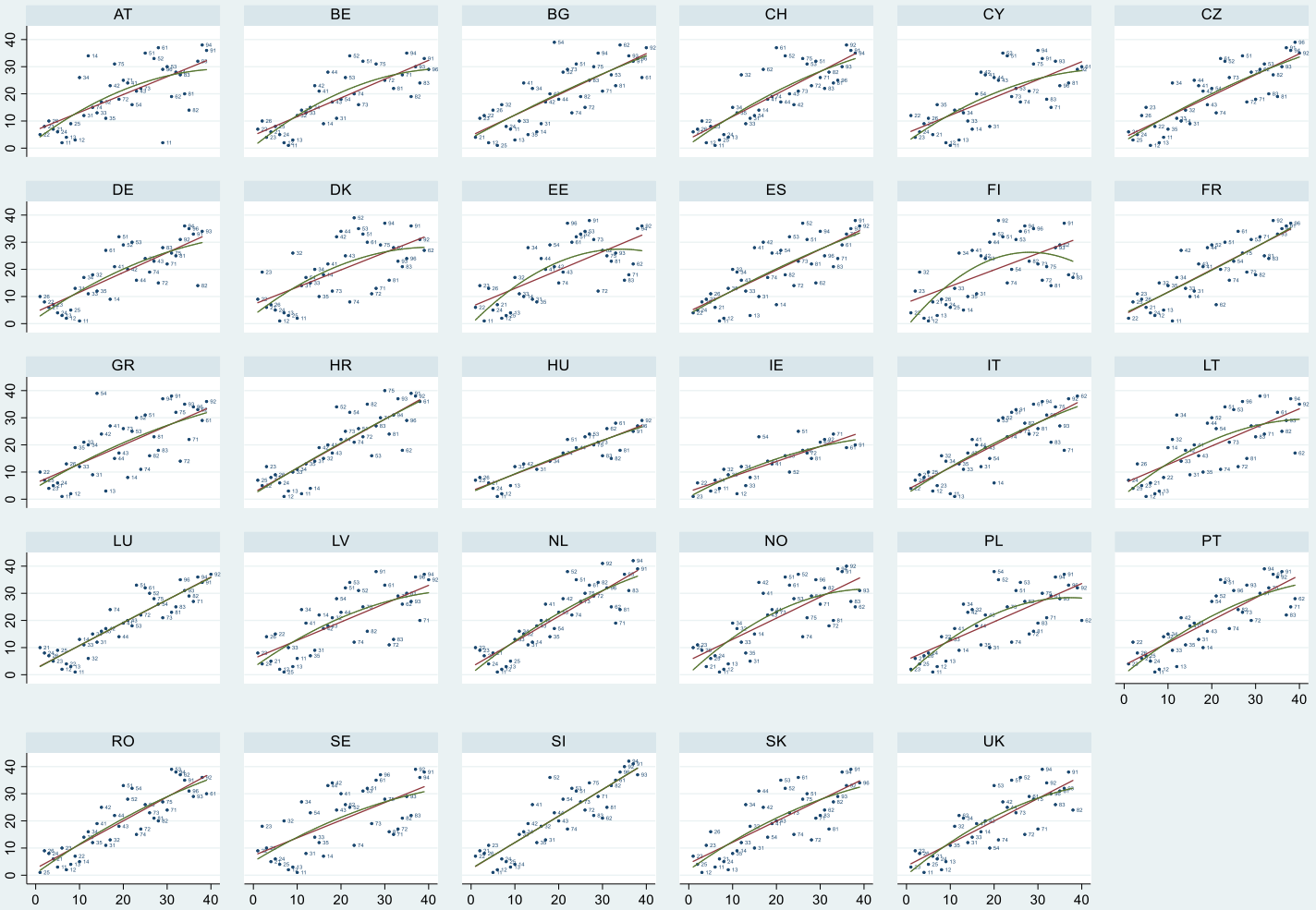
Source: EWCS 2015 and EU LFS, 2-digit occupations ranked by interactive intensity and mean educational level

Figure B.29: Correlations between the ranks by educational level and earnings ISCO88



Source: EU LFS, 2-digit occupations ranked by earnings and mean educational level

Figure B.30: Correlations between rank by educational level and earnings ISCO08



Source: EU LFS, 2-digit occupations ranked by earnings and mean educational level

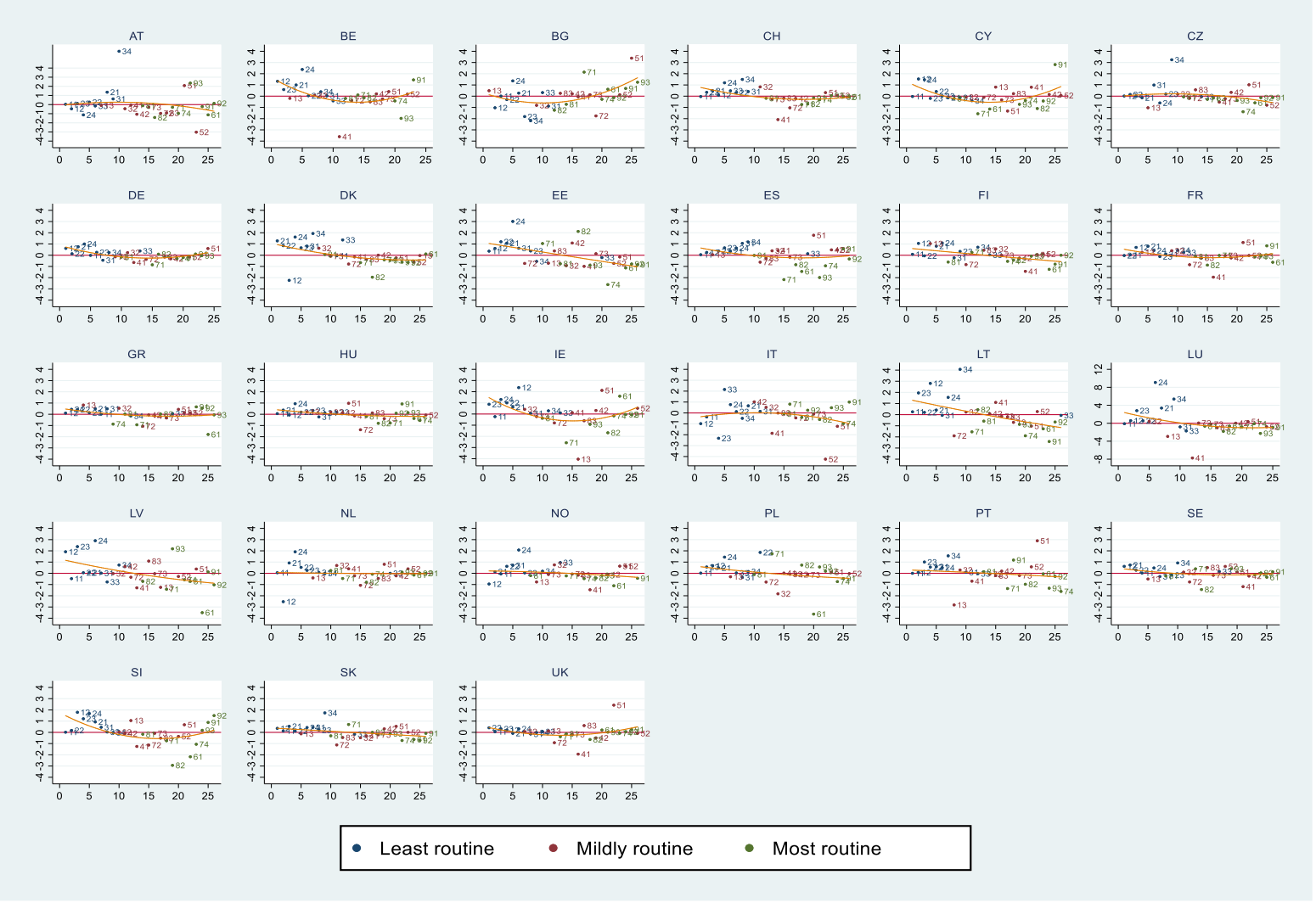
Figure B.31: Occupational change across terciles by task intensity index 2003-2010

Source: EWCS 2005 for task indexes and LFS 2003-2010 for calculating change in employment shares across occupations, disaggregated

Figure B.32: Occupational change across terciles by task complexity index 2011-2018

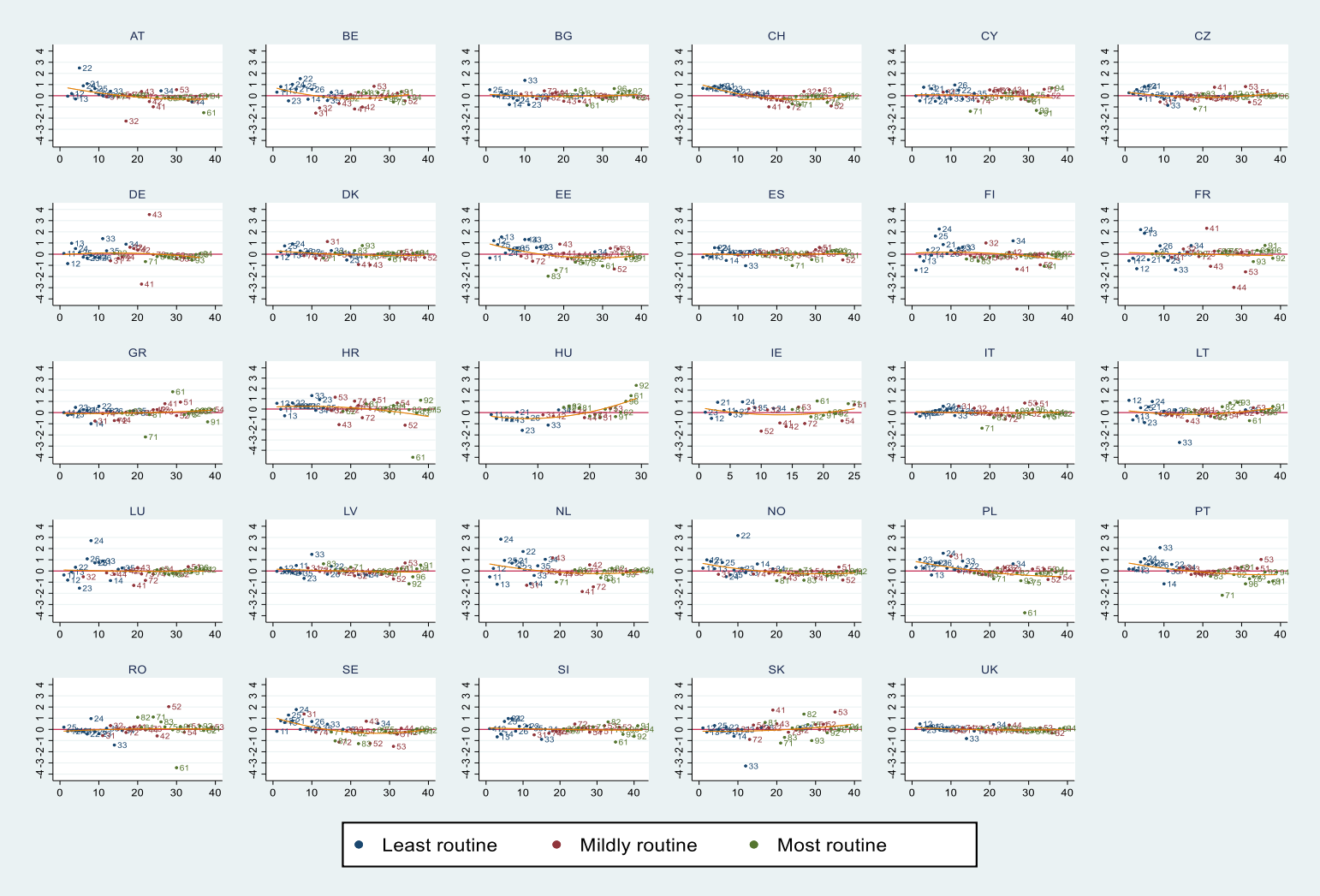
Source: EWCS 2015 for task indexes and LFS 2011-2018 for calculating change in employment shares across occupations

Figure B.33: Occupational change by task intensity and ranking by earnings 2003-2010



Source: EWCS 2005 for task indexes, EU SES (2006) for ranking by median hourly earnings, and LFS 2003-2010 for calculating change in employment shares across occupations

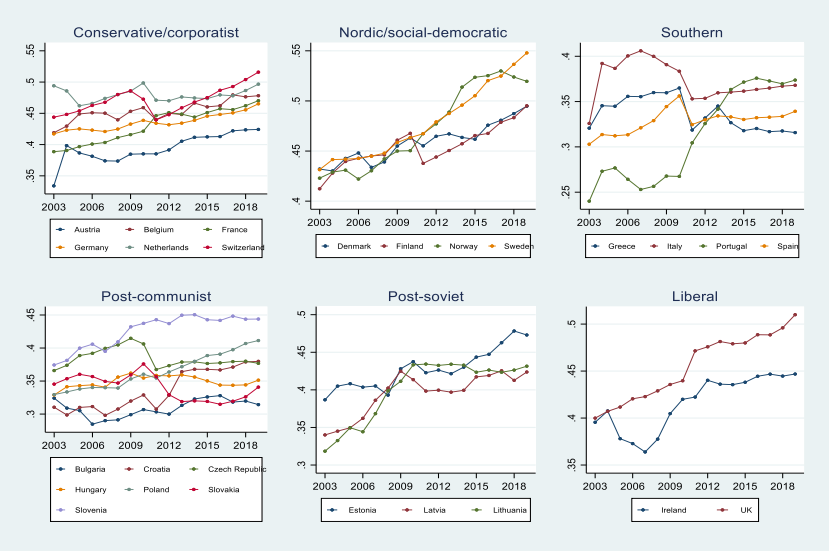
Figure B.34: Occupational change by task intensity and ranking by earnings 2011-2018



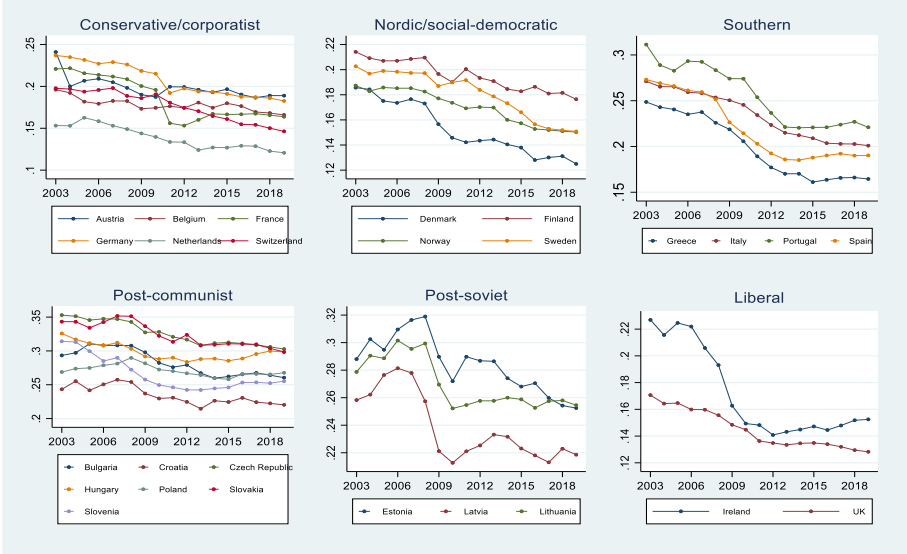
Source: EWCS 2015 for task indexes, EU SES (2014) for ranking by median hourly earnings, and LFS 2011-2018 for calculating change in employment shares across occupations

Figure B.35: Change in Employment share aross skill groups 2003-2018

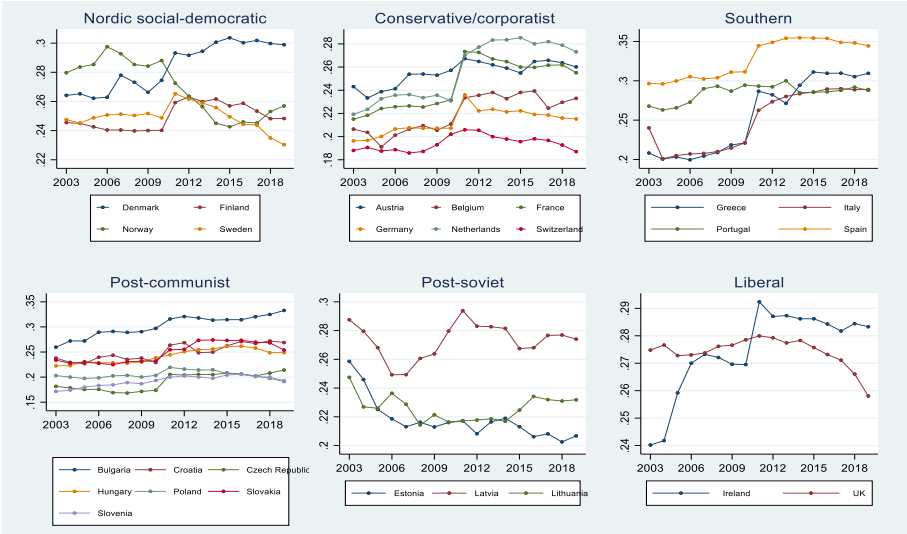
Managers, professionals, technicians and associate professionals



Crafts and trades workers, operators and assemblers

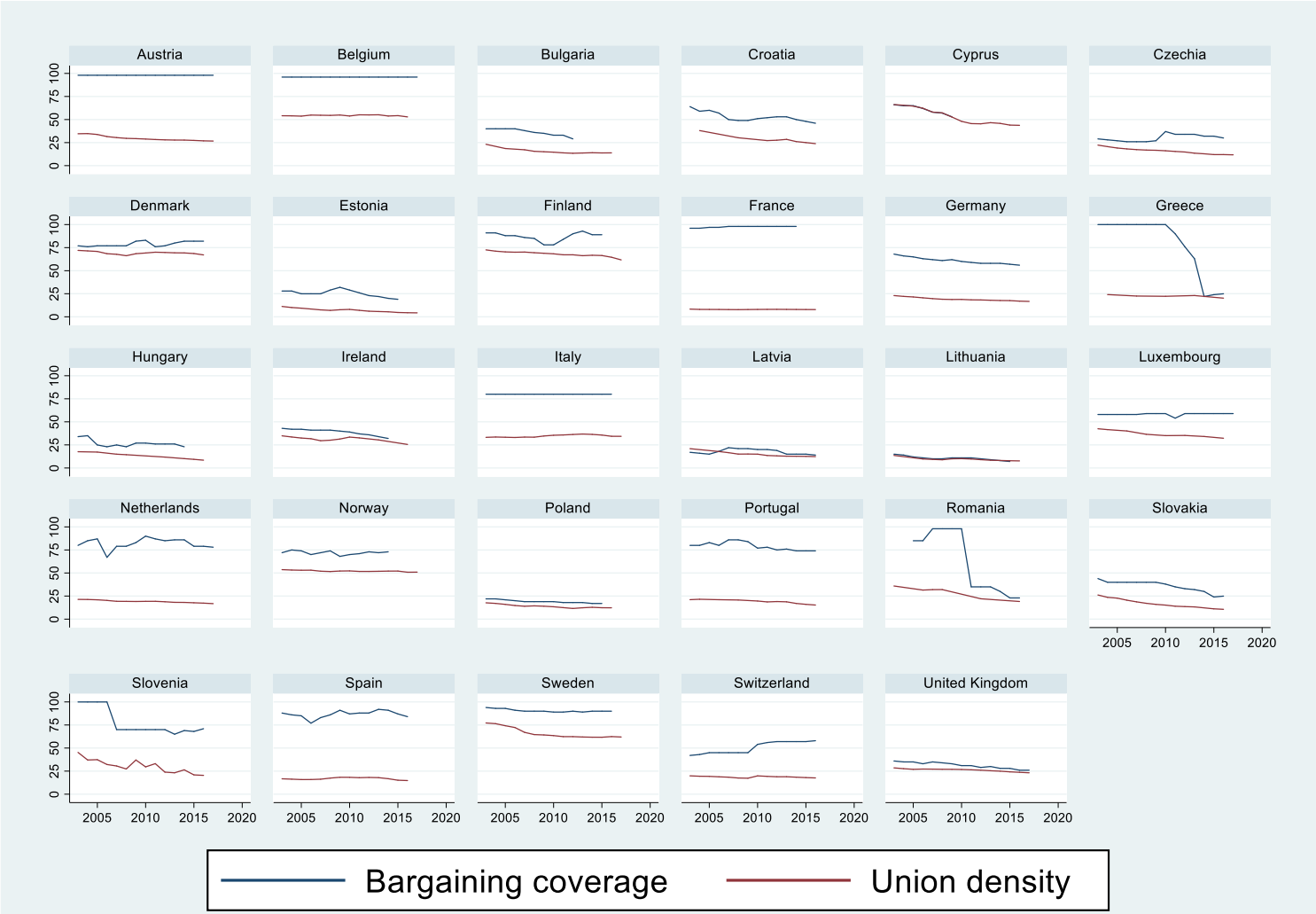


Service and Sales, Elementary occupations



Source: EU LFS, 2003-2018

Figure B.36: Change in Bargaining coverage and Trade union density



Source: ICTWSS database, OECD

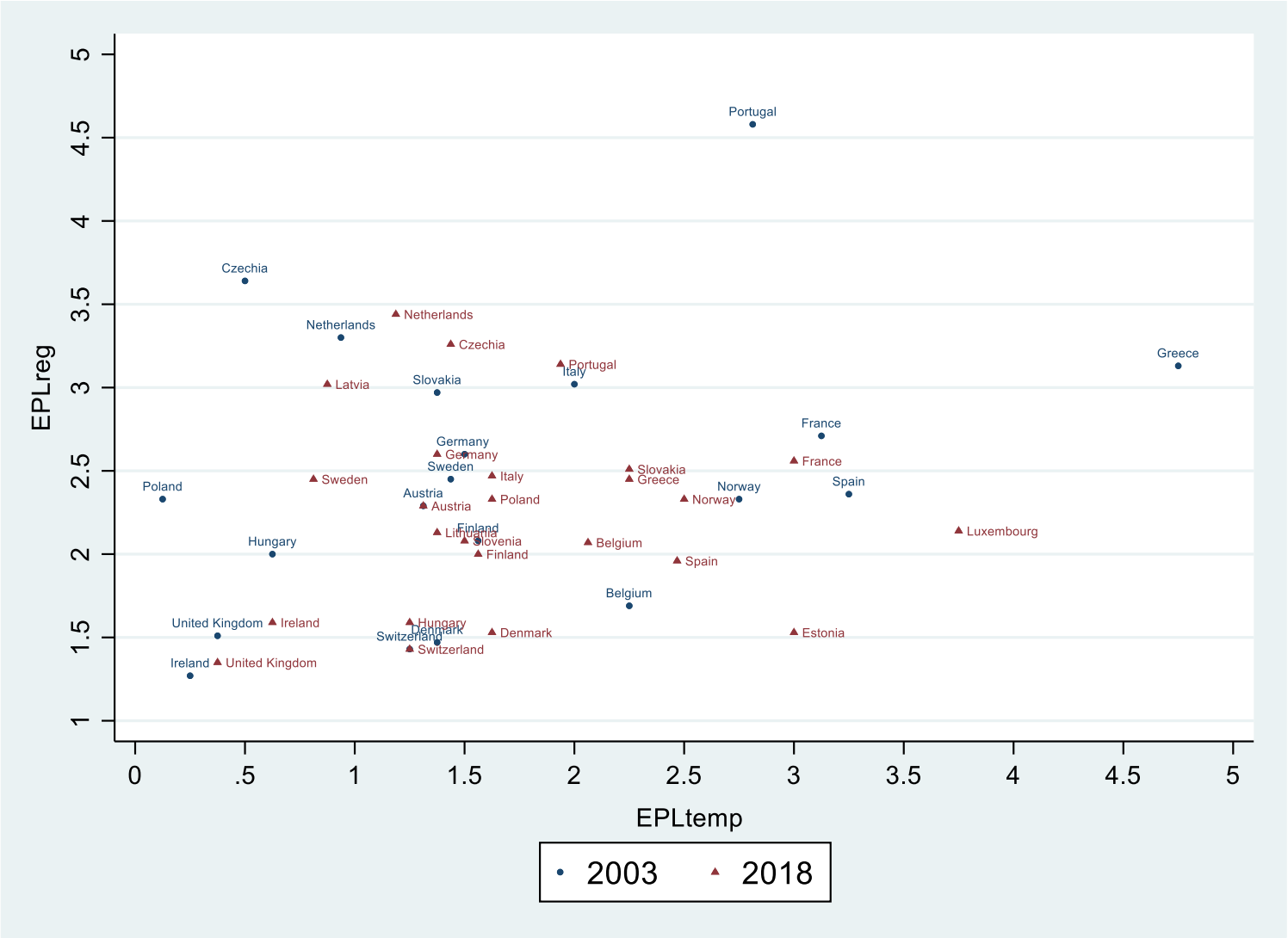
Figure B.37: Population by educational attainment level 25-64

Source: Eurostat [edat_lfse_03]

Figure B.38: Population with tertiary education by age

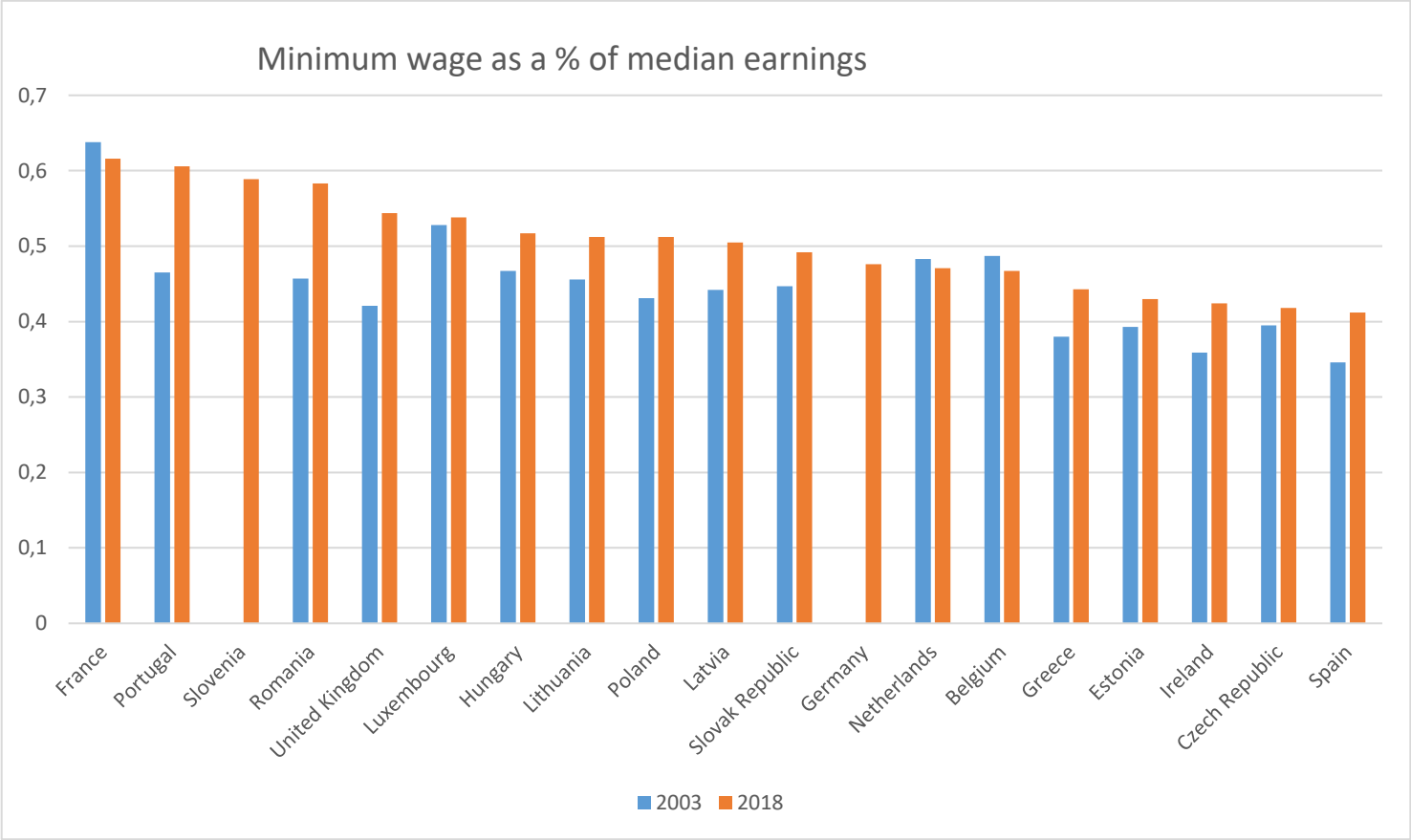
Source: Eurostat, [edat_lfs_9903]

Figure B.39: Change in employment protection legislation for regulary and temporary contracts



Source: OECD Employment database

Figure B.40: Cross-country variation in Minimum wages

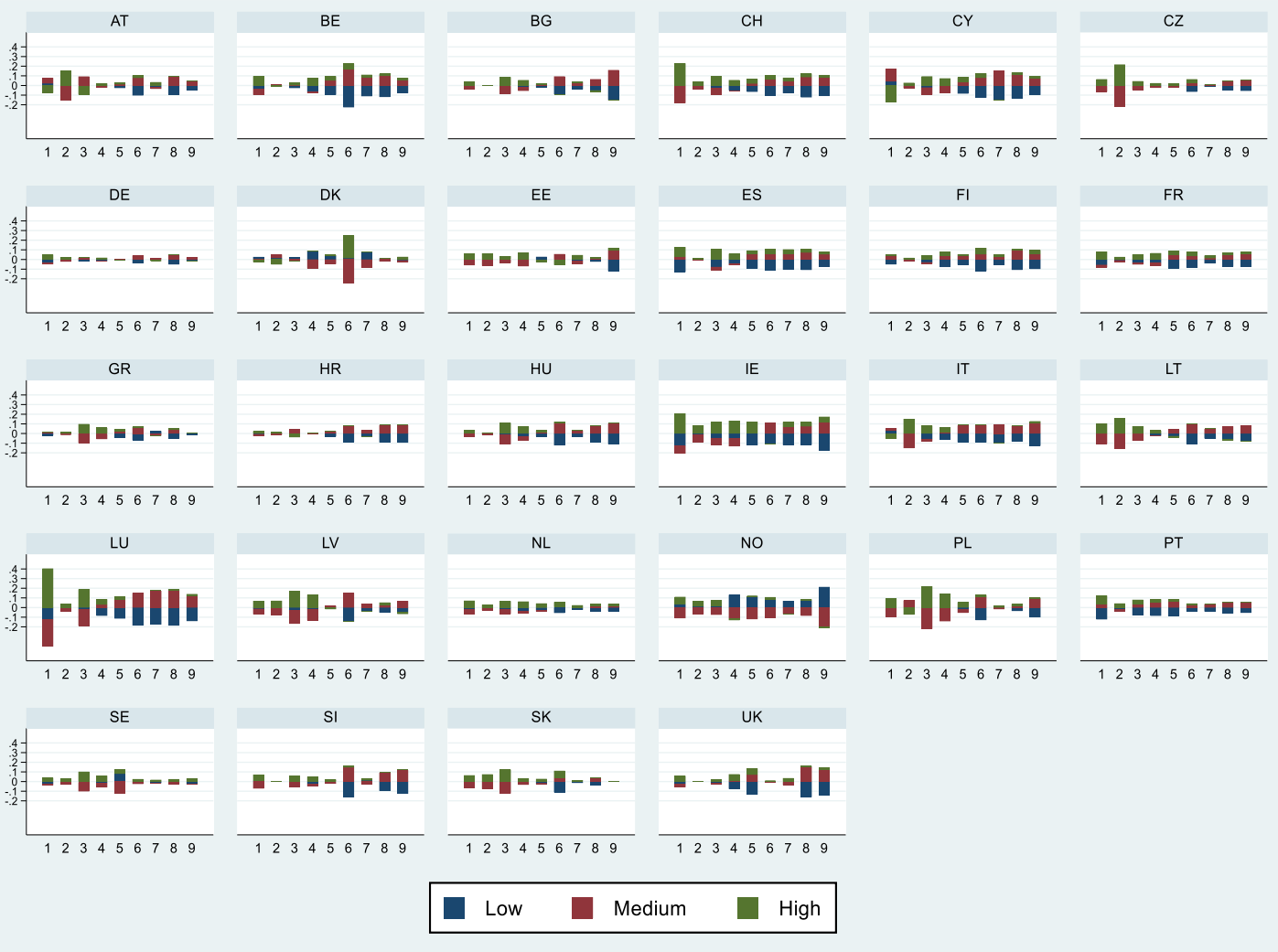


Source: OECD Employment database

Appendix C

Appendix to Chapter 4

Figure C.1: Change in educational composition of ISCO 1 digit occupations 2003-2010

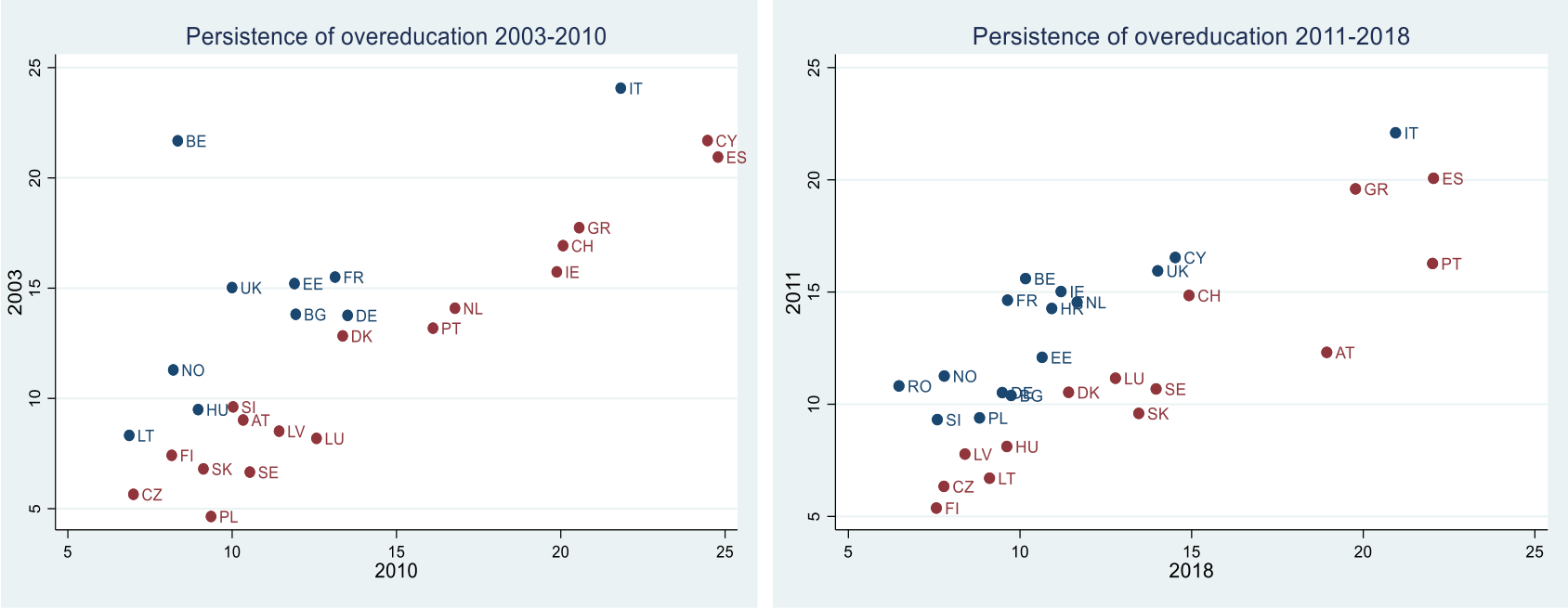


ISCO1 Legislators, Senior Officials and Managers; ISCO 2 Professionals; ISCO3 Technicians and Associate Professionals; ISCO4 Clerks; ISCO5 Service Workers and Shop and Market Sales Workers; ISCO6 Skilled Agricultural and Fishery Workers; ISCO7 Craft and Related Trade Workers; ISCO8 Plant and Machine operators and Assemblers; ISCO9 Elementary Occupations
Source: EU LFS

Figure C.2: Change in educational composition of ISCO 1 digit occupations 2011-2018

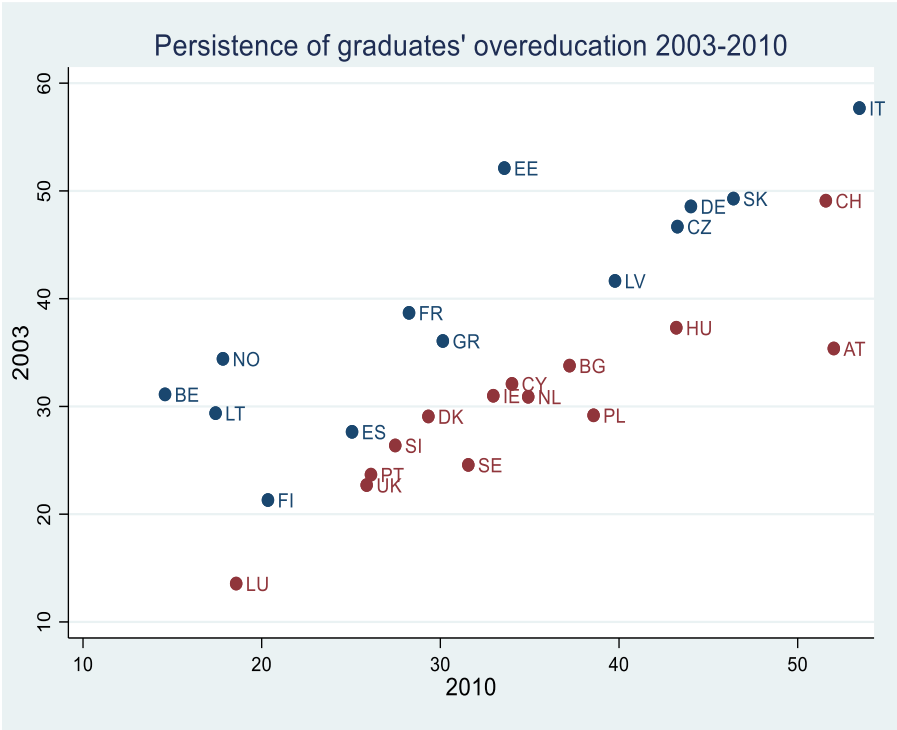
ISCO1 Legislators, Senior Officials and Managers; ISCO 2 Professionals; ISCO3 Technicians and Associate Professionals; ISCO4 Clerks; ISCO5 Service Workers and Shop and Market Sales Workers; ISCO6 Skilled Agricultural and Fishery Workers; ISCO7 Craft and Related Trade Workers; ISCO8 Plant and Machine operators and Assemblers; ISCO9 Elementary Occupations
Source: EU LFS

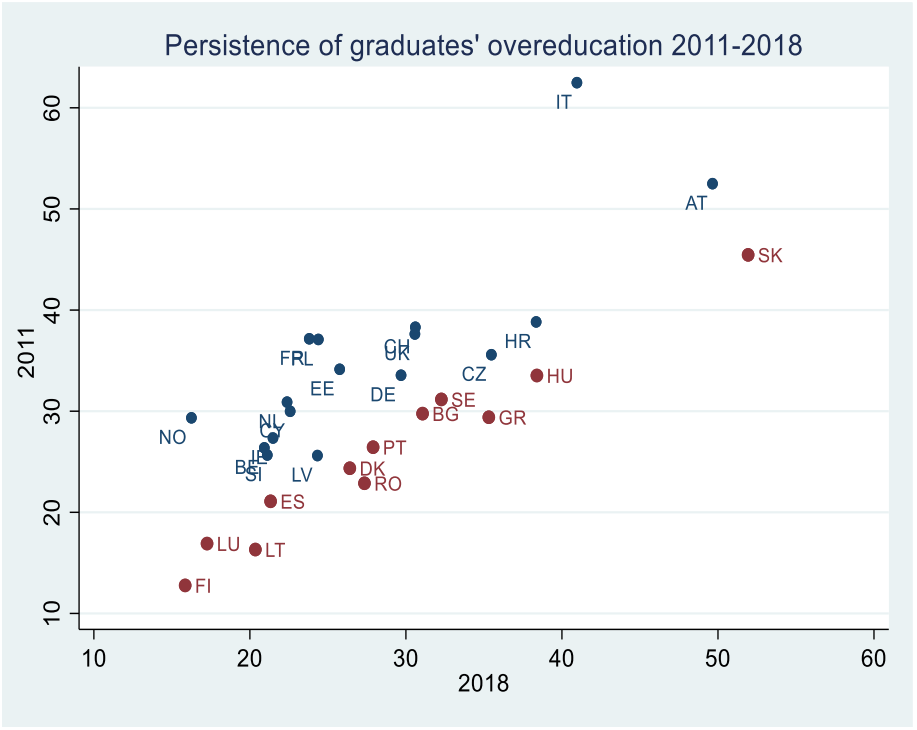
Figure C.3 and C.4: Incidence of overeducation and its persistence



Source: EU LFS

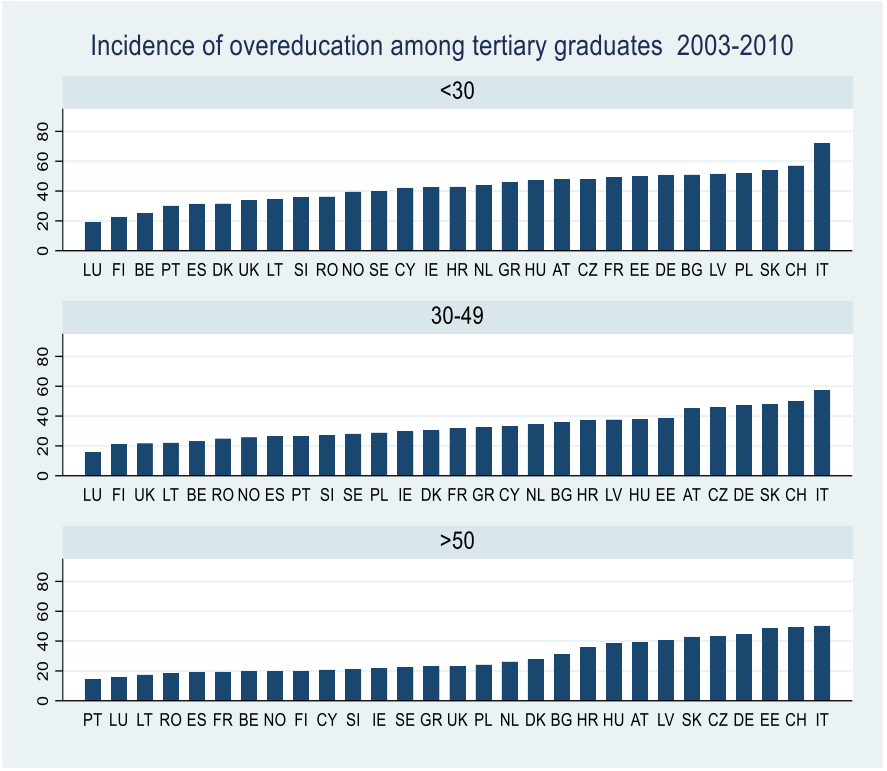
Figure C.5 and C.6: Incidence of overeducation its persistence among tertiary graduates

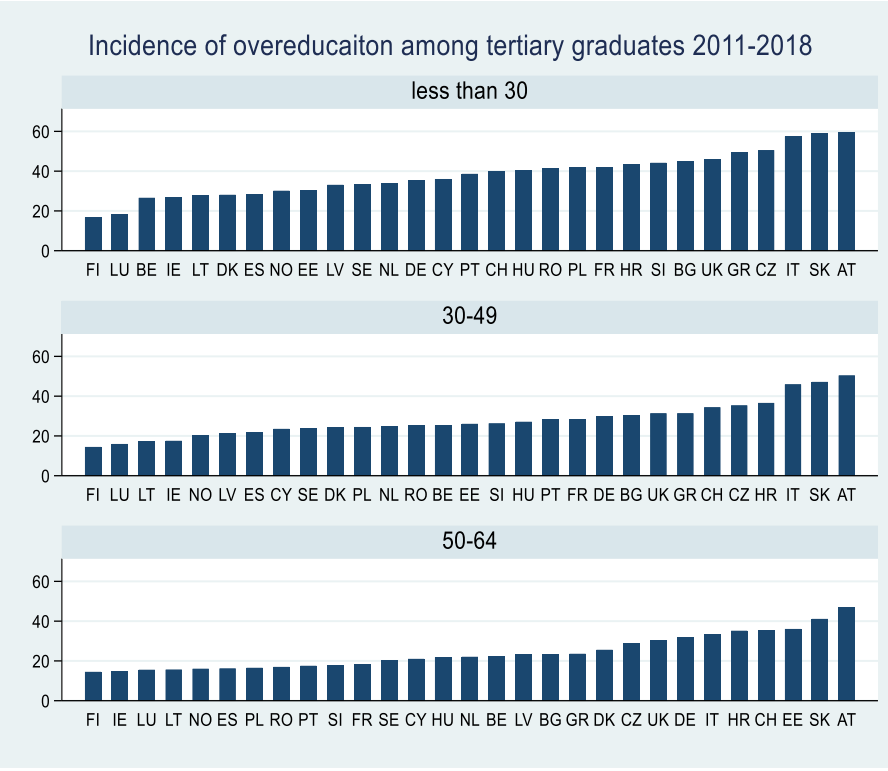




Source: EU LFS

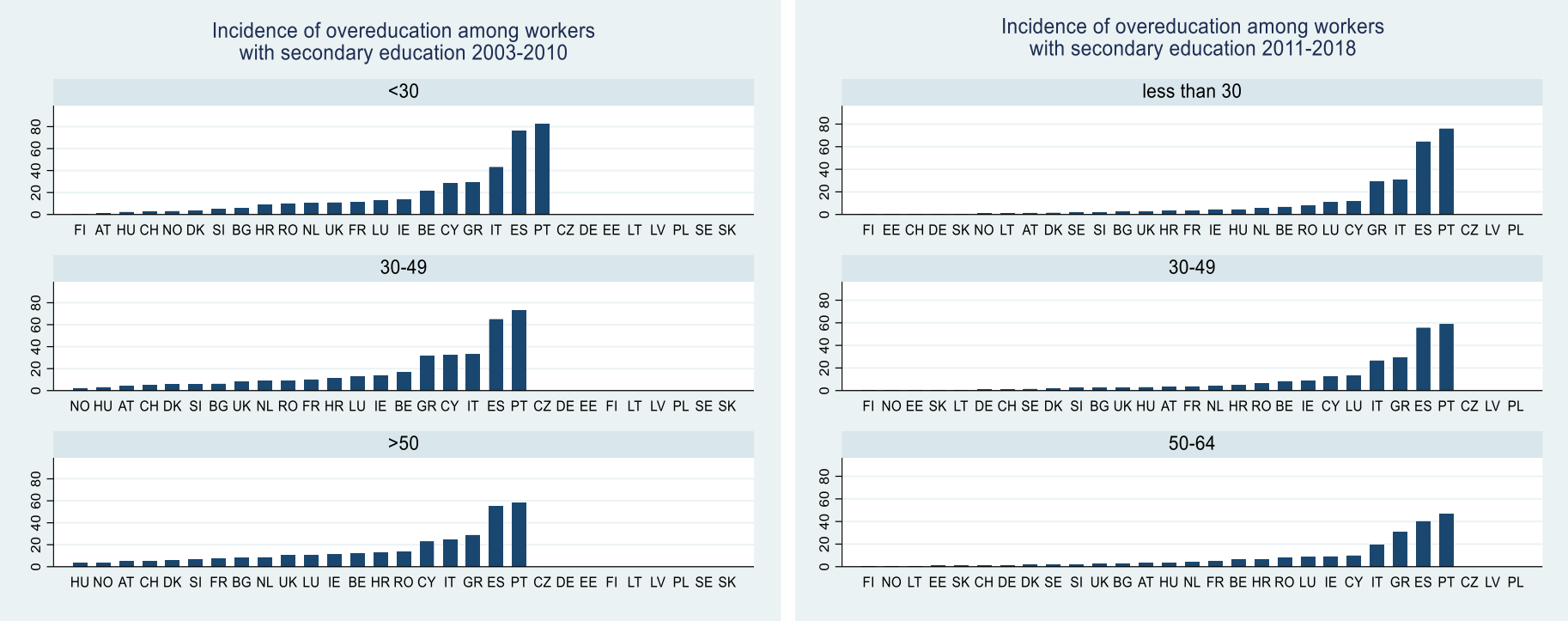
Figure C.7: Incidence of overeducation among tertiary graduates, by age group





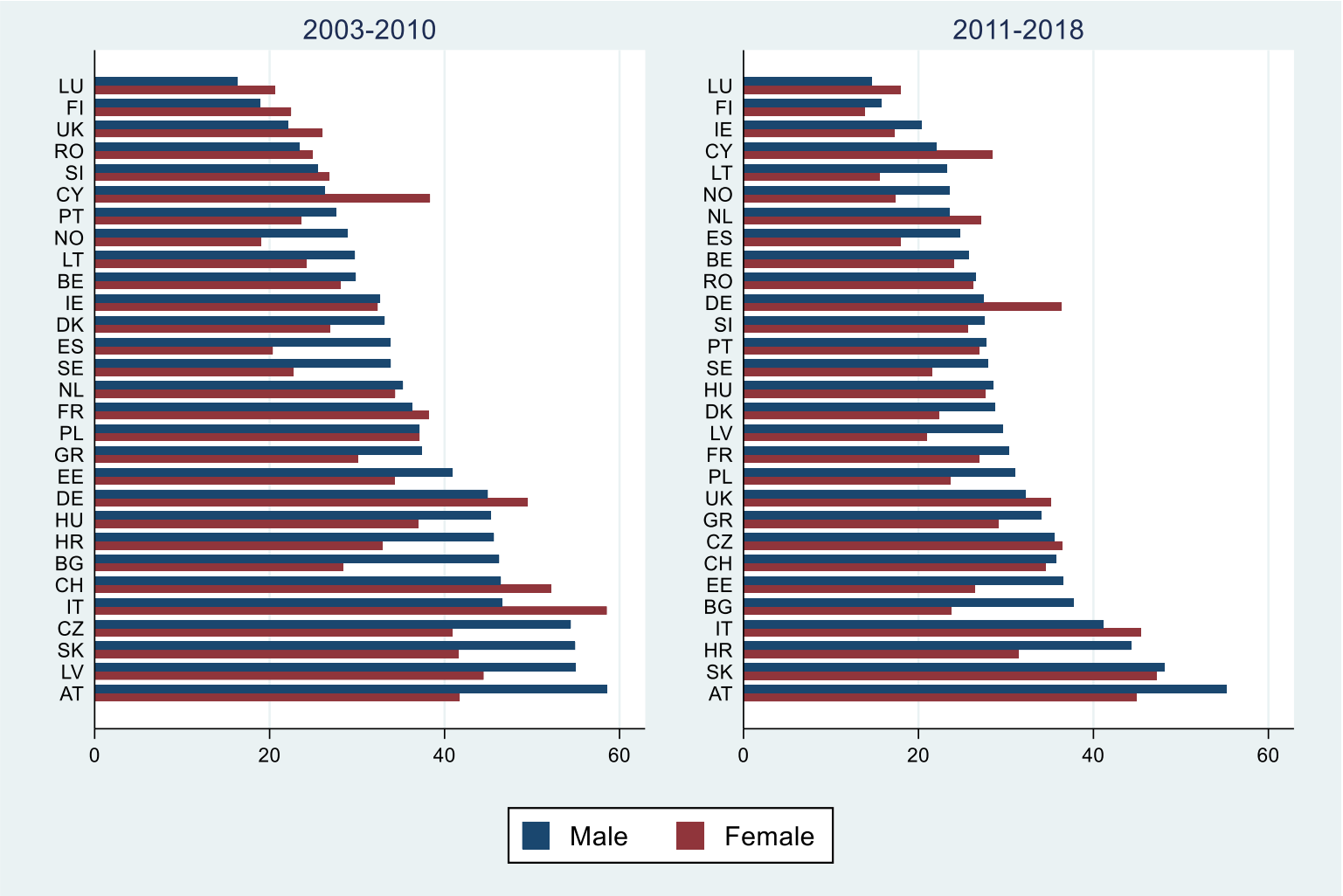
Source: EU LFS

Figure C.8: Incidence of overeducation among workers with upper-secondary and post-secondary non-tertiary education level



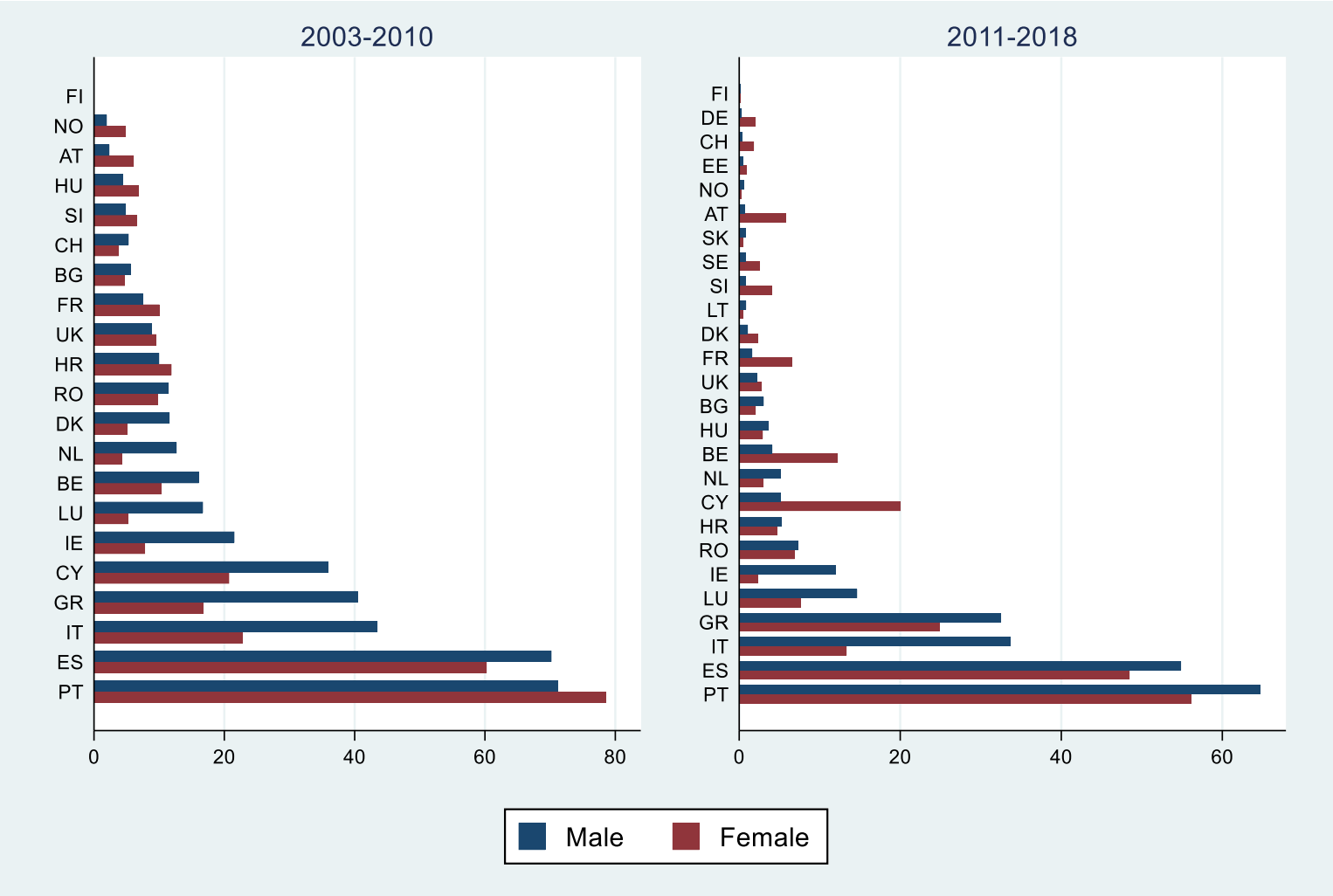
Source: EU LFS

Figure C.9: Incidence of overeducation among tertiary graduates, by gender



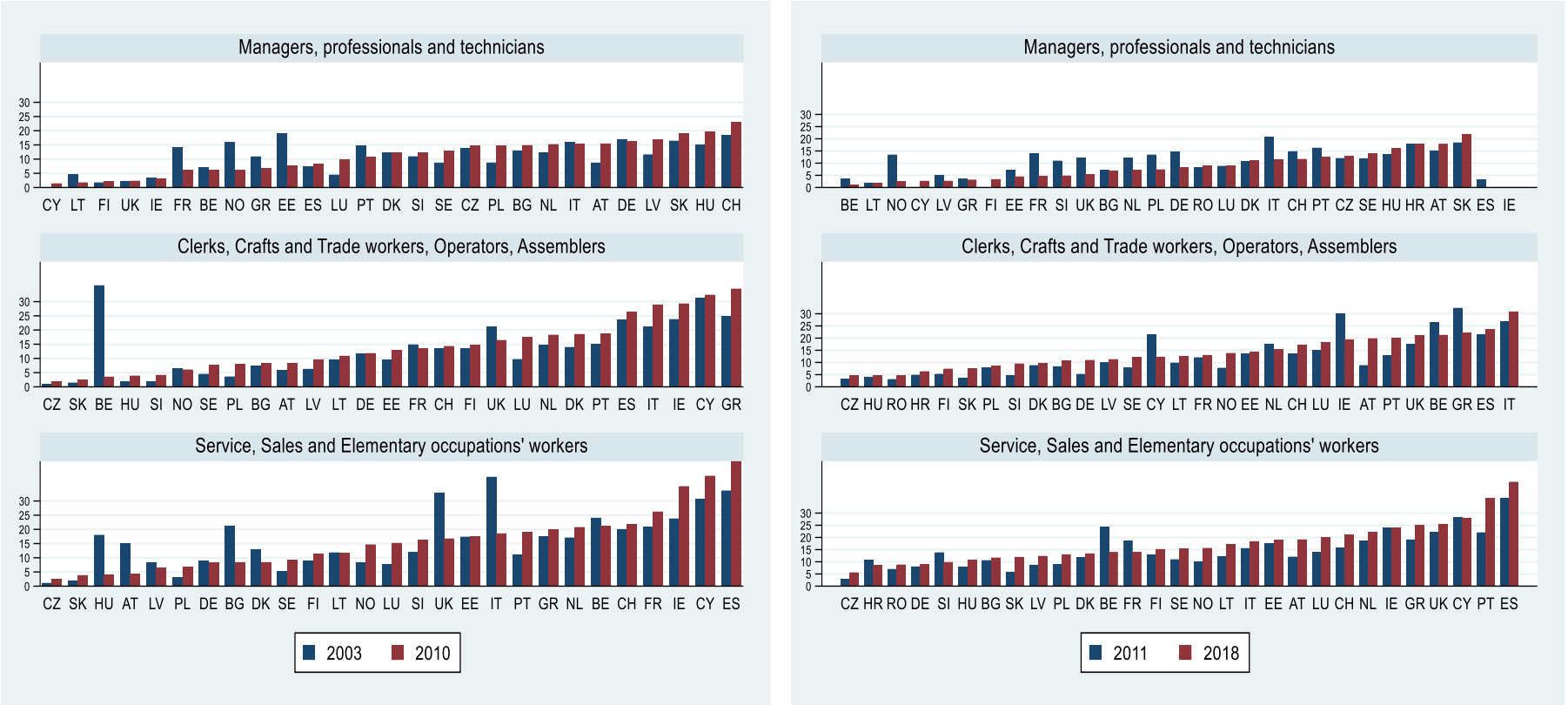
Source: EU LFS

Figure C.10. incidence of overeducation among upper-secondary and post-secondary non-tertiary workers



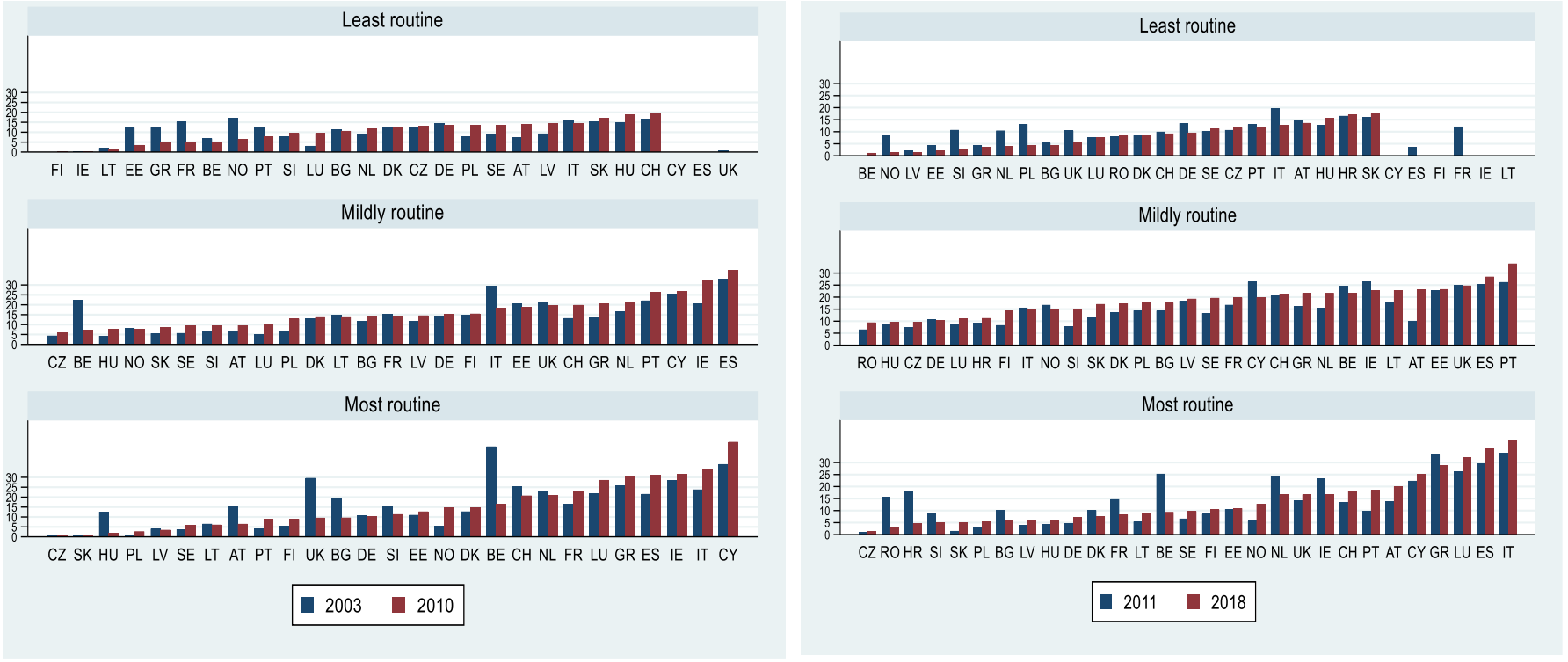
Source: EU LFS

Figure C.11 Change in the incidence of overeducation across skill groups



Source: EU LFS

Figure C.12: Change in the incidence of overeducation across occupational groups based on their task content



Source: EU LFS, groups are created on the basis of the previous analysis of task content of occupations using EWCS

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