TALLINNA ÜLIKOOLI RAHVUSVAHELISTE SOTSIAALUURINGUTE KESKUS

EDUCATION MISMATCH IN EUROPEAN COUNTRIES DURING THE 2008 FINANCIAL CRISIS AND AFTER THAT: DETERMINANTS BY OCCUPATIONAL GROUPS AND THE IMPACT OF MISMATCH ON SALARIES

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Rahvusvaheliste Sotsiaaluuringute Keskus (RASI) on Tallinna Ülikooli Ühiskonnateaduste Instituudi sotsiaalteaduslik interdistsiplinaarne teadus- ja arenduskeskus, mis teostab teadusprojekte. RASI teadurid on tegevad ekspertidena ühiskonnaelu analüüsimisel ja kujundamisel. TLÜ RASI uurimisteemad hõlmavad ühiskondliku ebavõrdsuse (või ka kihistumise) erinevaid tahke – sugu, rahvus, vanus, põlvkond, haridus, ametipositsioon. Viimastel aastatel on hakatud suurt tähelepanu pöörama elukestva õppe problemaatikale kui eluteed kujundavale ja sotsiaalset sidusust Eestis ning laiemalt kogu Euroopa Liidus tagavale tegurile. Teine uuem temaatika osakonna uurimistöös on seotud aktiivse vananemise küsimustega.

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1. Introduction

The existence of a potential gap between workers' educational attainment and the education actually used at the jobs has been a major concern of social scientists as well as policy makers (Sloane et al., 1999). Vertical mismatch includes two different processes: undereducation (upward intragenerational mobility) – workers possess lower qualifications than those required by their job – and overeducation (downward mobility) – they possess higher qualifications than necessary to do their job[1].

Paper highlights the implications of the gap between the jobs' educational requirements and the workers' actual educational attainment. Undereducation can have a negative impact on the aggregate output because either high-skilled jobs remain vacant, or they are filled with workers with lower educational attainment whose performance in those jobs is lower than optimal. On the individual level undereducation indicate upward social mobility. Overeducation might have very relevant consequences as well. From the macroeconomic perspective overeducation reflects a waste of human capital and national output is potentially lower than it could be if the skills of overeducated workers were fully utilised. Education mismatch can also affect wage inequality (Brunello and Wruuck, 2019). At the level of the organisations, there is some evidence to suggest that overeducation may be associated with lower productivity (Tsang, 1987; Kampelmann et al., 2020) and higher labour turnover (Hersch, 1991; Sicherman, 1991), leading in turn to lost investments in recruitment and training (Tsang et al., 1991; Alba-Ramirez, 1993). At the individual level, overeducated workers have been found to earn less than similarly educated workers whose jobs match their qualifications (Daly et al., 2000; Bauer, 2002; McGuinness and Sloane, 2011). Overeducated workers may also experience lower levels of job satisfaction (Battu et al., 1999; Mateos-Romero and Salinas-Jiménez, 2018) but also downward intragenerational social mobility. Education mismatch can reduce overall work motivation, expressing itself in more frequent absenteeism and higher turnover of the workforce (Tsang and Levin, 1985; Sicherman, 1991; Sloane et al., 1999). Mismatched workers might experience longer unemployment periods during their working life, with negative consequences on their skill endowment and on the probability to find a suitable job (Ordine and Rose, 2015; Berton et al. 2018). On the other hand, educational mismatches reduce job satisfaction thus increasing voluntary unemployment as well as job mobility (Verhaest and Omey, 2006). As a result, less-qualified workers may be displaced and 'bumped down' in the labour market, or into unemployment, by overeducated workers moving into their occupations, particularly in slack labour markets (Battu and Sloane, 2002).

Most of the previous analyses dealing with educational mismatch concentrate on the issue of overeducation (for reviews see McGuinness, 2006; Quintini, 2011; McGuinness et al., 2018b). Human capital deficit, such as undereducation receives relatively little attention in the literature despite that undereducation is assumed to have a direct negative impact on firm-level

[1] Occupational (labour market) mismatch literature has been placed primarily on formal qualification mismatches (education or formal qualification mismatches) and the mismatches between an individual's set of skills and the skills that are required for a certain job (skills mismatch) (McGuiness et al. 2018a). Because of improved data it has been possible to differentiate these two concepts. Recent empirical studies conclude that education mismatch and skills mismatch are not the same phenomenon (Allen et al. 2013; McGowan and Andrews 2015; Flisi et al. 2017; Choi et al. 2020). Employees can be formally well-matched but mismatched regarding skills (and vice versa).

productivity and determines a large share of the training investments of both employees and firms (McGuinness et al., 2018). In this paper we analyse under- as well as overeducation.

Most of previous research on labour market mismatch has relied on country-specific data sets. The research has focused on identifying the individual- and firm-level determinants of mismatch (Green and McIntosh, 2007; Boll et al., 2016; Muñoz de Bustillo et al., 2018) and the impact of mismatch on individual outcomes, such as salary or job satisfaction. However, there is also substantial evidence that the incidence of mismatch varies widely, not only across individuals, but also across labour market segments and countries. A small but growing body of research has begun to address this question through cross-country comparisons of the incidence of mainly overeducation perspective (see Di Petro, 2002; Poulikas, 2013; Boll et al., 2016; Davia et al., 2017; McGuinness et al., 2018; Delaney et al., 2020). Besides country comparisons many papers have analysed macroeconomic, demographic and institutional forces that drive educational mismatch (supply dynamics: Groot et al., 2000; composition of the labour force: Budria and Moro-Egido, 2018; McGuinness et al., 2018; employment protection legislation: McGowan and Andrews, 2015; Fregin et al., 2020; unemployment benefit systems: Verhaest et al., 2017; collective bargaining coverage: McGuinness, 2006; Verhaest et al., 2017; technological change: Mendes de Oliveira et al., 2000; Di Pietro, 2002; economic cycle: Verhaest and van der Velden, 2013; McGuinness et al., 2018).

There is a perception that overeducation predominantly affects tertiary graduates and the existing literature tends to be focused on this direction (see e.g., Chevalier and Lindley, 2009; Croce and Ghignoni, 2012; Baert et al., 2013; Carroll and Tani, 2015). The fact that overeducation can also occur at lower levels of educational attainment has been largely overlooked in research. Important shortcoming of most literature is also consideration of mismatched employees as a homogeneous group irrespective of their occupational position. To the best of our knowledge an in-depth examination of the incidence, determinants and effect on salaries by occupational group remains to be performed.

This paper uses data of European Union Labour Force Survey (EU-LFS) from 26 European countries to shed light on a number of previously under-researched issues regarding the incidence and drivers of educational mismatch. Our data and adopted empirical approach allow us to examine these issues within European countries during the financial crisis of 2007–2008 and after the crisis to investigate the relation between economic conditions and education mismatch as well as the impact of different drivers of mismatch during the crisis and after that. We also study the impact of educational mismatch on salaries of different occupational groups. We make three main contributions. Firstly, we trace the incidence of overeducation and undereducation of workers belonging to four broad occupational groups (high-skilled white-collars, low-skilled white-collars, high-skilled blue-collars and low-skilled blue-collars) across European countries in 2009 and 2014. Secondly, we investigate the relationship between educational mismatch rates and the composition of labour supply and demand as well as institutional factors within the European countries. Thirdly, we analyse the impact of educational mismatch on salaries for different occupational groups. Fourth, we study how the automation risk modify the impact of educational mismatch on salaries.

2. Theoretical explanations

2.1 Educational mismatch

Several labour market theories have been used to explain educational mismatch. For all these theories workers and employers are central economic agents in the analysis. The focus is on conditions affecting the supply of workers with different educational (skill) level and employers' demand for different type of work. Some theories emphasise supply side. Human capital theory suggests that overeducated workers accumulate skills that can be used to switch to higher level positions. Therefore, human capital theory regards educational mismatch as a negligible and temporary phenomenon, which is corrected by the market (Becker, 1964). The career mobility theory assumes that workers enter voluntarily to jobs for which they are overeducated to gain experience and training for career development and therefore overeducation is of limited duration and occurs predominantly at the beginning of individual careers (Sicherman and Galor, 1990).

Other theories emphasise the demand side of the labour market. According to the theory of job competition (Thurow, 1975) workers compete for jobs in certain occupations. They are ranked according to their educational level as a signal of their future job performance and trainability. An increase of supply of graduates on the labour market causes persistent overeducation of graduates whereas lower-educated persons become unemployed. According to signalling (screening) theory (Arrow, 1973; Spence, 1973; Stiglitz, 1975) some skills are acquired by workers to signal their level of productivity to potential employers. If the supply of education (skills) outperforms the demand for this education (skills) the rate of overeducation could increase.

Some theories take into account both the supply and demand sides of the labour market. Theory of job search (Jovanovic, 1979) assumes that in a labour market characterised by uncertainty and costly information, both employers and workers will spend time searching for qualified workers or job positions. Due to the search costs educated workers might be satisfied with finding a position at a level below their education. At the same time, employers are hiring applicants whose education exceeds current job requirements, as this could allow them to save training costs in the future. The theory postulates that overeducation may temporarily arise due to incomplete information on the labour market (Mortensen, 1986). Assignment theory postulates that heterogeneous workers apply for heterogeneous jobs (Sattinger, 1993). As a result, the perfect matching is unlikely, and some individuals end up in jobs for which they are over- or undereducated.

Job competition model and assignment theory predict that the situation of education mismatch will persist until a more efficient allocation of individuals to jobs arises as a result of improved matching processes or governmental policies intended to reduce such inefficiencies.

2.2 Effect of macro level characteristics on education mismatch

A potential source of cross-country differences in educational mismatch is variation in the extent to which there is *an imbalance between the demand for and supply* of skilled workers, either structurally or cyclically (Mendes de Oliveira et al., 2000; Barone and Ortiz, 2010; Croce and Ghignoni, 2012; Verhaest and Van der Velden, 2013). Overeducation can arise if the structure of

labour demand by educational level is rigid due to technological reasons and does not respond to the increase of supply of the skilled labour. On the one hand, an oversupply of educated workers may force jobseekers to accept jobs below their level of education. In addition, oversupply allows employers to prefer more highly educated and overeducated job seekers (Thurow, 1975). Therefore, oversupply of educated workers might lead to more overeducation.

Fluctuations in the economy will change the composition in the demand for labour and how workers are utilized within firms. Brunello and Wruuck (2019) mention that the relationship between educational mismatch and the business cycle is driven by several factors. On the one hand, in recession mismatch declines because low level jobs are disappearing and consequently mismatch decreases. On the other hand, mismatch increases because there are less vacancies and jobseekers are willing to accept jobs below their educational level. When the labour market is tight, employers are forced to downward their hiring standards which increases the incidence of undereducation (Healy et al., 2015).

Labour market institutions seem to be of particular theoretical relevance when it comes to optimal education matching as it may explain variations in allocation processes (Estevez-Abe et al., 2001; Hall and Soskice, 2001). The higher the employment protection, the higher the firing costs even with workers who are mismatched and not optimally productive. Strict regulations in firing of permanent employees make it more difficult for firms to adapt the labour force structure to address mismatch between the demand and supply of skills (Di Pietro, 2002). It reduces employers' ability to replace badly matched employees with well-matched jobseekers. The regulation of dismissal process also affects hiring processes. Strong EPL increases hiring risks on the side of employer. Dismissal costs would lower the expected returns and diminish the utility of hiring. The higher the costs for dismissals, the more employers will ensure that their workers match their jobs. It makes a positive relation between sticker EPL and optimal education matching more likely than as negative relations (Fregin et al., 2020).

2.3 Education mismatch and wages

Human capital theory suggests that a worker's productivity on-the-job is determined by his/her past investments into human capital through formal education or training. These investments are rewarded by the market, as workers are paid according to their marginal product. Job's requirements would not affect wages. Therefore, overeducated workers would receive similar returns to education as other workers with a similar level of education who are properly matched in their jobs. The theory of job competition and signalling theory emphasise the role of the job's requirements, assuming that job characteristics determine wages whereas education signals unobserved productivity (Spence, 1993) or the rank in the order of jobseekers. As a result, overeducated workers would suffer a wage penalty as compared with adequately educated jobseekers since overeducated workers hold jobs with lower educational requirements, but no wage premium would be observed for the higher educational attainment when compared with their adequately matched colleagues. Similar reasoning could be used for undereducated workers. They have higher wages than adequately placed individuals with the same level of education, but they do not suffer from wage penalty compared to adequately placed workers doing the same job (see also Kracke et al., 2018). Assignment theory assumes that productivity and consequently wages are determined by both individuals' and jobs' characteristics. Not only attained education but also the use of the acquired education in the job determines workers' wage. Overeducated workers would receive a wage premium as compared with their properly matched co-workers as a consequence of their higher levels of education. At the same time, they

would not use their skills properly and as a result would earn lower wages compared to workers with the same education but who are adequately placed (see also Mateo-Romero et al., 2018). Undereducated workers would suffer from a wage penalty compared to co-workers who are properly matched. However, they would earn higher wages in comparison with properly matched workers with the same level of education.

3. Previous research

3.1 Incidence of education mismatch

Substantial variation has been found in the incidence of overeducation between countries (Di Pietro, 2002; Croce and Ghignoni, 2012; Verhaest and Van der Velden, 2013). However, the results depend on the measurement approach[2] used (see also McGuinness et al., 2018b). An additional factor that can lead the differences between previous results relates to the age group and the number of occupational categories used. There has been found that overeducation rates have remained relatively unchanged over time in many EU countries and are actually declining in others (McGuinness et al., 2018a). McGuinness et al. (2018a) report that the incidence of overeducation in the EU, averaged over all countries and education levels, has remained stable at approximately 18 per cent from 2003 to 2013. But Muñoz de Bustillo et al. (2018) mark different patterns of overeducation across countries over time rather than a common trend. However, convergence in overeducation rates has taken place.

Undereducation has received much less attention. According to meta-analysis presented by McGuinness et al. (2018b), 98 papers were published on overeducation and only 30 papers on undereducation. Additionally, undereducation was not the sole focus of any paper. It was considered in conjunction with overeducation. Previous research indicates that overeducation is generally more common than undereducation, as being overeducated is on average roughly two and a half times more widespread than being undereducated (McGowan and Andrews, 2015).

3.2 The impact of individual and job characteristics

Among the individual level determinants *gender* differences have received a large amount of attention in the recent literature. In many countries the share of overeducated workers among women is higher than among men (Boll et al., 2016; Erdsiek, 2021). But a majority of previous studies have found that the effect of gender on overeducation risk is insignificant in multivariate models (Büchel and Pollmann-Schult, 2001; Green and McIntosh, 2007; Capsada-Muensch, 2015). Quintini (2011) found that women are more likely undereducated than men.

Another potentially relevant individual characteristic is the worker's *age*. Overeducation could be more common amongst young people since they are more likely to be employed in temporary or entry-level jobs where education demands could be lower. Both country-level and cross-country studies have found that young people are more likely to be overeducated than older workers (Allen et al., 2013; OECD, 2013). The European Commission (2012) also finds a decreasing probability of being overeducated as the age of workers increases. In contrast, Groot and van den

[2] Overall, the estimates obtained through the statistical approach tend to be lower than those based on the workers' self-assessment (Leuven and Oosterbeek, 2011).

Brink (2003) detect no significant impact of age on the incidence of overeducation. Other authors indicate that high-skilled workers from the youngest and the oldest age groups have a particularly high overeducation risks in EU countries (Boll et al., 2016). Muñoz de Bustillo et al. (2018) have detected three different patterns: a U-pattern (with overeducation decreasing with age until mid-age and increasing afterwards) in six countries; a decreasing pattern (decreasing overeducation with age throughout the working career) in 15 countries and L-pattern (with overeducation decreasing with age up to certain point and then remaining relatively stable) in nine countries. Older workers can suffer from skills obsolescence due to technological progress. As a result, incidence of undereducation should be higher for older age groups.

Studies focusing on the impact of *work experience* establish a more clear-cut picture. Most authors indicate a highly significant negative impact of increased experience on the incidence of overeducation (Alba-Ramirez, 1993; Sloane et al., 1999). On the other hand, undereducation is higher for more experienced workers (Quntini, 2011). Undereducated might have acquired further skills during work career, which are not reflected in their educational level but allow them to do more complex jobs than their education suggests.

Most previous studies have concentrated on analysis of overeducation of employees with tertiary education. There are only a few studies comparing educational mismatch of different *educational groups*. For example, Delaney et al. (2020) find that overeducation is highest among young workers educated to tertiary level and lowest for those employees educated to primary or less. Quintini's (2011) analysis indicate no significant impact of educational level on the incidence of undereducation.

Previous studies demonstrate that the incidence of educational mismatch is strongly related both to *job type and firm characteristics*. Workers in private firms are found to be less likely to be overeducated but more likely to be undereducated than workers in public sector. This result could be explained by the fact that public sector jobs often include education requirements (Quntini, 2011). The evidence on the links between *firm size* and education mismatch are ambiguous. Some cross-country studies have found that overeducation increases with firm size (Allen et al., 2013). There are several arguments in favour of this result. First, large firms are more complex and matching workers to the right jobs is more difficult. Second, larger firms are likely to be less financially constrained and can afford to use a recruitment strategy to ensure a continuous supply of high skills by hoarding overeducated workers (McGowan and Andrews, 2015). Other authors argue that education mismatch should decline with firm size, because larger firms offer more opportunities for highly educated workers compared to small firms (Quintini, 2011) and provide more space for career advancement.

Concerning the job type, the relevant distinction is between *fixed-term* and *permanent contract*. It appears that workers on fixed-term contracts are more likely to be overeducated than those on permanent contract (Green and McIntosh, 2007; Boll et al., 2016). Fixed-term contracts have transitory nature and workers are less concerned about educational levels, as they tend to view these matches as temporary solutions on their career.

Previous studies indicate that *economic sector* has also an impact on the rate of overeducation. Analysing the incidence of overeducation in the EU-15 countries Congregado et al. (2016) find that overeducation is higher in service sector and lower in agricultural sector. In terms of occupations, mismatch is higher in elementary occupations, in services and in technicians (Morrar and Zwick, 2021).

Table 1 summarises results of previous empirical studies presented above.

Table 1. Overview of previous empirical results: the impact of individual and job characteristics

	Impact on:	
	Overeducation	**Undereducation**
Individual level characteristics		
Gender	Women > men In multivariate models no gender differences	Women > men
Age	Younger > older High skilled younger and older workers > others age groups Different patterns: U-pattern; decreasing pattern; L-pattern	Older > younger
Work experience	Higher experience < low experience	Higher experience > low experience
Education	Highest among young workers with tertiary level, lowest among young workers with primary education	No impact
Job-related characteristics		
Private versus public	Workers in private firms > workers in public sector	Workers in private firms < workers in public sector
Firm size	Large firms > small firms Decreasing with firm size	Decreasing with firm size
Job type	Workers with fixed-term contract > workers with permanent contract	?
Economic sector	Higher in service sector; lower in agricultural sector	Higher in service sector, construction transportation
Occupation	Service workers, elementary occupations, technicians	

3.3 Determinants of cross-country differences

Di Pietro (2002) finds that on the supply side, increase in the *educational attainment* of the population is associated with higher overeducation, while on the demand side, increased *investment in research and development* is associated with lower overeducation. Figueiredo et al. (2017) as well as Cabus and Somers (2018) show that the recent increase in the average level of education may have had an effect of the intensification of mismatch. In contrary Ordine and Rose (2017) indicate that there is no strong relationship between country level overeducation rates and the share of individuals with tertiary education because supply may create 'its own demand'. However, the relationship between supply and demand seems to be important. Several studies have shown that a structural oversupply of educated workers does result in more overeducation. Davia et al. (2010) consider as a measure of the excess of educated labour supply the ratio of tertiary graduates to employment in professional and managerial positions and show that this measure has a positive effect on the incidence of overeducation.

Croce and Ghignoni, 2012) find that the *business cycle* affects the overall incidence of overeducation. Similarly, Verhaest and van der Velden (2013) find that the business cycle in the year of labour market entry explains cross-country differences in overeducation up to five years after graduation. Poulikas (2013) and Borgna et al. (2018) also demonstrate that during the financial crisis the average rate of overeducation in Europe increased.

Labour market institutions might also explain differences in education mismatch across countries. Previous research has highlighted the effects of flexible *labour market regulations* (Verhaest et al., 2017; Fregin et al., 2020). Verhaest and van der Velden (2013) report that EPL effect was unimportant in explaining cross-country differences in overeducation among a graduate cohort. Other authors have found that countries with a higher level of employment protection have experienced a higher incidence of overeducation (Croce and Ghignoni, 2012; McGowan and Andrews, 2015).

Overview of findings related to the impact of macro-level characteristics on educational mismatch are summarised in Table 2.

Table 2. Overview of previous empirical results: the impact of macro-level characteristics

	Impact on:	
	Overeducation	**Undereducation**
Rate of workers with tertiary education	Higher rate is increasing No difference	Not available
Investments in innovation	Higher investments are decreasing	Higher investments are increasing
Imbalance between demand and supply side	Oversupply of educated workers is increasing	Not available
Business cycle	In recession declines In recessions increases	In recession increases
Employment protection legislation	Higher EPL is increasing	Higher EPL is increasing

3.4 The impact of education mismatch on wages

Previous research consistently points to a wage penalty for overeducated individuals, relative to individuals with the same education in matched employment (McGuinness and Sloane, 2011; Mavromaras et al., 2013; Ordine and Rose, 2015; Kracke et al., 2018). McGuinness et al. (2018b) indicate in their meta-analysis that taking the average of different estimates overeducated individuals earn 13.6% less than matched individuals with similar levels of education. But overeducated workers earn more than adequately educated workers in jobs with requirements that match with their education (Bauer, 2002; Brynin and Longhi 2009; Hartog and Sattinger 2013). Levels et al. (2014) found that having more education than is required for a job is associated with higher wages: specifically, each additional year of education in excess of that required yields a wage premium of 3%. The empirical findings on undereducation are mixed. Verhaest and Omey (2006) find that undereducated receive wage premium relative to workers with the same education in a matched job. However, Sanchez-Sanchez and McGuinness (2015) and Di Pietro and Urwin (2006) find no statistically significant wage effect for undereducated workers. Still, undereducated workers are generally found to earn less than their adequately matched colleagues in jobs with similar requirements.

There are findings indicating that the estimated overeducation penalty might be overestimated if overeducated workers have lower average ability levels than adequately educated workers with a similar educational background (Verhaest and Omey, 2012). McGuinness (2003), Chevalier and Lindley (2009) and Sohn (2010) included ability related indicators in the earnings equation and still found substantial wage penalties of overeducation.

Some researchers have studied the interaction effect between experience and education mismatch. Cohn and Ng (2000) found evidence for a negative interaction effect between overeducation and experience, whereas the undereducation bonus increased with years of experience. This suggests that overeducated workers experience less skill acquisition or even a depreciation of their skills surplus; undereducated workers seem to compensate their skill deficit with more skill acquisition on-the-job.

Table 3. Overview of previous empirical results: impact of educational mismatch on salaries

	Undereducation	**Overeducation**
With the same **educational level**	Increasing	Decreasing
With the same **occupational group**	Decreasing	Increasing

4. Data and methods

We are using the EU-LFS data[3], focusing on two specific time periods: 2009 (during the great recession) and 2014 (after the recession). The analysis is based on the pooled data of 26 European countries[4] and the sample for the study is restricted to individuals who are working full-time.

First part of the analysis concentrates on educational mismatch. Most commonly used measures for analysing educational mismatch are workers' self-assessment, realized matches and job analysis approach (Flisi et al., 2014). We use the realized matches approach, which compares individual educational level with the modal or mean level of schooling of their respective occupation. We calculated the modal level of education based on four ISCED categories[5] for full-time workers for each ISCO-08 two-digit occupation group in each country separately. Accordingly, individuals are classified as being overeducated if their level of attained schooling is one level above the mode of their occupation, they are defined as matched if their educational

[3] Every year a certain number of changes are applied in the national labour market surveys. These changes can concern the conceptual level (e.g., definitions and concepts used by the labour force survey) or the measurement level (sampling strategy, data collection etc.), which is important because it may produce some discontinuity also in the time series (Eurostat, 2012). More information about comparability over time is available for each survey year in the Quality Report of the European Union Labour Force Survey.

[4] We excluded the following countries from the analysis: Malta because the information about the occupation was only available at the 1-digit level and Luxembourg, Croatia, Iceland, Switzerland because either data was not available for both years or due to small sample sizes.

[5] ISCED 0–2 primary education and less; 2 upper-secondary; 3 post-secondary non-tertiary; 4 short-cycle tertiary education and higher.

level is equal to the modal level of schooling and undereducated if their acquired education is below the mode of their occupation.

We selected realized matches approach because it is indicated to adjust to skills upgrading due to technological change or new formal qualification requirements, what might ease the comparisons across cohorts, time points and countries (Capsada-Munsech, 2019). Still, the critics point out that the overall increase in educational attainment in a country without structural employment change might lead to a supply driven increase in the modal educational level of many jobs. In such cases, the use of the realized matches approach will interpret such increase as an increase in terms of the requirements, even if the jobs actually have not changed and have roughly the same requirements than before and will therefore potentially underestimate the level of overeducation (Muñoz de Bustillo et al., 2018).

The aim of the report is to analyse the variation in both the levels and trends in over- and undereducation and the factors explaining the country-level variance. In the first part of the analysis, we are using descriptive statistics to show how educational mismatch differs between different time periods, by countries and occupational groups. Secondly, we use multilevel logistic regression to analyse the overall incidence of being overeducated (ref matched) and undereducated (ref matched). We include to the analysis different individual (e.g. gender, age group, job tenure, occupational group[6], automation risk of the occupation[7]), workplace (industry, size of the firm, type of contract) and macro-level characteristics (percentage of tertiary educated among working-age[8] population, unemployment rate, ratio of workers employed in managerial or professional occupations to people who have higher education[9], summary innovation index[10], strictness of employment protection legislation[11]) that reflect the potential demand- and supply-side as well as institutional and other structural characteristics which may have an effect on the incidence of over- and undereducation.

EU-LFS provides individual data on salary deciles. The vast literature traditionally uses the logarithm of salaries as an outcome. However, absolute amounts of salaries are not available in EU-LFS. Recent economic literature argues that categorical salary data with some thresholds are appropriate to relax the assumption of linearity (Bloome at al., 2018; Araki, 2020). This means, although linear models utilising continuous salary measures are preferable when analysing the link between education and salary, linear models with categorical outcomes may provide robust findings.

[6] High-skilled white-collar (ISCO 100-300), low-skilled white-collar (ISCO 400-500), high-skilled blue-collar (ISCO 600-700) and low-skilled blue-collar (ISCO 800-900).

[7] We are using the indicator of occupational automation risk from the TECHNEQUALITY project. The indicator measures the percentage of tasks on which less time will be spent, and it is coded for 2-digit ISCO-08 occupations.

[8] 25–64-year-olds.

[9] ISCED 5–8.

[10] It is a composite indicator obtained by taking an unweighted average of the indicators. Due to data revisions, summary innovation index results are not comparable across different time periods. 2009 data extracted from European Innovation scoreboard 2016 report and 2014 data from European Innovation scoreboard 2020 database.

[11] Individual and collective dismissals (regular contacts) version 1, which is extracted from OECD database (https://stats.oecd.org/Index.aspx?DataSetCode=EPL_OV)

In the third part we analyse the impact of educational mismatch on salaries. First, we use linear regression models, controlling for educational level (Appendix, Table 8A) and occupational group (Appendix, Table 9A) in separate analyses. In the following step, we analyse the impact of educational mismatch in four broad occupational groups using multilevel linear regression, controlling also for educational level (Appendix, Tables 10A-13A) and occupational group (Appendix, Tables 14A-17A). We include to the salary analysis same individual and workplace characteristics which we are using in the multilevel logistic regression models. In addition, we add to the multilevel linear regression analysis a model with the interaction of automation risk with educational mismatch variables to examine how the automation risk of the occupational group modify the effect of educational mismatch on salaries.

5. Results

Descriptive results show (Figure 1) that across all European countries observed in this paper, undereducation and overeducation rate has remained rather stable between 2009 and 2014, i.e., during and after the 2008 financial crisis. Undereducation rate is somewhat higher than overeducation, in 2014 respectively 18.1% and 15.6%. However, there are considerable country differences (see Appendix, Table 1A). Undereducation decreased the most in Belgium, France, Lithuania and the UK, while increase is most notable in Hungary, Italy, Spain, Romania, Slovenia, Cyprus and Poland (percentage change from 2009 to 2014 $\geq$ 20%). Overeducation dropped considerably in Denmark, Ireland, Cyprus, Poland, Spain and Italy, and expanded in the UK, Portugal, Norway, Belgium and Slovakia. One way to explain the differences in educational mismatch is that there is an imbalance between the demand for and supply of skilled workers which is caused by structural or cyclical changes in the economy. Pouliakas (2013) and Borgna et al. 2018 have indicated that during the financial crisis the average rate of overeducation in Europe increased. Our analysis does not confirm this for all the countries. Overall, the results show that the recession affected countries differently concerning the educational mismatch.

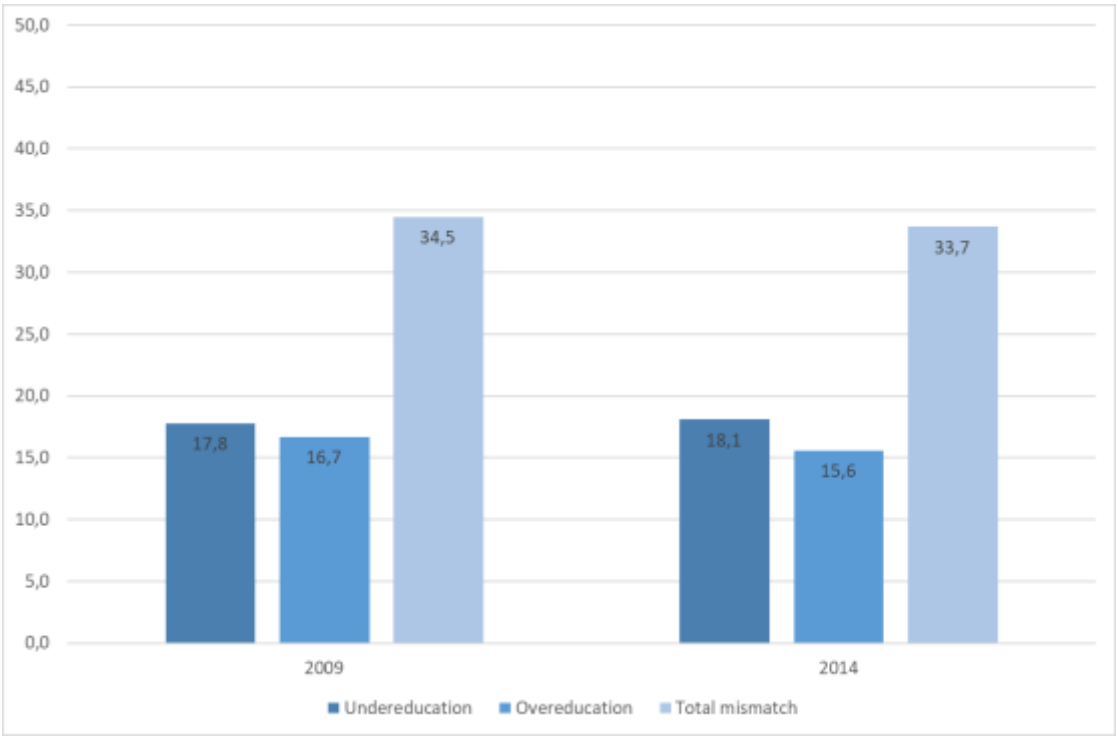

Figure 1. Under- and overeducation rate in 2009 and 2014, pooled data (%)
Source: Authors' calculations based on EU-LFS 2009, 2014; realized matches approach, sample restricted to full-time workers.

In the following, we focus on the pooled data to examine individual, job-related and macro-level characteristics on over- and undereducation by four major occupational groups. According to Figure 2 the share of undereducated workers is highest in high-skilled white-collar (ISCO 1–3) occupational groups in 2014 and 2009 and overeducation is the highest for both years specifically in the low-skilled white-collar (ISCO 4–5) occupational groups. Among low-skilled blue-collar (ISCO 8–9) workers over- and undereducation rate is distributed rather evenly, while for high-skilled blue-collar group (ISCO 6–7) overeducation is somewhat higher than undereducation. Results by occupational groups by countries are presented in the Appendix (see Tables 2A to 5A).

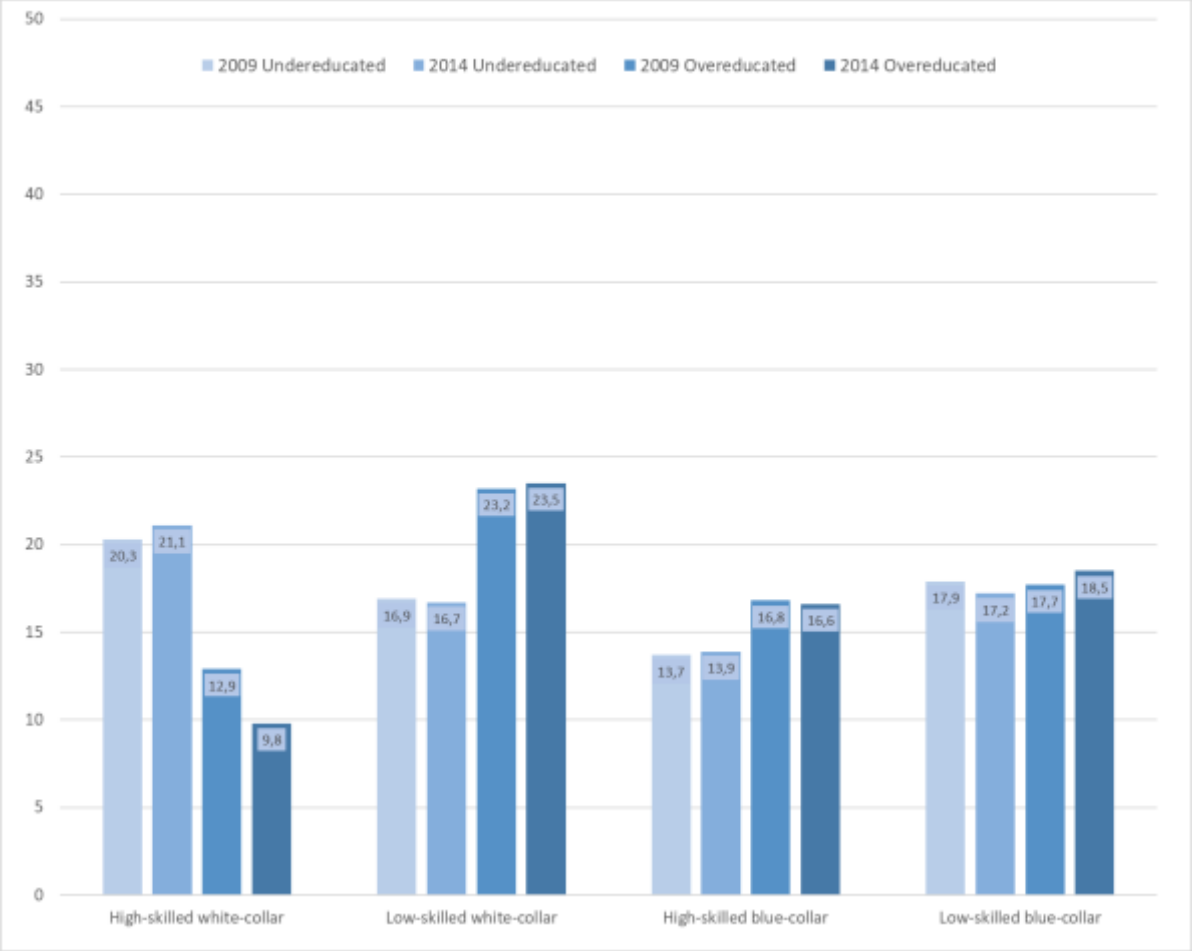

Figure 2. *Under- and overeducation rates by occupational groups in 2009 and 2014* (%)
Source: Authors' calculations based on EU-LFS 2009, 2014; realized matches approach, sample restricted to full-time workers.

5.1 The impact of individual and job-related characteristics on educational mismatch

Beginning with individual characteristics, results from multilevel logistic regressions summarised in Table 3 show that contrary to some previous findings regarding *gender* differences, men are more likely than women to be over- and undereducated in both time periods, with the exception of overeducation in 2014, where there is no statistically significant gender impact. The latter finding on overeducation in 2014 confirms majority of studies applying multivariate analysis.

In accordance with several previous findings, we observe that *age* of a worker tends to decrease the probability of being overeducated (ref the youngest, i.e., 20–29-year-olds) and this holds for both 2009 and 2014. For undereducation we find that it increases with age and in 2014 in particular, probability of being undereducated is lowest among 30–39-year-olds and highest among 50+ age group, which could be expected as technological innovation is associated with skills obsolescence in older age groups. Overall, economic crisis of 2008 does not seem to have change the impact of age on educational mismatch.

Research on educational mismatch (mostly concerning overeducation) has not focused on variations between different occupational classes, however, our results indicate significant *occupational group* differences. It appears that overeducation in both time periods is highest among low-skilled white-collars (ref high-skilled white-collars) but is rather high also among low-skilled blue-collars. In 2009, undereducation is highest among low-skilled white-collars as well, while undereducation is lowest among high-skilled blue-collars in both 2009 and 2014. So mostly educational mismatch seems to affect middle class occupational groups particularly.

We are also interested in the impact of automation risk of occupations on educational mismatch. Higher automation risk is associated with increasing overeducation. However, in both years automation risk tends to decrease the probability of being undereducated compared to those who are matched in their jobs.

Work experience or job tenure is clearly reducing the probability of being overeducated both during and after the economic recession. Results are in line with previous findings also regarding undereducation, as we observe that higher tenure is increasing undereducation, suggesting that with time undereducated workers may obtained further skills to perform more complex tasks than assumed by their level of education.

Regarding job-related characteristics, it appears that results considering *contract type* impact on overeducation in both years contradict previous findings as workers with permanent contract are more likely to be overeducated than those with temporary contract (although in 2014 the association is weaker). However, results indicate that workers on permanent contract are less mismatched in terms of undereducation because they have lower probability to be employed in jobs where higher level of education is expected.

According to *firm size*, previous findings for educational mismatch are rather mixed. Our results show that overeducation probability is lower in middle sized firms with 11–19 and 20–49 employees (ref up to 10). However, lending support to some of the previous findings, overeducation is highest in large firms (50+ employees), suggesting that these firms have more resources to employ high-skilled workers. Additionally, we find that undereducation decreases with firm size in both time periods. Thus, results imply that larger firms might offer more opportunities for career advancement.

Previous studies on the impact of *economic sector* suggest higher overeducation in service sector, which our results confirm, as overeducation is highest in both years among those working in administration and services (ref construction, mining, etc.). However, contrary to previous findings, in 2009 overeducation is lowest in retail, accommodation and catering sector compared to construction, mining, etc. In both years we find highest probability of undereducation in retail, accommodation and catering (the effect is clearer in 2009). Yet undereducation appears to be lowest in administration and services, also in both 2009 and 2014.

Table 4. Impact of individual and job-related characteristics on over- and undereducation in 2009 and 2014

	Overeducation		Undereducation	
	2009	**2014**	**2009**	**2014**
Gender (ref women)	Men > women	No impact	Men > women	
Age (ref 20–29)	Decreasing with age		Increasing with age	Decreasing for 30–39 and highest for 50+
Occupational group (ref high-skilled white-collars)	Highest for low-skilled white-collars and low-skilled blue-collars		Highest for low-skilled white-collars; lowest for high-skilled blue-collars	Lowest for high-skilled blue-collars
Job tenure (months)	Higher tenure is decreasing		Higher tenure is increasing	
Contract type (temp.)	Higher with permanent contract		Lower with permanent contract	
Firm size (ref up to 10)	Lower in middle-sized firms; highest in large firms		Decreasing with firm size	
Economic sector (ref construction, mining, etc.)	Decreasing/lowest in retail, accommodation and catering; highest in administration and services	Highest in administration and services	Highest in retail, accommodation and catering; lowest in administration and services	Highest in retail, accommodation and catering; lowest in administration and services
Automation risk	Increasing with higher automation risk		Decreasing with higher automation risk	

Note: Summary of results presented in Appendix, Table 6A–Table 7A.

5.2 The impact of macro-level characteristics on educational mismatch

Results of the multilevel analysis summarised in Table 5 indicate that in case of overeducation only *unemployment rate*, as one indicator of the fluctuations in the economy, has significant impact. Expectedly, higher unemployment rate is increasing overeducation in both 2009 and 2014. Regarding undereducation, unemployment rate shows no significant impact in both years.

The rate of working-age population with *tertiary education* is increasing undereducation in both time periods. However, the impact of *investment in innovation* on undereducation is in the expected direction – higher investments tend to increase undereducation. Combining supply and demand of knowledge and skills, *imbalance between demand and supply*, i.e., structural oversupply of workers with higher education indicates decreasing impact on undereducation. Results regarding the impact of the *employment protection legislation* contradict previous findings, as stronger regulations are associated with decreasing undereducation.

Table 5. Impact of macro-level characteristics on over- and undereducation in 2009 and 2014

	Overeducation		Undereducation	
	2009	2014	2009	2014
Rate of population with tertiary education	No impact		Increasing	
Investments in innovation	No impact		Increasing	
Imbalance between demand and supply side	No impact		Decreasing	No impact
Unemployment rate	Increasing		No impact	
Employment protection legislation	No impact		Decreasing	

Notes: Summary of results presented in Appendix, Table 6A–Table 7A.

5.3 The impact of educational mismatch on salaries

In Table 6 we summarise results from the linear regression examining impact of over- and undereducation (ref matched workers) on *salaries*, first by controlling for highest educational level completed, and second by controlling for occupational group (for more detail see Appendix Table 8A and 9A). When controlling for educational level, overeducation tends to decrease salary, while undereducation tends to increase salary. The impact is similar for both 2009 and 2014. This lends support to previous research indicating wage penalty for overeducated (McGuinness, 2003; Chevalier and Lindley, 2009; Sohn, 2010; McGuinness and Sloane, 2011; Mavromaras et al., 2013; Ordine and Rose, 2015; Kracke et al., 2018) and wage premium for undereducated (Verhaest and Omey, 2006) relative to those with same education in matched jobs. Our findings show that the existence of a wage penalty due to overeducation and a wage premium due to undereducation are not symmetric. Overeducation has stronger effect on wages than undereducation.

When controlling for occupational group, the impact of educational mismatch has a reversed effect. Namely, in this model overeducation is associated with higher salary and undereducation with lower salary. These results regarding overeducation also support some of previous findings (Levels et al., 2014) that overeducation increases wages, and in general, undereducated workers compared to matched workers are found to have lower salary. The negative effect of undereducation is stronger than a positive effect of overeducation.

Table 6. Impact of over- and undereducation on salaries in 2009 and 2014

	2009	2014
Educational level[1]		
Overeducation	Decreasing	Decreasing
Undereducation	Increasing	Increasing
Occupational group[2]		
Overeducation	Increasing	Increasing
Undereducation	Decreasing	Decreasing

Notes: [1]Summary of results presented in Appendix Table 8A (model 3).
[2]Results are presented in Appendix Table 9A (model 3).

The analysis by occupational groups indicates the patterns of the impact of over-and undereducation on salaries, again first by controlling for the effect of educational level, second excluding the effect of educational level (see Table 7). Previous studies have not investigated the impact of mismatch on salaries by occupational groups, however, our analysis shows some significant differences. While controlling for educational level, results show that for several occupational groups the effect of mismatch on salaries is in line with results presented above on

a pooled dataset (see Table 6). Yet in some instances we find no significant mismatch impact, particularly during the economic crisis in 2009. Most notably, there is no significant impact of mismatch on salaries for high-skilled blue-collars in 2009 and 2014. It could be that these jobs have concrete tasks which require relatively standardised skills and perhaps educational level is not directly associated with performance of such tasks. In 2009, we find no significant mismatch effect in terms of both over- and undereducation for low-skilled white-collars and only undereducation for low-skilled blue-collars. Finally, for low-skilled blue-collars, there appears to be no significant effect on salaries of undereducation in 2009 and overeducation in 2014. Some previous studies also do not observe statistically significant effect on salaries for undereducated workers (Sanchez-Sanchez and McGuinness, 2015; Di Pietro and Urwin, 2006).

When not controlling for educational level, the effect of mismatch is rather homogenous across all occupational groups, namely overeducation tends to increase salaries, while undereducation tends to decrease salaries compared to matched workers. But with one exception, because for high-skilled white-collars overeducation in both years is associated with wage penalty, therefore matched workers appear to be most advantaged. For high-skilled white-collars the undereducation penalty is highest. Our previous analysis indicated that the rate of undereducation is higher for this occupational group compared to other groups. There has been some criticism about expansion of higher education. Our results seem to indicate that this expansion is not quick enough to fill the demand for highly educated workers. At the same time, overeducation has quite strong positive impact on salaries of low-skilled white-collars. As our analysis shows, the rate of overeducation is highest among this occupational group. Perhaps some highly skilled workers prefer to work in jobs demanding lower educational level due to higher salaries. Alternatively, structural factors could explain this result. There are not enough jobs demanding higher education. However, we suppose there is much variation across countries in this regard.

Table 7. Impact of over- and undereducation on salaries of different occupational groups in 2009 and 2014

	Overeducation		Undereducation	
	2009	**2014**	**2009**	**2014**
Model with educational level[1]				
High-skilled white-collar	decreasing	decreasing	increasing	increasing
Low-skilled white-collar	no impact	decreasing	no impact	increasing
High-skilled blue-collar	no impact	no impact	no impact	no impact
Low-skilled blue-collar	decreasing	no impact	no impact	increasing
Model excluding educational level[2]				
High-skilled white-collar	decreasing	decreasing	decreasing	decreasing
Low-skilled white-collar	increasing	increasing	decreasing	decreasing
High-skilled blue-collar	increasing	increasing	decreasing	decreasing
Low-skilled blue-collar	increasing	increasing	decreasing	decreasing

Note: [1]Summary of results presented in Appendix, Table 10A–Table 13A (model 1). [2]Summary of results presented in Appendix, Table 14A-17A (model 1).

5.4 The modifying impact of automation risk on educational mismatch on salaries

As a final step, we investigate whether and how automation risk is associated with the effect of educational mismatch on salaries, while controlling for the educational level. It appears that in 2009 and 2014, automation risk is decreasing salaries (Table 8, model 2). Furthermore,

automation risk tends to amplify the negative impact of overeducation on salaries but reduce the positive impact of undereducation on salaries (interaction effect not significant in 2014) (Table 8, model 3 interaction effects).

Moreover, the analysis reveals some differences by occupational groups (while not controlling for the educational level, see Appendix Table 14A-17A)[12]. Overall, among the *high-skilled white-collars* wage penalty for undereducation is higher than for overeducation (compare also with Table 7 above). For this occupational group in case of lower automation risk there are no significant differences in salaries between matched and overeducated workers. Yet increase in automation risk is associated with clear wage penalty for overeducated compared to matched and the penalty for under- and overeducation equalises. Among *low-skilled white-collars* low automation risk is related to clear wage advantage for overeducated compared to both matched and undereducated workers. However, higher automation risk closes the wage gap between matched and undereducated, but in 2014 also for overeducated. We find no modifying effect of automation risk for *high-skilled blue-collars*. Finally, in case of *low-skilled blue-collars*, low automation risk yields in no differences between matched, over- and undereducated workers. While higher automation risk gives advantage to overeducated and results in wage penalty for undereducated.

Overall, we observe a somewhat surprising trend, as during the economic crisis high automation risk seems to have positive impact on salaries of low-skilled white- and blue-collars. We might assume that during the crisis there was an urgency to fill these jobs and hence to pay higher salaries. Additionally, these results could reflect the measurement of automation risk variable, because data on automation of occupations was gathered in 2019 and therefore some jobs that were considered at a high risk of automation in 2019, might have not been at the risk in 2009. So for instance in the group of low-skilled white-collars general clerk tasks (e.g., classifying and filing information, input and process text and data, proofreading and correcting, preparing invoices) or among low-skilled blue-collars assemblers work (assembling the components or parts of electrical, electronic or mechanical machinery equipment) in 2009 probably was less automated by machines and computers compared to 10 years later. Accordingly, we could expect that in 2009 the effect of automation and digitalisation on the salary of these occupational groups is positive.

[12] In this analysis we do not control for two variables, i.e., occupational group is fixed, but the models do not control for the highest educational level completed.

Table 8. Impact of automation risk on over- and undereducation on salaries in 2009 and 2014

	2009, pooled sample			2014, pooled sample		
Male (ref female)	.973***	.958***	.958***	.969***	.943***	.941***
Age group (ref 20-29)						
30-39	.784***	.781***	.778***	.797***	.784***	.783***
40-49	.996***	.997***	.994***	1.053***	1.036***	1.035***
50+	.833***	.831***	.828***	.879***	.867***	.866***
Job tenure (months)	.003***	.003***	.003***	.004***	.004***	.004***
Educational mismatch (ref matched)						
Undereducation	1.108***	.995***	1.340***	1.408***	1.290***	1.413***
Overeducation	-1.201***	-1.120***	-.715***	-1.630***	-1.516***	-1.166***
Educational level (ref tertiary education)						
Primary or less	-3.669***	-3.459***	-3.452***	-4.294***	-4.044***	-4.059***
Secondary	-2.133***	-2.037***	-2.081***	-2.526***	-2.405***	-2.420***
Postsecondary	-.455***	-.425***	-.441***	-1.471***	-1.395***	-1.383***
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.347***	-.364***	-.364***	-.881***	-.893***	-.893***
Administration and services	-.120***	-.140***	-.139***	-.424***	-.486***	-.484***
Firm size (ref less than 11)						
11-19	.156***	.164***	.162***	.310***	.315***	.315***
20-49	.290***	.298***	.295***	.250***	.251***	.251***
50+	.673***	.687***	.685***	.558***	.583***	.582***
Don't know, but more than 10	.306***	.302***	.299***	.589***	.605***	.606***
Permanent (ref temporary)	1.435***	1.443***	1.442***	1.011***	.996***	.993***
Automation risk		-1.083***	-.584***		-2.330***	-2.045***
Undereducation*automation risk			-1.001***			-.317
Overeducation* automation risk			-1.127***			-.940**
Constant	4.593***	4.941***	4.794***	5.495***	6.349***	6.262***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$
Source: Own calculations based on EU-LFS 2009 and 2014.
Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

6. Conclusions

Using data of European Union Labour Force Survey (EU-LFS) from 26 European countries the report shed light on a number of previously under-researched issues regarding the incidence and drivers of educational mismatch as well as the impact of educational mismatch on salaries. We examine these issues within European countries during the financial crisis of 2007–2008 and after the crisis (in 2014) to investigate the relation between economic conditions and education mismatch, the impact of different drivers of mismatch during the crisis and after that as well as the impact of educational mismatch on salaries. We pay special attention on the modifying role of automation risk on the incidence of educational mismatch and its effect on salaries.

Our results show that undereducation and overeducation rate has remained rather stable between 2009 and 2014, but the recession affected countries differently concerning the educational mismatch. Results about the impact of most socio-demographic measures as well as of job-related characteristics on the incidence of educational mismatch are in line with the previous findings.

Previous research on educational mismatch (mostly concerning overeducation) has not focused on variations between different occupational groups. Our analysis indicates substantial differences between occupational groups. Overeducation is highest among low-skilled white-collars. Overeducation is rather high also among low-skilled blue-collars. There are some differences between 2009 and 2014: in 2009 undereducation was highest among low-skilled white-collars but in 2014 among high-skilled white-collars. Our analysis shows that educational mismatch seems to affect middle class occupational groups in particular.

Higher automation risk is associated with increasing overeducation and therefore with increasing intragenerational downward mobility. However, in both years automation risk tends to decrease the probability of being undereducated (and also intergenerational upward social mobility) compared to those who are matched in their jobs. We do not have previous studies to rely on for explanations, but it seems rather logical that higher automation risk would increase overeducation (certain jobs [will] disappear and one must accept jobs below acquired educational level); and decrease undereducation. However, we should mention the imprecise measurement of the probability that a job is automated. We have used a measure developed in the TECHNEQUALITY project. The measure is based on human resources professionals' expert assessments of the time spent on certain job tasks in the next five years. It may well be that these trends do not apply to the workers in our sample, especially since our window of observation starts already in 2009, when these occupations might not have been under the risk of automation. Nevertheless, it is possible that this measure picks up long term trends already visible 10 years earlier.

From macro level characteristics *unemployment rate*, as one indicator of the fluctuations in the economy, has significant impact on overeducation as expected. Therefore, it seems that fewer available jobs mean more willingness to accept jobs requiring lower educational credentials than attained. Therefore, higher unemployment is also increasing downward mobility. On the supply side, increase in the *educational attainment* of the population is associated with higher undereducation and hence facilitating upward mobility. It appears that higher supply of highly educated workers might increase educational level of certain occupations (even when actual educational level or skill requirements have not increased) and those who were employed in these occupations before, find themselves undereducated. On the demand side, increased investment in research and development is also associated with higher undereducation (and higher upward mobility) as expected. But supply and demand have no effect on overeducation. Our result seems to support the previous conclusion that supply may create 'its own demand' (see Ordine and Rose, 2017). A structural oversupply of educated workers does result in less undereducation. Previous research has indicated the effects of flexible labour market regulations. Our results show that employment protection legislation has no impact on incidence of overeducation, but stronger regulations are associated with decreasing undereducation. The explanation could be that countries with stricter regulations are rather avoiding hiring workers with lower education than is required by their job position, because it will be difficult to replace them afterwards.

It is generally found that overeducated workers earn less than adequately educated workers with a similar educational background. Similarly, undereducated workers seem to earn more than adequately educated workers with a similar educational background. Our results support these previous findings and job assignment theory indicating that not only attained education but also the use of the acquired education in the job determines workers' wage. A wage penalty due to overeducation seems to be stronger than a wage premium due to undereducation. However, there

seems to be some differences between occupational groups. Overeducation is indeed decreasing and undereducation increasing salaries for high-skilled white-collars in 2009 and 2014. Nevertheless, there are no differences in salaries of matched, under- and overeducated among high-skilled blue-collars. For low-skilled white-collars we found expected effects in 2014. During the crisis the impact of educational mismatch was insignificant. Perhaps high rate of overeducated among this group could explain this result.

Previous research consistently suggests that overeducated workers earn more than adequately educated workers in jobs with requirements that match their education and undereducated earn less. Once again, our result supports these conclusions for all workers irrespective of occupational group as well as low-skilled white-collars and both groups of blue-collars. But for high-skilled white-collars over- and undereducation have negative effect on salaries. This result could be explained by country variations. Assumingly, in countries with fast educational expansion, but relatively slow technological innovation, overeducation indeed could result in wage penalty because there are not enough jobs for highly educated workers. While in countries where the process of educational expansion and technological innovation are more in balance, overeducation might not have significant impact on salaries.

Overall, our results indicate that automation risk decreases salaries; more specifically increases the negative impact (wage penalty) of overeducation and decreases the positive impact (wage premium) of undereducation. However, this impact varies across occupational groups. Higher automation risk in the group of high-skilled white-collars leads to wage penalty in case of overeducated relative to matched workers, but the wage gap between over- and undereducated decreases. For low-skilled white-collars, increase in automation risk also tends to close the wage gap, but more clearly between matched and undereducated. Analysis does not reveal significant modifying effect of automation risk on salaries among high-skilled blue-collars. In case of low-skilled blue-collars higher automation risk tends to increase salaries for overeducated and decrease salaries for undereducated. Interestingly, during the economic crisis higher automation risk is positively associated with salary for both low-skilled occupational groups. Partly the explanation could be that there was rather high demand for such jobs and therefore salaries were higher. Additionally, these results could point to the fact that in 2009 low-skilled occupational groups (e.g., clerks, sales workers, assemblers, plant and machine operators) were not in such high risk of automation as they are about 10 years later, because the baseline for the measure we use for automation risk is 2019.

We suppose that the contribution of different theories as well as the most appropriate policy recommendations will vary across countries and more research is needed in this respect. Our results seem to indicate that overeducation among low-skilled white-collars is less common in lower wage economies. Therefore, structural factors are a key determinant of mismatch. Previous research states that the relative demand for intermediate labour declines as economies grow due to skill-biased technological change. But country level differences could also be driven by variations in the strength of labour market institutions across countries. The relative role of structural demand and labour market institutions in explaining country differences in terms of the effect of educational mismatch on salaries is a matter for future research.

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Appendix

Table 1A. Over-and undereducation rates in 2009 and 2014 (%), country differences

	Overeducation		Undereducation	
	2009	2014	2009	2014
AT	19.8	18.2	17.1	17.4
BE	11.5	13.8	27.9	21.5
BG	12.6	11.3	13.6	13
CY	24	16.1	15.6	19.2
CZ	10.2	8.2	7.9	8.3
DE	19.6	17.1	17.6	20.5
DK	15.8	10	22.1	20.7
EE	15.8	18.3	20.3	18.2
ES	26.6	20.7	9.9	14
FI	6.2	5.7	25.4	21.9
FR	11.8	12.7	28.6	22.8
GR	24.4	26.8	13.7	12.6
HU	16.9	16	7.7	14.3
IE	22.1	14.7	23.5	27.2
IT	25.3	20.1	10.9	17.2
LT	22.8	20.7	17.4	13.9
LV	17.1	14.1	16.7	17.1
NL	15.4	12.8	25.2	24.4
NO	5.7	6.9	28.7	26
PL	12.4	9.2	11.1	13.4
PT	18.1	23.3	4.9	5.2
RO	16.2	15.5	8.4	11.2
SE	14.8	14.5	21.9	21.9
SI	9.7	9.5	11.2	14.5
SK	9.8	11.8	6.2	6.9
UK	8.7	15.9	32	23.9

Source: Authors' calculations based on EU-LFS 2009, 2014; realized matches approach, sample restricted to full-time workers.

Table 2A. Overeducation rates by occupational groups in 2009 and 2014 (%), country differences

	Overeducation High-skilled white-collar		**Overeducation** Low-skilled white-collar	
	2009	2014	2009	2014
AT	29	19	19.1	19.9
BE	7.7	4.9	7.3	31.7
BG	15.7	6.3	15.8	17.1
CY	0	0	33.3	27.6
CZ	19.2	13.5	5.9	10.1
DE	21.3	14.8	25.1	27.7
DK	13.8	10.7	12.8	11.9
EE	4	7.1	38.5	40
ES	8.6	0	39.5	30.7
FI	1.9	0	13.8	13.8
FR	7.1	5.9	19.4	25.1
GR	9.4	2.9	29.5	34.2
HU	22	12.1	12	27.3
IE	10.9	0	29.5	16.4
IT	16.6	11	24.2	11.5
LT	0	2.1	45.9	42.2
LV	19.1	5.5	24.6	31.4
NL	10.3	5.8	20.5	22.7
NO	0.7	1.3	14.2	16.9
PL	17.6	6.4	22.1	21.4
PT	13.5	20.6	37.5	34.8
RO	17.8	12.9	13	18
SE	17.6	11.2	16.7	23.8
SI	11.9	11.5	6.3	12.1
SK	22.2	20.8	5.6	13
UK	2.2	12	21.8	27.1

Source: Authors' calculations based on EU-LFS 2009, 2014; realized matches approach, sample restricted to full-time workers.

Table 3A. *Overeducation rates by occupational groups in 2009 and 2014* (%), country differences

	Overeducation High-skilled blue-collar		**Overeducation** Low-skilled blue-collar	
	2009	2014	2009	2014
AT	13.1	16.5	6.3	15.2
BE	11.1	13.1	30	19.1
BG	12.7	16.9	5.2	7.1
CY	36.8	15.4	38.6	29.7
CZ	1.2	1.5	1.6	1.1
DE	17.1	13.1	6.1	11.6
DK	8.7	3.9	35.4	10.9
EE	18.4	20	18	19.8
ES	35.6	33	34.2	34.8
FI	8.3	9.2	7.1	7.7
FR	7.8	10.4	18.6	17.2
GR	30.8	36.6	42.6	51.9
HU	5	12.7	27.3	14
IE	23.2	30.4	46.4	42.7
IT	35.6	34.7	35	39.1
LT	38	33.8	33.8	30
LV	13.2	17	8.8	11.2
NL	11	7.4	36.5	41
NO	9.5	11.9	8.8	14
PL	3.8	5.9	4.3	5.9
PT	8	16.4	11.7	20.8
RO	20.8	20.2	7.4	7.5
SE	8	10.6	9.2	18.3
SI	2.1	4.4	13.6	7.8
SK	1.4	3.5	0.9	3.2
UK	10.5	14	7.7	13.9

Source: Authors' calculations based on EU-LFS 2009, 2014; realized matches approach, sample restricted to full-time workers.

Table 4A. *Undereducation rates by occupational groups in 2009 and 2014* (%), country differences

	Undereducation High-skilled white-collar		**Undereducation** Low-skilled white-collar	
	2009	2014	2009	2014
AT	9.2	17.4	16.7	16
BE	20.8	19.2	43.2	16.3
BG	7.5	14.4	7.8	7.6
CY	23	17.1	14.7	21.8
CZ	8.4	12.8	5.6	3.4
DE	16.2	24.7	15.5	12.8
DK	21	14.2	27.7	22.8
EE	28.8	24.5	7.3	9.1
ES	16.3	18.7	16.1	20
FI	26.5	23.9	23	21.4
FR	30.1	23.8	24.5	16.7
GR	22.3	17.8	21.4	19.2
HU	4.8	16.4	7.6	6.6
IE	18.9	24.2	31.8	39.2
IT	17.7	22.8	17.2	29.3
LT	26.5	17.6	13.4	12.7
LV	17.8	23.9	7.2	5.3
NL	26.9	26.6	25.3	19.1
NO	29.7	27.9	26.6	23.1
PL	11.8	18.6	3.3	8.5
PT	17.9	9.4	0	6.7
RO	5.6	12.2	8	8.7
SE	18.6	23.5	21	17.4
SI	6.5	12.4	5.1	5.1
SK	7.9	11.5	2.5	2.6
UK	34.2	22.1	23.5	21.7

Source: Authors' calculations based on EU-LFS 2009, 2014; realized matches approach, sample restricted to full-time workers.

Table 5A. *Undereducation rates by occupational groups in 2009 and 2014* (%), country differences

	Undereducation High-skilled blue-collar		**Undereducation** Low-skilled blue-collar	
	2009	2014	2009	2014
AT	21.2	16.5	32.7	21.6
BE	35.5	29.1	21	29.7
BG	17.3	10.4	23.5	19.9
CY	8.8	25.6	10	15.6
CZ	4.6	3.9	14.1	10.2
DE	16.9	16	29	25.2
DK	26.8	23.6	12.6	39.1
EE	16.1	14.7	18	17.2
ES	0	7.8	0	0
FI	21.1	16.5	31.1	21.4
FR	30.9	24.8	28.2	26.8
GR	0.6	2.7	0	0.5
HU	11.5	8	10	23.1
IE	41.1	27.4	6.2	16.2
IT	0	3.5	0	0
LT	9.2	11.1	10.8	9.4
LV	18.4	14.1	22	17.9
NL	37.3	33.9	3.4	6.6
NO	26	19.3	33.6	30.1
PL	13.7	10.9	14.3	11.8
PT	0	0	0	0
RO	5.3	7.2	19.6	20.1
SE	23.9	20.7	32.2	23.6
SI	23.2	19.4	18.1	25.6
SK	2.5	4	9.7	8.2
UK	25.3	24.3	42.9	34.8

Source: Authors' calculations based on EU-LFS 2009, 2014; realized matches approach, sample restricted to full-time workers.

Table 6A. Impact of individual, job and macro-level characteristics on overeducation in 2009 and 2014

	Overeducation 2009, pooled sample							Overeducation 2014, pooled sample						
Male (ref female)	.002	.050***	.050***	.058***	.050***	.050***	.050***	-.007	-.011	-.011	-.027***	-.011	-.011	-.012*
Age group (ref 20-29)														
30-39	-.109***	-.099***	-.099***	-.099***	-.099**	-.099***	-.100***	-.123***	-.100***	-.100***	-.087***	-.100***	-.100***	-.101***
40-49	-.312***	-.322***	-.322***	-.347***	-.322***	-.322***	-.323***	-.364***	-.368***	-.368***	-.347***	-.368***	-.368***	-.368***
50+	-.405***	-.417***	-.418***	-.477***	-.418***	-.417***	-.419***	-.497***	-.523***	-.523***	-.511***	-.523***	-.523***	-.522***
Job tenure (months)	-.002***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***	-.001***
Industry (Ref construction, mining etc)														
Retail, accommodation, catering	.043***	-.093***	-.093***	-.084***	-.093***	-.093***	-.093***	.198***	.030***	.030***	.026**	.030***	.030***	.030***
Administration and services	.130***	.134***	.134***	.148***	.134***	.134***	.135***	.144***	.111***	.111***	.105***	.111***	.111***	.112***
Firm size (ref less than 11)														
11-19	-.084***	-.072***	-.072***	-.085***	-.072***	-.072***	-.072***	-.062***	-.038***	-.038***	-.039***	-.0380***	-.038***	-.037***
20-49	-.054***	-.037***	-.037***	-.038***	-.037***	-.037***	-.038***	-.063***	-.025**	-.025**	-.027**	-.020**	-.025**	-.025**
50+	.100***	.120***	.120***	.128***	.120***	.120***	.120***	.065***	.127***	.127***	.130***	.127***	.127***	.128***
Don't know, but more than 10	-.053***	-.060***	-.060***	-.062***	-.060***	-.060***	-.061***	.003	.008	.008	.011	.008	.008	.008
Permanent contract (ref temporary)	.039***	.061***	.061***	.066***	.061***	.061***	.061***	-.010	.021*	.021*	.026**	.021*	.021*	.021*
Occupational group (ref high-skilled white-collar)														
Low-skilled white-collar		.580***	.580***	.554***	.580***	.580***	.574***		.914***	.914***	.920***	.914***	.914***	.907***
High-skilled blue-collar		.040***	.040***	.018	.040***	.040***	.034***		.327***	.327***	.374***	.327***	.327***	.321***
Low-skilled blue-collar		.474***	.474***	.497***	.474***	.474***	.470***		.713***	.713***	.768***	.713***	.713***	.708***

Automation risk	.966***							3.80***						
Macro-level variables														
Unemployment rate			.055*							.034*				
EPL				.056							.025			
ISCO1-2/ISCED 5-8 ratio					-.258							-.295		
Innovation						.047							.272	
Tertiary							.007							.005
Constant	-1.679***	-1.618***	-2.092***	-1.771***	-1.442*	-1.639***	-1.773***	-2.811***	-1.833***	-2.174***	-1.854***	-1.649***	-1.950***	-1.964***
Number of groups	26	26	26	21	26	26	25		26	26	23	26	26	25

*** $p \leq .001$; ** $p \leq .01$; * $p \leq .05$

Source: Own calculations based on EU-LFS 2009 and 2014

Notes: Multilevel logistic regression. Coefficients are calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 7A. Impact of individual, job and macro-level characteristics on undereducation in 2009 and 2014

	Undereducation 2009, pooled sample							Undereducation 2014, pooled sample						
Male (ref female)	-.011	.064***	.064***	.085***	.064***	.064***	.063***	-.023***	.042***	.042***	.060***	.042***	.042***	.039***
Age group (ref 20-29)														
30-39	.022*	.020*	.020*	.045***	.020*	.020*	.026**	-.080***	-.104***	-.104***	-.125***	-.104***	-.104***	-.102***
40-49	.324***	.320***	.320***	.380***	.320***	.321***	.322***	.188***	.171***	.171***	.179***	.171***	.171***	.174***
50+	.601***	.597***	.597***	.640***	.597***	.597***	.604***	.437***	.424***	.424***	.435***	.424***	.424***	.426***
Job tenure (months)	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***	.001***
Industry (Ref construction, mining etc)														
Retail, accommodation, catering	.259***	.141***	.141***	.159***	.141***	.141***	.142***	.082***	.020*	.020*	.035***	.020*	.020*	.019*
Administration and services	-.282***	-.361***	-.361***	-.381***	-.361***	-.361***	-.355***	-.224***	-.322***	-.322***	-.349***	-.322***	-.322***	-.317***
Firm size (ref less than 11)														
11-19	-.084***	-.088***	-.088***	-.093***	-.088***	-.088***	-.091***	-.089***	-.112***	-.112***	-.106***	-.112***	-.112***	-.112***
20-49	-.136***	-.150***	-.150***	-.141***	-.150***	-.150***	-.150***	-.182***	-.225***	-.225***	-.219***	-.226***	-.225***	-.225***
50+	-.223***	-.254***	-.254***	-.236***	-.254***	-.254***	-.253***	-.245***	-.321***	-.321***	-.312***	-.321***	-.321***	-.319***
Don't know, but more than 10	-.037**	-.052***	-.052***	-.064***	-.052***	-.052***	-.052***	-.077***	-.116***	-.116***	-.127***	-.116***	-.116***	-.116***
Permanent contract (ref temporary)	-.187***	-.188***	-.188***	-.192***	-.188***	-.188***	-.189***	-.318***	-.339***	-.339***	-.346***	-.339***	-.339***	-.340***
Occupational group (ref high-skilled white-collar)														
Low-skilled white-collar		.076***	.076***	.111***	.076***	.076***	.080***		-.244***	-.244***	-.239***	-.244***	-.244***	-.243***
High-skilled blue-collar		-.420***	-.420***	-.444***	-.420***	-.420***	-.414***		-.670***	-.670***	-.725***	-.670***	-.670***	-.665***
Low-skilled blue-collar		-.039***	-.039***	-.102***	-.039***	-.039***	-.035***		-.146***	-.146***	-.210***	-.146***	-.146***	-.144***
Automation risk	-.705***							-1.198***						
Macro-level variables														
Unemployment rate			-.025							-.020				
EPL				-.592***							-.391**			
ISCO1-2/ISCED 5-8 ratio					-2.636**							-.703		
Innovation						2.298***							1.614***	
Tertiary							.071***							.042***

Constant	-1.265***	-1.436***	-1.223***	.005	.367	-2.472***	-3.312***	-.795***	-.976***	-.771***	-.051	-.538	-1.667***	-2.311***
Number of groups	26	26	26	21	26	26	25	26	26	26	23	26	26	25

*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$

Source: Own calculations based on EU-LFS 2009 and 2014

Notes: Multilevel logistic regression. Coefficients are calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 8A. Impact of individual and job-related characteristics and educational mismatch on salaries, controlling for educational level in 2009 and 2014

	Salary 2009, pooled sample			Salary 2014, pooled sample		
Educational mismatch (ref matched)						
Undereducation	-.836***	.209***	.233***	-.495***	.854***	.794***
Overeducation	.007	-.828***	-.692***	-.242***	-1.087***	-.920***
Educational level (ref higher education)						
Primary and less		-2.764***	-2.939***		-3.416***	-3.479***
Secondary		-1.756***	-1.844***		-2.172***	-2.205***
Postsecondary		-.456***	-.389***		-1.123***	-1.024***
Gender (ref female)			1.097***			1.139***
Age group (ref 20-29)						
30-39			.781***			.786***
40-49			.845***			.996***
50+			.560***			.764***
Firm size (ref less than 11)						
11-19			.329***			.268***
20-49			.277***			.399***
50+			.603***			.832***
Don't know but more than 10			.712***			.103***
Industry (ref construction, mining)						
Retail, accommodation, catering			-.390***			-.466***
Administration and services			-.259***			-.193***
Permanent contract (ref fixed)			.474***			1.026***
Job tenure (months)			.005***			.004***
Constant	6.149***	7.457***	4.969***	6.398***	7.866***	4.726***
R Square	.015	.117	.286	.006	.175	.372

Linear regression, unstandardized coefficients. *** $p \leq .001$; **$p \leq .01$; * $p \leq .05$

Source: Own calculations based on EU-LFS 2009 and 2014.

Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 9A. Impact of individual and job-related characteristics and educational mismatch on salaries, controlling for occupational group in 2009 and 2014

	Salary 2009, pooled sample					Salary 2014, pooled sample				
Educational mismatch (ref matched)										
Undereducation	-.825***	-.883***	-.938***	-1.095***	-1.059***	-.494***	-.623***	-.691***	-.933***	-.924***
Overeducation	.000	.200***	.318***	.117***	.199***	-.241***	.106***	.226***	-.378***	-.382***
Occupational group (high-skilled white-collar)										
Low-skilled white-collar		-2.195***	-1.734***	-1.899***	-2.399***		-2.361***	-1.884***	-2.173***	-2.321***
High-skilled blue-collar		-1.556***	-2.023***	-2.109***	-2.274***		-1.880***	-2.222***	-2.412***	-2.470***
Low-skilled blue-collar		-2.100***	-2.395***	-2.433***	-2.723***		-2.467***	-2.681***	-2.849***	-2.990***
Gender (ref female)			1.127***	1.125***	1.116***			1.141***	1.140***	1.152***
Age group (ref 20-29)										
30-39			.770***	.770***	.766***			.806***	.800***	.801***
40-49			.861***	.864***	.866***			.997***	1.000***	1.005***
50+			.617***	.616***	.617***			.809***	.812***	.820***
Firm size (ref less than 11)										
11-19			.349***	.348***	.333***			.308***	.306***	.305***
20-49			.356***	.350***	.331***			.495***	.484***	.482***
50+			.699***	.689***	.660***			.959***	.946***	.937***
Don't know, 10+			.708***	.700***	.692***			.236***	.230***	.230***
Industry (ref construction, mining)										
Retail, accommodation, catering			-.533***	-.523***	-.444***			-.565***	-.549***	-.529***
Administration and services			-.437***	-.447***	-.408***			-.328***	-.347***	-.312***
Permanent contract (ref fixed)			.502***	.502***	.503***			1.036***	1.036***	1.037***
Job tenure (months)			.004***	.004***	.004***			.003***	.003***	.003***
Educational mismatch* occgroup										
Undereducation*lowwhite				.317***	.267***				.460***	.455***
Undereducation*highblue				.336***	.293***				.426***	.412***
Undereducation*lowblue				.209***	.167***				.501***	.489***
Overeducation*lowwhite				.547***	.440***				1.159***	1.139***
Overeducation*highblue				.210***	.111				.866***	.867***
Overeducation*lowblue				-.026	-.118*				.565***	.566***

Automation risk					2.413***					1.462***
Constant	6.146***	7.286***	4.858***	4.918***	4.205***	6.398***	7.624***	4.503***	4.635***	4.123***
R Square	.014	.159	.311	.313	.317	.006	.203	.384	.389	.391

Linear regression, unstandardized coefficients. *** $p \leq .001$; **$p \leq .01$; * $p \leq .05$

Source: Own calculations based on EU-LFS 2009 and 2014.

Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 10A. Impact of individual and job-related characteristics and educational mismatch on salaries, high-skilled white-collars 2009 and 2014

	2009, high-skilled white-collar, pooled sample			2014, high-skilled white-collar, pooled sample		
Male (ref female)	.992***	.979***	.982***	.825***	.791***	.792***
Age group (ref 20-29)						
30-39	1.038***	1.031***	1.022***	1.102***	1.094***	1.093***
40-49	1.426***	1.419***	1.412***	1.445***	1.446***	1.446***
50+	1.377***	1.368***	1.358***	1.386***	1.388***	1.387***
Job tenure (months)	.002***	.001***	.001***	.002***	.002***	.002***
Educational mismatch (ref matched)						
Undereducation	.611***	.569***	.591***	.592***	.567***	.192
Overeducation	-.738***	-.696***	.250*	-.877***	-.840***	-.179
Educational level (ref tertiary)						
Primary and less	-2.296***	-2.209***	-2.176***	-2.389***	-2.348***	-2.346***
Secondary	-1.600***	-1.528***	-1.494***	-1.680***	-1.649***	-1.648***
Postsecondary	-.682***	-.639***	-.718***	-2.092	-1.859	-1.810
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.281***	-.250***	-.251***	-.592***	-.534***	-.532***
Administration and services	-.231***	-.220***	-.228***	-.344***	-.305***	-.307***
Firm size (ref less than 11)						
11-19	.128**	.129**	.115*	.283***	.289***	.291***
20-49	.353***	.358***	.349***	.395***	.410***	.414***
50+	.741***	.745***	.735***	.682***	.673***	.676***
Don't know, but more than 10			.100			.511***
Permanent (ref temporary)	.124	.110	1.545***	.464***	.508***	1.348***
Automation risk	1.542***	1.546***	1.766***	1.384***	1.351***	4.352***
Undereducation*autom risk		1.084***	-.122		4.371***	1.153
Overeducation* autom risk			-3.377***			-2.063*
Constant	4.308***	3.959***	3.761***	4.785***	3.381***	3.388***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$
Source: Own calculations based on EU-LFS 2009 and 2014.
Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 11A. Impact of individual and job-related characteristics and educational mismatch on salaries, low-skilled white-collars 2009 and 2014

	2009, low-skilled white-collar, pooled sample			2014, low-skilled white-collar, pooled sample		
Male (ref female)	.927***	.943***	.943***	.970***	.973***	.975***
Age group (ref 20-29)						
30-39	.471***	.469***	.469***	.424***	.426***	.425***
40-49	.655***	.659***	.659***	.562***	.564***	.567***
50+	.428***	.419***	.418***	.262***	.264***	.266***
Job tenure (months)	.004***	.004***	.004***	.005***	.005***	.005***
Educational mismatch (ref matched)						
Undereducation	1.090	.890	.567	.749***	.728***	-.076
Overeducation	-.300	-.085	-.400	-.445*	-.427*	-.660*
Educational level (ref tertiary)						
Primary and less	-2.448*	-1.999*	-1.983*	-2.197***	-2.157***	-2.048***
Secondary	-.887	-.641	-.585	-1.107***	-1.085***	-1.148***
Postsecondary	.137	.105	.085	-.384	-.381	-.382
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.491***	-.390***	-.389***	-.938***	-.934***	-.926***
Administration and services	-.033	.079	.076	-.403***	-.393***	-.388***
Firm size (ref less than 11)						
11-19	.137*	.125*	.124*	.398***	.397***	.396***
20-49	.282***	.266***	.268***	.206***	.206***	.205***
50+	.607***	.565***	.566***	.671***	.669***	.666***
Don't know, but more than 10			.375**			.910***
Permanent (ref temporary)	.436***	.379**	1.325***	.915***	.913***	.583***
Automation risk	1.332***	1.328***	1.096***	.582***	.583***	-.247
Undereducation*autom risk		1.408***	.775*		.114	1.516**
Overeducation* autom risk			.772*			.416
Constant	3.483***	2.509**	2.597***	4.526***	4.450***	4.659***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$

Source: Own calculations based on EU LFS 2009 and 2014.

Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 12A. Impact of individual and job-related characteristics and educational mismatch on salaries, high-skilled blue-collars 2009 and 2014

	2009, high-skilled blue-collar, pooled sample			2014, high-skilled blue-collar, pooled sample		
Male (ref female)	1.505***	1.478***	1.484***	1.370***	1.315***	1.308***
Age group (ref 20-29)						
30-39	.972***	.975***	.974***	.768***	.778***	.779***
40-49	1.000***	.999***	.998***	.899***	.906***	.907***
50+	.747***	.742***	.741***	.805***	.819***	.818***
Job tenure (months)	.002***	.002***	.002***	.002***	.002***	.002***
Educational mismatch (ref matched)						
Undereducation	.161	.177	1.154	-.929	-.838	-1.775
Overeducation	-.698	-.703	-.712	.437	.026	.984
Educational level (ref tertiary)						
Primary and less	-2.350	-2.347	-2.346	-.090	-.543	-.472
Secondary	-1.579	-1.578	-1.578	-.324	-.706	-.634
Postsecondary	-.412**	-.412**	-.411**	X	X	X
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.322***	-.311***	-.313***	-.858***	-.856***	-.850***
Administration and services	-.497***	-.469***	-.471***	-.800***	-.816***	-.818***
Firm size (ref less than 11)						
11-19	.345***	.350***	.350***	.221	.235	.244
20-49	.308***	.315***	.315***	.285**	.296**	.301**
50+	.799***	.810***	.812***	.513***	.519***	.518***
Don't know, but more than 10			.765***			.966***
Permanent (ref temporary)	.808***	.764***	1.628***	.967***	.967***	.577***
Automation risk	1.610***	1.621***	2.381***	.590***	.579***	-2.430*
Undereducation*autom risk		1.945***	-2.569		-2.482**	2.415
Overeducation* autom risk			.019			-2.409
Constant	3.798	3.080	2.906	3.663***	5.048***	4.964***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$

Source: Own calculations based on EU LFS 2009 and 2014.

Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 13A. Impact of individual and job-related characteristics and educational mismatch on salaries, low-skilled blue-collars 2009 and 2014

	2009, low-skilled blue-collar, pooled sample			2014, low-skilled blue-collar, pooled sample		
Male (ref female)	1.140***	1.135***	1.123***	1.148***	1.111***	1.110***
Age group (ref 20-29)						
30-39	.488***	.470***	.464***	.311***	.283***	.285***
40-49	.515***	.506***	.500***	.658***	.615***	.613***
50+	.245***	.227***	.228***	.455***	.403***	.403***
Job tenure (months)	.003***	.003***	.003***	.003***	.003***	.003***
Educational mismatch (ref matched)						
Undereducation	.173	.217*	2.88***	.257*	.357***	.552
Overeducation	-.291**	-.321***	-1.929	-.185	-.287**	-2.282***
Educational level (ref tertiary)						
Primary and less	-1.075***	-1.147***	-1.094***	-1.035***	-1.228***	-1.170***
Secondary	-.505***	-.547***	-.503***	-.493***	-.587***	-.527***
Postsecondary	.056	.070	.039	-1.840	-1.926	-1.877
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.456***	-.458***	-.458***	-1.175***	-1.238***	-1.238***
Administration and services	-.615***	-.610***	-.605***	-1.020***	-1.000***	-1.001***
Firm size (ref less than 11)						
11-19	.204**	.186*	.185*	.142	.143	.140
20-49	.174**	.170**	.168**	-.062	-.060	-.068
50+	.425***	.429***	.424***	.224***	.253***	.247***
Don't know, but more than 10			.224			.321
Permanent (ref temporary)	.227	.237	.891***	.295	.325*	.698***
Automation risk	.860***	.892***	.281	.710***	.698***	-3.934***
Undereducation*autom risk		-1.424*	-6.314***		-3.660***	-.448
Overeducation* autom risk			3.871			4.774**
Constant	3.149***		3.020***	3.961***	5.748***	5.789***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$

Source: Own calculations based on EU LFS 2009 and 2014.

Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 14A. Impact of individual and job-related characteristics and educational mismatch on salaries, high-skilled white-collars 2009 and 2014

	2009, high-skilled white-collar, pooled sample			2014, high-skilled white-collar, pooled sample		
Male (ref female)	1.043***	.997***	1.001***	.782***	.744***	.745***
Age group (ref 20-29)						
30-39	1.147***	1.116***	1.097***	1.144***	1.133***	1.133***
40-49	1.526***	1.495***	1.480***	1.440***	1.441***	1.441***
50+	1.472***	1.439***	1.419***	1.340***	1.344***	1.343***
Job tenure (months)	.001***	.001***	.001***	.002***	.002***	.002***
Educational mismatch (ref matched)						
Undereducation	-.781***	-.732***	-.134	-.908***	-.905***	-1.129***
Overeducation	-.414***	-.327***	1.257***	-.524***	-.488***	.331
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.414***	-.305***	-.303***	-.658***	-.591***	-.590***
Administration and services	-.093***	-.077**	-.099***	-.040	-.002	-.004
Firm size (ref less than 11)						
11-19	.297***	.281***	.254***	.275***	.282***	.284***
20-49	.507***	.501***	.480***	.428***	.445***	.449***
50+	.926***	.914***	.890***	.785***	.772***	.776***
Don't know, but more than 10			.172			.617***
Permanent (ref temporary)	.225	.194	1.592***	.567***	.612***	1.341***
Automation risk	1.589***	1.596***	4.821***	1.379***	1.343***	5.098***
Undereducation*autom risk		3.225***	-2.063***		4.924***	.689
Overeducation* autom risk			-5.803***			-2.557**
Constant	3.489***	2.550***	2.118**	4.271***	2.700***	2.645***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$
Source: Own calculations based on EU LFS 2009 and 2014.
Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 15A. Impact of individual and job-related characteristics and educational mismatch on salaries, low-skilled white-collars 2009 and 2014

	2009, low-skilled white-collar, pooled sample			2014, low-skilled white-collar, pooled sample		
Male (ref female)	.926***	.943***	.943***	.963***	.975***	.978***
Age group (ref 20-29)						
30-39	.469***	.467***	.467***	.422***	.431***	.429***
40-49	.651***	.656***	.657***	.552***	.563***	.566***
50+	.423***	.414***	.415***	.248***	.255***	.259***
Job tenure (months)	.004***	.004***	.004***	.005***	.005***	.005***
Educational mismatch (ref matched)						
Undereducation	-.466***	-.464***	-.826***	-.311***	-.317***	-1.059***
Overeducation	.618***	.579***	.175	.634***	.622***	.577**
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.492***	-.389***	-.389***	-.949***	-.931***	-.921***
Administration and services	-.036	.079	.076	-.388***	-.346***	-.340***
Firm size (ref less than 11)						
11-19	.139*	.126*	.125*	.403***	.396***	.393***
20-49	.283***	.266***	.269***	.209***	.210***	.207***
50+	.608***	.565***	.566***	.679***	.670***	.665***
Don't know, but more than 10			.373**		.909***	.904***
Permanent (ref temporary)	.433***	.376**	1.327***	.918***	.574***	.573***
Automation risk	1.334***	1.330***	1.106***	.568***	.479*	.138
Undereducation*autom risk		1.434***	.772*			1.751***
Overeducation* autom risk			.831*			.123
Constant	2.688**	1.934*	2.090*	3.456***	3.224***	3.369***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$
Source: Own calculations based on EU LFS 2009 and 2014.
Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 16A. Impact of individual and job-related characteristics and educational mismatch on salaries, high-skilled blue-collars 2009 and 2014

	2009, high-skilled blue-collars, pooled sample			2014, high-skilled blue-collar pooled sample		
Male (ref female)	1.505***	1.478***	1.484***	1.370***	1.313***	1.306***
Age group (ref 20-29)						
30-39	.973***	.976***	.975***	.769***	.779***	.780***
40-49	1.004***	1.003***	1.002***	.899***	.907***	.907***
50+	.751***	.746***	.745***	.806***	.821***	.820***
Job tenure (months)	.002***	.002***	.002***	.002***	.002***	.002***
Educational mismatch (ref matched)						
Undereducation	-.616***	-.597***	.379	-.697***	-.676***	-1.615
Overeducation	.786***	.778***	.733	.753***	.719***	1.649
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.322***	-.311***	-.313***	-.857***	-.854***	-.849***
Administration and services	-.495***	-.467***	-.469***	-.799***	-.814***	-.817***
Firm size (ref less than 11)						
11-19	.345***	.349***	.349***	.217	.228	.238
20-49	.309***	.317***	.316***	.285**	.294**	.300**
50+	.802***	.813***	.815***	.513***	.519***	.519***
Don't know, but more than 10			.764***			.965***
Permanent (ref temporary)	.806***	.762***	1.627***	.966***	.966***	.574***
Automation risk	1.610***	1.621***	2.357***	.589***	.577***	-2.434*
Undereducation*autom risk		1.935***	-2.562		-2.510**	2.418
Overeducation* autom risk			.117			-2.525
Constant	2.016	1.302	1.134	3.334***	4.329***	4.312***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$
Source: Own calculations based on EU LFS 2009 and 2014.
Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.

Table 17A. Impact of individual and job-related characteristics and educational mismatch on salaries, low-skilled blue-collars 2009 and 2014

	2009, low-skilled blue-collar, pooled sample			2014, low-skilled blue-collar, pooled sample		
Male (ref female)	1.179***	1.180***	1.166***	1.218***	1.197***	1.193***
Age group (ref 20-29)						
30-39	.482***	.467***	.460***	.312***	.288***	.289***
40-49	.497***	.489***	.484***	.636***	.595***	.593***
50+	.226***	.212***	.213***	.418***	.366***	.368***
Job tenure (months)	.003***	.003***	.003***	.003***	.003***	.003***
Educational mismatch (ref matched)						
Undereducation	-.352***	-.337***	2.405***	-.228***	-.220***	.171
Overeducation	.147*	.152*	-1.813	.212**	.192**	-2.003**
Industry (Ref construction, mining etc)						
Retail, accommodation, catering	-.474***	-.474***	-.474***	-1.193***	-1.251***	-1.251***
Administration and services	-.724***	-.723***	-.713***	-1.209***	-1.223***	-1.216***
Firm size (ref less than 11)						
11-19	.200**	.182*	.180*	.150	.155	.149
20-49	.176**	.171**	.168**	-.067	-.067	-.073
50+	.431***	.431***	.426***	.216**	.240***	.233***
Don't know, but more than 10			.186		.302	.297
Permanent (ref temporary)	.190	.198	.888***	.275	.686***	.688***
Automation risk	.854***	.889***	.574	.700***	-3.172***	-3.347***
Undereducation*autom risk		-1.109	-6.479***			-.904
Overeducation* autom risk			4.636*			5.168**
Constant	2.537***	2.987***	2.274	3.249***	4.656***	4.733***

Multilevel linear regression*** $p \leq .001$; **$p \leq .01$; * $p \leq .05$
Source: Own calculations based on EU LFS 2009 and 2014.
Notes: Calculated based on full-time workers. CH, MT, IS, LU, HR excluded from the analysis.