Educational mismatches and skills: new empirical tests of old hypotheses

Oxford Economic Papers 66 (2014), 959–982 **959**
doi:10.1093/oep/gpu024

Educational mismatches and skills: new empirical tests of old hypotheses

By Mark Levels*, Rolf van der Velden†, and Jim Allen†

*Research Center for Education and the Labor Market, Maastricht University, P.O. Box 616, 6200 MD Maastricht; e-mail: m.levels@maastrichtuniversity.nl and College for Interdisciplinary Education Research
†Research Center for Education and the Labor Market, Maastricht University

This article empirically explores how the often reported relationship between educational mismatches and wages can best be understood. Exploiting the newly published Programme for International Assessment of Adult Competencies (PIAAC) data, we are able to achieve a better estimation of the classical Duncan and Hoffman ORU model than previous papers by controlling for heterogeneity of observable skills. Our findings suggest that (i) a considerable part of the effect of educational mismatches can be attributed to skills heterogeneity, and (ii) that the extent to which skills explain educational mismatches varies by institutional contexts, particularly the extent to which collective wage bargaining is regulated. These observations suggest that skills matter for explaining wage effects of education and educational mismatches, but also that the extent to which this is the case depends on collective wage bargaining.

JEL classifications: I21, I25, J23, J24.

1. Introduction

In this article, we empirically explore how the often reported relationship between educational mismatches and wages can best be understood. Exploiting the newly published data from the Programme for International Assessment of Adult Competencies PIAAC (OECD, 2013a), we are able to achieve a better estimation of the classical ORU (over, required, under) model (Duncan and Hoffman, 1981) by controlling for heterogeneity of observable skills. Our findings suggest that a considerable part of the effect of educational mismatches can be attributed to skills heterogeneity. Our observations further suggest that the extent to which skills explain wage effects of education and educational mismatches co-depends on institutional contexts.

The incidence and wage effects of educational mismatches have been well established by empirical studies (see Groot and Maassen van den Brink, 2000; Hartog, 2000; Green *et al.*, 2002; Sloane, 2003; Quintini, 2011). Empirical analyses consistently show that (i) people who work in jobs for which they are overqualified earn less than workers who have the same level of education, but who work in jobs that

require that level of education; and that (ii) overeducated people earn more than people who work in equivalent jobs but have attained the level of schooling required for that job (Sicherman, 1991; Hersch, 1991; García-Serrano and Malo-Ocaña, 1996; Dekker *et al.*, 2002; Sloane, 2003). Many papers have aimed to explain these stylized facts (Duncan and Hoffman, 1981; Hartog and Oosterbeek, 1988; Sloane *et al.* 1999; McGuinness, 2006). Much of the debate has focussed on the question of whether the match between a worker's education and the education required for his or her job has a distinct effect on productivity, in addition to the effect of education itself. Many authors have proposed theoretical reasons for this assertion, for example, citing job assignment theory (Hartog, 1977; Sattinger, 1993, 2012). Job assignment theory proposes that even if we accept that the skills obtained in education contribute positively to productivity in general, the extent to which workers can use those skills may depend on productivity limits imposed by job characteristics. For overeducated workers, job constraints may allow only a limited use of their skills. On the other side, undereducated workers may overutilize their skills.

However, research shows that educational mismatches and skill mismatches correlate only weakly (Allen and van der Velden, 2001; Green and McIntosh, 2007; Quintini, 2011). Two explanations have been put forward to explain the observed effects of educational mismatches and the weak relation with skills mismatches. First, heterogeneous skills theory (Allen and van der Velden, 2001; Green and McIntosh, 2007) points out that considerable variation in skills exists within educational levels. If we accept that this is the case, it is likely that relatively high-skilled workers will tend to be sorted into more complex jobs that match their skills better than jobs that formally require their own level of education, whilst low-skilled workers will be sorted into less complex jobs that also provide a better match to their actual skill levels. According to this view, the skills possessed by these workers, rather than the mismatch they nominally experience, is what drives the observed wage effects.

Second, Allen and van der Velden (2001) propose an alternative explanation for the wage effects of over- and undereducation and their weak relation to skills mismatches, namely, that it is the result of institutional regulation of the labour market. Because workers' skills and productivity can rarely be observed perfectly by employers, pay rates will need to be established through some form of bargaining. It has been forcefully argued by scholars such as Spence (1973) that under such conditions employers aim to base workers' wages on perceived signals of their likely productivity with given observable characteristics (such as specific educational qualifications) working in a comparable job or performing comparable tasks. It is usually supposed that resorting to such signals will be temporary until better information about the worker's actual performance becomes available. However, when wage setting is strongly institutionalized, basing wages on formal characteristics such as the required qualification for a given job may become a permanent feature rather than a temporary solution in lieu of better information. Similarly, labour laws may restrict employers' ability to adjust wages to match

performance or dismiss underperforming workers. If this is true, there may be substantial wage effects of educational mismatches that cannot be explained by individual productivity differences, whether due to differences in skills or to poor matching between actual and required skills. If so, we would expect to observe these 'unexplained' wage effects of educational mismatches to occur more often in situations where wage-setting is more strongly affected by institutional arrangements. Because not only pay rates but also job requirements in general are more based on institutional arrangements, we would simultaneously expect that educational mismatches occur less often in these strongly institutionalized settings.

To date, the debate about which theory best explains the relationship between educational mismatches and wages has been hampered by data problems (Sloane, 2003). The most important problem is that there has been no large-scale data set that combines measures of required education and skills. Green *et al.* (2002) and Quintini (2011) have used the International Adult Literacy Survey (IALS); although this data set includes good measures of skills, it lacks reliable data on required level of education. Other data sets simply lack good measures of skills or are not large enough to cover institutional variation across different countries. As a consequence, most existing studies that explore the extent to which skills explain the relation between education and wages focus on educational attainment (Denny *et al.*, 2004; Blau and Kahn, 2005; Hanushek and Zhang, 2006; Patrinos *et al.*, 2006; Fasih *et al.*, 2012). This literature suggests that skills indeed contribute to explaining the wage effects of acquired education, but also that there is considerable cross-country variation that remains to be explained.

The recently collected international large-scale PIAAC data provide reliable measurements of all the elements needed to explore the relevance of skills for explaining wage effects of overeducation, undereducation, and required education. More specifically, the data contain measurements of individuals' earnings, years of acquired and required schooling, as well as direct measures of key information processing skills. As such, PIAAC allows us to better distinguish between the various theoretical explanations for the relationship between educational (mis)matches and wages than any previous data set. Although the measured skills are not the perfect measure of all relevant abilities, and much skill heterogeneity will plausibly remain unobserved, these data can be used to establish whether the relationships between wages and overeducation, undereducation, and required education can partly be attributed to skills heterogeneity. Furthermore, the cross-national character of the data allows for exploring the role of labour market institutions.

A recent paper by Hanushek *et al.* (2013) also uses the PIAAC data but concentrates solely on the returns to skills and acquired schooling. Our contribution to the literature is two-fold. First, we are the first to use this data set to explore to what extent the wage effects of overeducation, undereducation, and required education can be explained by skills across a large number of OECD countries. As indicated earlier, previous data sets have severe limitations to assess these effects adequately.

Second, we use this unique data set to examine to what extent institutional conditions frame these relations.

In the next section, we formally deduce hypotheses from the abovementioned theories. More specifically, we seek to answer the following research questions:

(i) To what extent are required education, overeducation, and undereducation related to individual wages?
(ii) To what extent can the effects of required education, overeducation, and undereducation on individual wages be explained by individual differences in skills?
(iii) To what extent is there cross-national variation in the extent to which the relationship between wages on the one hand, and required education, overeducation, and undereducation, on the other hand, can be explained by skills heterogeneity?
(iv) To what extent is this cross-national variation related to differences in labour market institutions?

2. Theory and hypotheses

In a significant expansion of the classic Mincerian wage function (Mincer, 1974), Duncan and Hoffman (1981) proposed a model that allows for distinguishing between individuals' attained level of education and the level of education required in their job. In this so-called ORU model, it is possible to estimate the effects of overeducation o, required education r and undereducation i on wages in the following general form:

$$lnW_i = \delta_o E^o{}_i + \delta_r E^r{}_i + \delta_u E^u{}_i + \boldsymbol{c}'_i\alpha + \boldsymbol{x}'_i\beta + \varepsilon_i \tag{1}$$

in which Wi is the observed wage of individual i, $E^o{}_i$ is the number of years of overeducation, $E^r{}_i$ is the number of years of required education, and $E^u{}_i$ the number of years of undereducation. To account for unobserved heterogeneity between countries, we include a vector with country fixed effects dummies, denoted as $\boldsymbol{c}$. Furthermore, $\boldsymbol{x}$ is a vector that contains control variables, such as work experience (linear and squared), and ε_i is an idiosyncratic error term. To allow for differentiation between education and skills, we expand eq. (1) with a vector of direct observations of skills, denoted as $\boldsymbol{s}$. The model reads:

$$lnW_i = \delta_o E^o{}_i + \delta_r E^r{}_i + \delta_u E^u{}_i + \boldsymbol{c}'_i\alpha + \boldsymbol{x}'_i\beta + \boldsymbol{s}'\gamma + \varepsilon_i \tag{2}$$

In eq. (2), the wage returns of skills are denoted by γ. Note that we do not assume that an individual's education and skills are uncorrelated. On the contrary, we expect that education and also control variables like family background and work experience affect skills, but that conditional on these variables, skills can be quite heterogeneous. By including the skills in the ORU model, we will be able to see whether skills affect wages over and above their effect through education.

As described earlier, previous findings show that:

$$\delta_r > \delta_o > |\delta_u| > 0 \tag{3}$$

The basic idea of this article is that the various theories that have been put forward make different predictions about the extent to which these parameters are driven by individual skills differences and about their cross-national variability. In the remainder of this section, we formally derive such hypotheses. To do so, we specify two (nested) specifications of eq. (2), one in which skills are not controlled for, and a second specification in which skills are controlled for. For reasons of clarity and precision, we describe the various hypotheses in logical terms and treat the two specifications as two different conditions under which the same model will yield different predictions. Under the first specification, all skills variables are restricted to zero, so that $\boldsymbol{s} = \mathbf{0}$. Note that under this specification, eq. (2) collapses to the standard ORU model described in eq. (1). Under the second specification, we put no restrictions on the skills variables in eq. (2), so that $\boldsymbol{s} > \mathbf{0}$.

Based on these specifications, we can formulate the following formal hypotheses based on the heterogeneous skills theory. In its strongest form, the heterogeneous skills theory leads to the following prediction:

Hypothesis 1 (strong)

$$(\delta_r \mid \mathbf{s} > 0) = (\delta_o \mid \mathbf{s} > 0) = (|\delta_u| \mid \mathbf{s} > 0) = 0 \qquad \&$$

$$(\gamma \mid \mathbf{s} > 0) > 0$$

In words: after controlling for skills, we expect no significant effect of required education, overeducation, or undereducation on wages, whilst we do expect skills to have an effect. Note that testing this hypothesis would require that we observe all relevant skills, which is highly improbable, if not impossible. Under these conditions, a weaker version of this hypothesis is more realistic. This hypothesis states that a significant part of the original relationships is explained by observed skills. In that case the absolute values of δ_r, δ_o, and δ_u are significantly lower in eq. (2) than in eq. (1).

Hypothesis 1 (weak)

$$(\delta_r \mid \mathbf{s} > 0) < (\delta_r \mid \mathbf{s} = 0) \qquad \&$$

$$(\delta_o \mid \mathbf{s} > 0) < (\delta_o \mid \mathbf{s} = 0) \qquad \&$$

$$(|\delta_u| \mid \mathbf{s} > 0) < (|\delta_u| \mid \mathbf{s} = 0) \qquad \&$$

$$(\gamma \mid \mathbf{s} > 0) > 0$$

To answer research questions iii and iv, we will consider eqs (1) and (2) separately for each country. The country estimates of γ in eq. (2) will provide us with an

estimate of the extent to which skills affect wages in the different countries and comparing δ_r, δ_o, and δ_u in eqs (1) and (2) can indicate the extent to which skills explain the wage returns to overeducation, undereducation, and required education in each country. So let ${\zeta_r}^c$ be the proportion of the wage returns to required education explained by skills in country c, ${\zeta_o}^c$ be the proportion of the wage returns to overeducation explained by skills in country c, and ${\zeta_u}^c$ be the proportion of the wage returns to undereducation explained by skills in country c. Furthermore, ${\delta_r}^c$ is the effect of required education on wages in country c, ${\delta_o}^c$ is the effect of overeducation on wages in country c, ${\delta_u}^c$ is the effect of undereducation on wages in country. Then, it follows that:

$$ {\zeta_r}^c = (({\delta_r}^c \mid \mathrm{s} = 0) - ({\delta_r}^c \mid \mathrm{s} > 0))/({\delta_r}^c \mid \mathrm{s} = 0) \tag{4a} $$

$$ {\zeta_o}^c = (({\delta_o}^c \mid \mathrm{s} = 0) - ({\delta_o}^c \mid \mathrm{s} > 0))/({\delta_o}^c \mid \mathrm{s} = 0) \tag{4b} $$

$$ {\zeta_u}^c = ((\mid {\delta_u}^c \mid \mid \mathrm{s} = 0) - (\mid {\delta_u}^c \mid \mid \mathrm{s} > 0))/(\mid {\delta_u}^c \mid \mid \mathrm{s} = 0) \tag{4c} $$

We can then answer research question iv with the following equations:

$$ \gamma_c = \lambda_0 + \lambda_s CWB_c + \varepsilon_c \tag{5a} $$

$$ {\zeta_r}^c = \lambda_0 + \lambda_r CWB_c + \varepsilon_c \tag{5b} $$

$$ {\zeta_o}^c = \lambda_0 + \lambda_o CWB_c + \varepsilon_c \tag{5c} $$

$$ {\zeta_u}^c = \lambda_0 + \lambda_u CWB_c + \varepsilon_c \tag{5d} $$

in which CWB_c is a variable measuring the prevalence of collective wage bargaining in country c and ε_c is an idiosyncratic error term. The parameter λ_o is an intercept, λ_s is the relationship between collective wage bargaining and the wage returns to skills by country, denoted by γ_c. Parameters λ_r, λ_o, and λ_u denote the relationship between collective wage bargaining and the extent to which wage returns to required education, overeducation, and undereducation are explained by skills. Following the previous discussion on institutional theory, we predict that:

Hypothesis 2

$$ (2a)\lambda_s < 0 \quad \& $$

$$ (2b)\lambda_o < 0 \quad \& $$

$$ (2c)\lambda_r < 0 \quad \& $$

$$ (2d)\lambda_u < 0 $$

In words: we expect the country-specific effects of skills on wages to be negatively related to countries' collective wage bargaining (CWB): in countries with stronger collective wage bargaining, skills have lower effects on wages (hypothesis 2a). Moreover we expect that the country-specific proportion of the effects of required education, overeducation, and undereducation that is explained by skills are negatively related to the country's CWB (hypotheses 2b–d). In countries in which collective wage bargaining is more prevalent, education-related wage differentials should be less strongly explained by skills.

3. Data and measurements

The data we use for the analyses come from the PIAAC survey, collected by the OECD (2013a) in 24 highly industrialized countries. The survey is designed to provide valid and reliable estimates of adults' competences in key information-processing skills; to identify proficiency differences between subgroups of the population; to understand development, maintenance, and use of skills; as well as to determine the impact of proficiency levels on life chances (OECD, 2013a). National samples contain over 5,000 adults between the age of 16 and 65. Respondents were interviewed using computer-assisted personal interviews, although for the testing pencil-and-paper data collection strategies were also used. The data hold information on demographic and socio-economic background characteristics, as well as on skills use in the work place and at home. They contain direct measurements of skills. Respondents were given assessment tests designed to directly measure their cognitive skills in various domains. More specifically, these tests measured numerical and literacy skills, as well as respondents' capacity to solve problems in technology-rich environments. For detailed information on the scaling procedures and reliability of the tests, we refer to the technical report (OECD, 2013b).

To prepare the data for our analyses, we made a number of selections. First, we only selected males who were employed full-time. This was based on the reported number of usual working hours per week. Full-time workers are defined as workers with a minimum of 36 working hours a week. To avoid outliers, we excluded everybody reporting more than 80 working hours a week. We excluded those who were self-employed, people who served in the armed forces, and unpaid family workers. We also excluded people who indicated that their primary status was student or internship. To avoid outliers in the wage distribution we excluded the top and bottom 1% in each country. We excluded France and Russia, as these data were not yet available, as well as Australia, which has put restrictions on the use of the data. The working sample consists of some 1,200 cases in most countries. In Canada the sample existed of 6,069 cases, from which we took a random sample of 20%, resulting in $N_{Canada} = 1{,}190$ cases to reduce possible bias due to oversampling of Canadian respondents. Missing values were deleted listwise. The total working sample contains $N = 26{,}322$

Table 1 Descriptive statistics

	Minimum	Maximum	Mean	SD
Numeracy skills	80.39	420.24	284.34	47.11
Literacy skills	78.86	415.64	281.20	42.92
Monthly wage (US$)	512.90	213,198.31	3,490.01	3,497.65
Required education	0	22	12.93	3.13
Overeducation	0	18	0.89	1.78
Undereducation	0	14	0.51	1.27
Work experience	0	55	19.87	12.18
Number of working hours per week	36	80	43.89	7.53
1st-generation migrants	0	1	0.08	0.27
1.5-generation migrants	0	1	0.01	0.09
2nd-generation migrants	0	1	0.02	0.13
2.5-generation migrants	0	1	0.05	0.21
Remigrants	0	1	0.01	0.09
Highest level of mothers' or fathers' education	1	3	1.90	0.75

Note: $N = 26{,}322$.
Source: PIAAC.

respondents from 21 countries. A detailed overview of the sample selection is presented in Appendix 1.

3.1 Measurements

Below, we discuss the measurement of the variables we use. An overview of descriptive statistics of all the variables in our model is given in Table 1.

3.1.1 *Wages* As our dependent variable, we use the natural logarithm of the monthly wage, adjusted for purchasing power parity to account for cross-national differences. Respondents in the top and bottom 1% on this variable in each country are omitted from the analyses to avoid outliers. Monthly wages in our data set range from US$513 to US$213,198. The mean wage is US$3,490.

3.1.2 *Educational attainment* Educational attainment is measured in PIAAC in the nominal number of years respondents have spent in formal education. The measure is derived from the reported highest level of education in national education systems, converted into nominal years of schooling by the PIAAC consortium and country experts (OECD, 2013b).

3.1.3 *Required education* The PIAAC questionnaire contains a question asking respondents what education level they thought was required for their current jobs. Verbatim, this question was: 'If applying today, what would be the usual qualifications, if any, that someone would need to *get* this type of job'? Based on the answers respondents gave to this question and information about national education systems, this was converted into a cross-nationally comparable

measure of nominal years of formal education needed to get the job (OECD, 2013b). The measure ranges from 0 to 22 years, with a mean of 12.9 years.[1]

3.1.4 *Overeducation* Our measure is derived from the measures of respondents' educational attainment and the education level required for their job. Following the usual operational definition we define the extent of overeducation as:

$$E^O = E^A - E^R \quad \text{if} \quad E^A > E^R$$

and

$$E^O = 0 \qquad \text{if} \quad E^A \leq E^R$$

where respondents' educational attainment in years of schooling is E^A and $E^O \geq 0$.

3.1.5 *Undereducation* Similarly, we define the extent of undereducation as:

$$E^U = E^R - E^A \quad \text{if} \quad E^R > E^A$$

and

$$E^U = 0 \qquad \text{if} \quad E^R \leq E^A$$

with $E^U \geq 0$.

3.1.6 *Skills* PIAAC contains measures of three types of skills—literacy skills, numeracy skills, and skills related to problem solving in technology-rich environments (OECD, 2013a). All three skills measures are constructed using adaptive testing; plausible values are calculated using item response theory (IRT). The tests on problem solving in technology-rich environments were only presented to people who reported they had at least some computer experience, were willing to take the computer-based assessment, and had at least minimum levels of computer abilities. Including these tests would nonrandomly reduce our sample size with almost 33%. We therefore restrict ourselves to the measurements of numeracy and literacy to operationalize skills. As the skill proficiencies of literacy and numeracy are highly correlated ($r = 0.905$) we only use numeracy for the analysis. The OECD (2013b) defines numeracy as 'the ability to access, use, interpret and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life'. The tests of numeracy measure how well respondents are able to use mathematical information to solve problems that might actually occur in real life. Numeracy is measured with 10 plausible values. We use the first of the reported plausible values as an indication of the numeracy skills of individuals.

[1] In Appendix 2, we present the distribution of people in jobs who reported that their job required no education over occupational groups. As can be noted, only 0.2% of the workers reported that no education was needed, most of them in the lower ISCO categories.

3.1.7 *Work experience* We also control for the effect work experience has on wages by including the total numbers of years respondents reported to have had paid work during their lifetime in a linear and a quadratic term.

3.1.8 *Working hours* Although we select people working full-time (defined as 36 hours or more), there is still considerable variation in number of working hours. Therefore we control for the number of hours individuals weekly work in their current job. As already indicated, we excluded respondents reporting to work more than 80 hours a week to avoid outliers. The mean number of hours worked is 43.89.

3.1.9 *Immigration status* Migrants have a wage penalty related to their migrant status (see, e.g., Chiswick, 1978). Moreover, both overeducation and undereducation have differing interpretations for migrants. Overeducation can partly be linked to problematic transferability of human capital, whilst undereducation might be explained by favourable self-selection of immigrants (Chiswick and Miller, 2008). To reduce noise related to the different interpretations of ORU with immigrants, we control for immigrant status. We use dummies to distinguish first-generation immigrants (both parents and respondent were foreign-born), 1.5-generation immigrants (respondent and one parent foreign-born, one parent born in test country), second-generation immigrants (both parents foreign-born, respondent born in test country), 2.5-generation immigrant (respondent and one parent born in test country, one parent foreign-born), and remigrants (i.e., respondent foreign-born, both parents non–foreign-born). People without an observed history of migration are the reference category.

3.1.10 *Socioeconomic origin* In general, it might be expected that people with higher socioeconomic background end up in higher quality and better paying jobs, all else being equal. Parents with a higher socioeconomic status are also more likely to have children with higher cognitive abilities (Hanushek and Woessmann, 2011). We use dummies to control for the effects of socioeconomic origin class, distinguishing people with lower educated (ISCED 1 or 2) parents (reference) from those with medium educated (ISCED 3 or 4) or higher educated (ISCED 5 or 6) parents. We take the highest education level of father or mother (whichever is the highest).

3.1.11 *Country fixed effects* We control for unobserved heterogeneity between countries by including country dummies. Austria is the reference category.

3.1.12 *Collective wage bargaining (CWB)* To measure the extent to which collective bargaining affects wage setting in countries, we use the OECD measure of the percentage of countries' workforces covered by collective agreements. It ranges from 12 (Korea) to 99 (Austria). Data were taken from Venn (2009, pp. 17–18).

Table 2 ORU model: regression required education, overeducation, and undereducation on log earnings

	Model 1		Model 2	
	B	β	B	β
Intercept	6.247***		6.003***	
ORU				
Required education (δ_r)	0.078***	0.422***	0.067***	0.361***
Overeducation (δ_o)	0.032***	0.099***	0.024***	0.074***
Undereducation (δ_u)	−0.019***	−0.042***	−0.012***	−0.027***
Numeracy skills (γ/100)			0.138***	0.119***
Controls[a]	Y	Y	Y	Y
Adjusted R^2	0.594		0.603	

Notes: Presented parameters are unstandardized (B) and standardized (β) OLS regression coefficients. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.
[a]Estimates for control variables in Appendix 3.
Source: PIAAC.

4. Analyses and results

In Table 2 we present our explanatory analyses, using numeracy test scores as proxies for workers' skills. In Model 1 we follow the classical Duncan and Hoffman (1981) ORU model, as described in eq. (1). In Model 2 we estimate an extended version of this model by including the numeracy skills. This model follows eq. (2).

The results of Model 1 are in line with previous findings. First, the relationship between required years of schooling and wages is positive. The strength of the relationship ($\delta_r = 0.078$) indicates that each additional year of required schooling yields a wage premium of some 8%. The effect of overeducation is less than half that size, with an estimate of $\delta_o = 0.032$. Having more education than is required for a job pays off but not as much as the years of required education for that job. Each additional year of education more than is strictly required yields a wage premium of some 3%. Undereducation is negatively related to wages ($\delta_u = -0.019$). The absolute effect size is smaller than the effect size of overeducation. Each year of undereducation yields a wage penalty of some 2%.

In Model 2, the proficiency score on numeracy skills is added to the model. Numeracy skills ($\gamma = 0.138$) are positively related to wages. If we compare the standardized effects, the effect size (standardized parameter = 0.119) is around one third of the effect of required education (standardized parameter = 0.361). Compared to Model 1, the relationship between required education and wages is reduced with 15% to $\delta_r = 0.067$. We can also see that the effect of overschooling is reduced with 25% to $\delta_o = 0.024$. Differences in numeracy skills account for 38% of the effect of underschooling as observed in Model 1.[2]

[2] Please note that our model by definition constrains the parameters across countries to be the same. This is taken up in Table 5, where we provide the results per country.

How do these findings bear on the hypotheses we formulated? The strong version of the heterogeneous skills theory predicted that after controlling for skills, there would be no residual effect of required education, overeducation, and undereducation on wages. That is clearly not the case. However, the results do clearly show that a significant part of all three effects can be explained by skills, suggesting that the weaker version of the heterogeneous skills theory is supported by the data.

Before we continue to draw conclusions, we test the sensitivity of these main conclusions to sample selection and alternative model specifications. In Tables 3 and 4, we present alternative model specifications to test whether our results are robust. First, it should be noted that we measure only a subset of people's actual skills. It might be the case that higher level jobs less strongly require a high proficiency in elementary numeracy skills and more strongly demand skills we do not observe. As such, it might be the case that the extent to which skills explain ORU differ for different types of jobs. We reran the original analyses on subsets of both people in higher skilled (ISCO08 > 3) and lower skilled (ISCO08 ≤ 3) jobs. The results are presented in the first four models of Table 3. Although the coefficients differ somewhat in strength, our main conclusions are unaffected.

Second, the use of years of schooling as a measure for education (and, by consequence, for overeducation and undereducation) in cross-national analyses could be criticized. The main assumption when using this variable is that each year of education has a similar effect on skills within a country (and in Table 2 also across countries). But a year of tertiary education may have a different impact on the acquisition of skills than a year of pre-college education. Using dummies indicating the different ISCED levels might be a way out. Although the ISCED-classification certainly also raises problems of comparability (for an extensive discussion see Schneider, 2009), this critique directly pertains to the construct validity of our most important measures. In Table 3 we therefore present an alternative specification to Models 1 and 2, using ISCED-levels to indicate the acquired and required level of education. In this specification, we classified overeducation and undereducation as follows. First we assessed the respondent's own level of education distinguishing lower education (ISCED 1 and 2; the reference category), medium education (ISCED 3 and 4), and higher education (ISCED 5 and 6). Then, we compared this education level with the education level their job requires and use dummies to signify overeducation (i.e., their educational attainment is higher than their job demands) and undereducation (i.e., their education is lower than their job demands). The interpretation of the coefficients deviates slightly from the interpretation of Models 1 and 2. Now, the coefficient for overeducation represents the wage effect of being overeducated compared to those with a similar level of education, but who are working in a job that matches their education level and therefore has an opposite sign compared to the same coefficient in eqs (1) and (2). The same applies for the coefficient for undereducation, that now signifies the wage difference between people who are undereducated and those who have a similar education level but have a job at the right level of education. The

Table 3 Robustness checks for Models 1 and 2 in Table 2

	Alternative specification with only low-status jobs		Alternative specification with only high-status jobs		Alternative specification with different measurement of ORU	
	Model 1(a)	Model 2(a)	Model 1(b)	Model 2(b)	Model 1(c)	Model 2(c)
Intercept	6.612***	6.428***	6.379***	6.059***	7.040***	6.552***
	0.030	*0.033*	*0.036*	*0.041*	*0.021*	*0.025*
Required education (years)	0.051***	0.043***	0.070***	0.061***		
	0.002	*0.002*	*0.002*	*0.002*		
Overeducation (years)	0.016***	0.010***	0.028***	0.022***		
	0.002	*0.002*	*0.003*	*0.003*		
Undereducation (years)	−0.012***	−0.006*	−0.018***	−0.012***		
	0.003	*0.003*	*0.003*	*0.003*		
Middle educated (ISCED)					0.081***	0.038***
					0.008	*0.008*
Higher educated (ISCED)					0.418***	0.313***
					0.009	*0.009*
Overeducated (ISCED)					−0.195***	−0.175***
					0.007	*0.006*
Undereducation (ISCED)					0.159***	0.137***
					0.008	*0.008*
Numeracy skills		0.103***		0.144***		0.195***
		0.007		*0.009*		*0.005*
Controls[a]	Y	Y	Y	Y	Y	Y

Notes: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$. Standard errors in italics. [a]Estimates for control variables in Appendix 4.
Source: PIAAC.

alternative analysis supports our main conclusions, namely, that heterogeneous skills partly drive the effects of educational mismatches.

Another issue is that our model assumes stability in the relationship between education and skills over time. This is not necessarily the case. A year of schooling for a cohort that attended school in the 1960s or 1970s may have yielded more or less skills than a year of schooling for a cohort that attended school in the 1980s or 1990s due to changes in the quality of instruction over time. In Table 4 we estimate the same models again separately for the older (41 and older) and the younger (16–40-year-olds) cohort. This does not affect the main results.

Finally, the sample of our original analyses was restricted to full-time working males. In Table 4 we have added a robustness check running the original model specification on a sample of full-time working females. Again the results do not basically change.[3]

[3] Overeducation may be a particular problem for those who fail to find full-time work, and we may be missing a group of people for whom overeducation and inability to find full-time work are related. We have considered looking at part-time workers as well, but decided against it in this article. The

Table 4 Robustness checks for Models 1 and 2 in Table 2

	Alternative specification with only people younger than 40		Alternative specification with only people of 40 years or older		Original specification ran on fulltime working women	
	Model 1(d)	Model 2(d)	Model 1(e)	Model 2(e)	Model 1(f)	Model 2(f)
Intercept	6.248***	6.045***	6.350***	6.106***	6.019***	5.774***
	0.032	*0.034*	*0.041*	*0.042*	*0.024*	*0.027*
Required education (years)	0.071***	0.062***	0.085***	0.071***	0.084***	0.075***
	0.001	*0.002*	*0.001*	*0.001*	*0.001*	*0.001*
Overeducation (years)	0.035***	0.028***	0.029***	0.020***	0.038***	0.031***
	0.002	*0.002*	*0.002*	*0.002*	*0.002*	*0.002*
Undereducation (years)	−0.027***	−0.021***	−0.021***	−0.013***	−0.028***	−0.022***
	0.003	*0.003*	*0.002*	*0.002*	*0.002*	*0.002****
Middle educated (ISCED)						
Higher educated (ISCED)						
Overeducated (ISCED)						
Undereducation (ISCED)						
Numeracy skills		0.115***		0.158***		0.135***
		0.008		*0.008*		*0.006*
Controls[a]	Y	Y	Y	Y	Y	Y

Notes: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$. Standard errors in italic.
[a]Estimates for control variables in Appendix 4.
Source: PIAAC.

Our main conclusions are largely insensitive to changing measurement of the relevant variables and to subsampling of higher and lower status jobs, older and younger cohorts or women instead of men. This suggests our conclusions are reasonably robust. There are, however, three additional remarks that are relevant here. First, it must be noted that we do not observe all skills that are relevant in theory, and it is more than likely that the relationship between overeducation and skills would be even further reduced if we would be able to control for the now unobserved skills. In other words, our test of the heterogeneous skills theory is highly conservative.

Second, the expectation that it would be possible to explain all the wage variance that is related to required education, overeducation, and undereducation presupposes that employers are perfectly informed about all the relevant skills and other productive attributes of workers. This seems unrealistic. In practice, it is very plausible that there is at least some uncertainty, and as a consequence there will be some tendency to assign wages based on observable features of workers and jobs

opportunities for part-time work also vary considerably across countries and might as such distort the interpretation of the findings. We plan to take this issue up in a separate publication.

rather than entirely on actual productive skills. Consequently, even if we possessed the perfect knowledge that most employers lack, in the form of a precise measurement of all relevant skills, the strong version of the heterogeneous skills theory is unlikely to be fully confirmed. There will be some residual effect indicating that people are rewarded partly based on easily observable features such as education and job titles.

This leads directly on to the third point, which is that we would expect the size of this residual effect of formal characteristics to depend to a large extent on the particular institutional arrangements that prevail in a country. One implicit assumption underlying our specification of the classical ORU model in Models 1 and 2 is that both the effects of skills and the extent to which skills explain wage effects of overeducation and undereducation do not differ cross-nationally. However, as we argued, such heterogeneity of effects can theoretically be expected. In countries in which wage setting is largely a matter that is decided between employer and employee, with little regard needing to be paid to laws and institutions designed to protect workers' rights, we would expect the residual effect of formal characteristics to be quite small and largely transient. However, in countries in which protectionist labour market laws and institutions play an important role, we would expect the residual effect to be far larger and more permanent. This is precisely the point of our second hypothesis, and we now turn to it.

Based on institutional theory, we posited the hypothesis that the extent to which individual skills affect wages over and above the effects of required education, overeducation, and undereducation is larger in countries in which collective bargaining is less prevalent. Moreover, we hypothesized that the extent to which skills can explain the relationship between required education, overeducation, and undereducation on the one hand and wages on the other hand is larger in countries in which collective bargaining is less prevalent. To test these hypotheses, we relaxed the assumption of cross-national homogeneity of effects and examined cross-national variation in the effects of skills on wages and on the proportion of the wage effects of required education, overeducation, and undereducation that can be attributed to skills. To establish this proportion for each country, we ran the model specified in eq. (2) separately for each country. In the first column of Table 5, we present the country scores on the collective bargaining scale. In the second column, we present the wage effects of skills in each country according to eq. (2). Full models are presented in Appendix 5. There is indeed considerable cross-national variation in the effect of numeracy skills on wages, ranging from a low and non-significant 0.047 in the Czech Republic to a high 0.225 in Germany.

Figure 1 presents the country-level relationship between collective wage bargaining and the wage returns to numeracy skills. On the *x*-axis of the graph, we have ordered countries according to the extent to which wages are set collectively. The index holds information about the percentage of the total workforce in countries that is covered by collective bargaining processes. On the *y*-axis the countries are ordered based on the effect of numeracy skills on wages. The figure

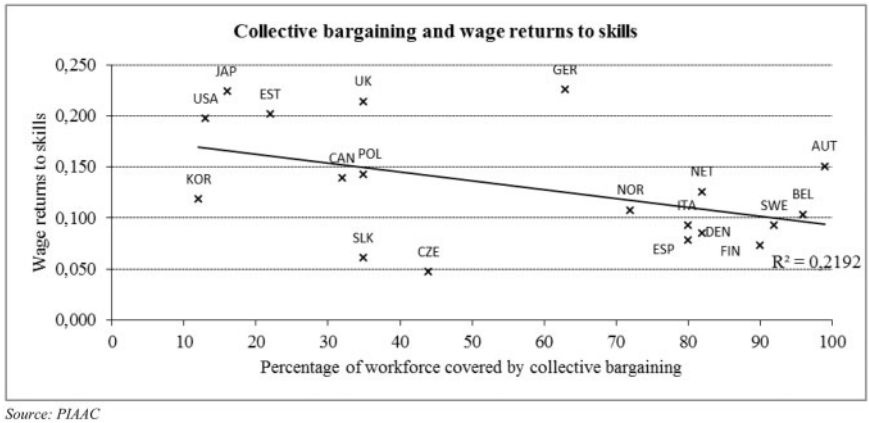
Table 5 ORU model by country: returns to skills; returns to required education, overeducation, and undereducation on ln(earnings); and the proportion of effects explained by skills

	CWB	γ	% δ_r^a interpeted by γ	% δ_o^a interpeted by γ	% δ_u^a interpeted by γ
Austria	99	0.150***	12	13	n/a†
Belgium	96	0.103***	15	14	20
Canada	32	0.139***	17	22	28≠
Cyprus	n/a‡	0.055	4	9	11
Czech Republic	44	0.047	6	10	n/a†
Denmark	82	0.085***	10	18	n/a†
Estonia	22	0.201***	25	n/a†	n/a†
Finland	90	0.073***	8	15	8
Germany	63	0.225***	19	35	n/a†
Ireland	n/a‡	0.171***	16	34≠	29
Italy	80	0.092***	10	24	22
Japan	16	0.224***	20	61≠	49≠
Korea	12	0.118***	11	17	14
Netherlands	82	0.126***	12	23	23
Norway	72	0.107***	14	18	19
Poland	35	0.143***	18	34	47≠
Slovak Republic	35	0.061	5	6	n/a†
Spain	80	0.078***	8	20	8
Sweden	92	0.093***	13	28	29≠
UK	35	0.214***	16	39	32
USA	13	0.197***	18	51	26

Notes: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.
‡No macro data available.
†No effects to explain as the original association does not significantly deviate from zero.
≠Association becomes insignificant after controlling for skills.
Source: PIAAC.

shows that the wage returns to skills are indeed lower in countries with a stronger collective agreement coverage.

Table 5 also presents information about country differences in the extent to which skills explain the correlation between wages and required years of schooling, overeducation, and undereducation. The table shows that large cross-national variation exists. In Canada (17%), the USA (18%), Poland (18%), Germany (19%), Japan (20%), and Estonia (25%), skills are important explanations for the returns to required education. In contrast, in Cyprus (4%), the Czech Republic (6%), and the Slovak Republic (5%), skills contribute much less to the explanation of the relation between required education and wages. In Ireland (34%) and Japan (61%), skills explain (nearly) all of the returns to overeducation, as the effects of overeducation on wages are no longer significant. In the USA, more than half of the association between overeducation and wages can be explained by skills. In Cyprus and the Slovak and Czech Republics barely any of this effect is explained by skills. In Japan, Sweden, Canada, and Poland, the relation between



Source: PIAAC

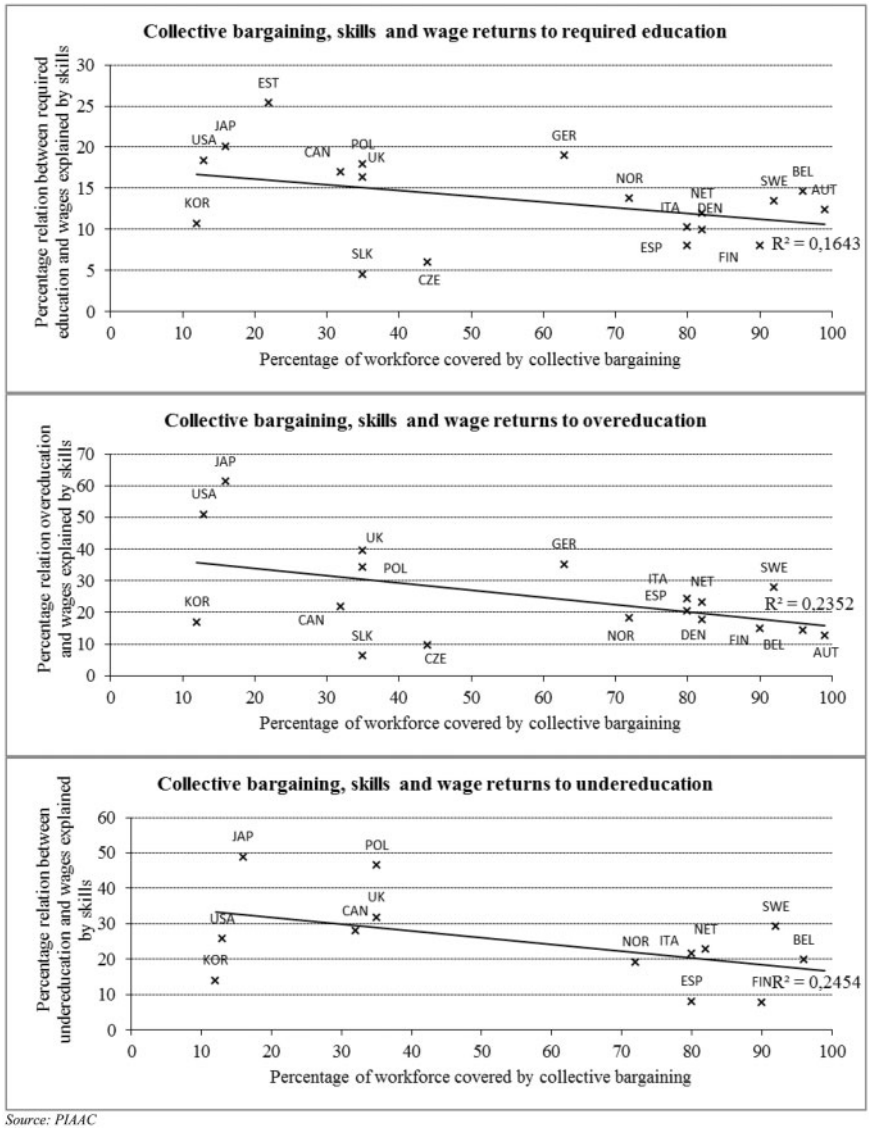
Fig. 1 Country-level relationship between labour market institutions and the effect of numeracy skills of earnings.
Source: PIAAC.

undereducation and wages is fully explained by skills. On the other hand, the proportion of the wage effect of undereducation that is explained by skills is very low in Finland (8%), Cyprus (11%), and Spain (8%).

Figure 2 shows how collective wage bargaining in countries is related to the extent to which wage effects of required education, overeducation, and undereducation are explained by skills. On the horizontal axis, we ordered countries according to the extent to which employees are covered by CWB. On the *y*-axis the countries are ordered based on the extent to which the relationship between required education (top panel), overeducation (middle panel), and undereducation (bottom panel) can be explained by individuals' skills.

In the top panel of Fig. 2 we can see that the extent to which the wage effects of required education are explained by skills is somewhat stronger in the low CWB countries than in the strong CWB countries. The middle panel of Fig. 2 shows a somewhat stronger negative relationship between CWB and the extent to which skills can explain the relationship between overeducation and wages, which is in line with the institutional hypothesis. It indicates that in strong CWB countries the wage effects of overeducation are less driven by skills than in low CWB countries. Furthermore, the overall proportions that are explained in each country are higher and the relation is somewhat stronger than is the case for required education. The bottom panel shows that there is also a negative relation between CWB and the extent to which the wage effect of undereducation is explained by skills. This indicates that the wage effects of undereducation are more strongly driven by skills in the high CWB countries, which supports the institutional theory.

It would seem that as institutional theory predicts, individuals' skills are less rewarded in countries in which wage setting is more strongly collectivized. Also,



Source: PIAAC

Fig. 2 Relationship between collective wage bargaining and the extent to which effects of required education, overeducation, and undereducation on log-earnings in these countries are explained by skills.
Source: PIAAC.

it seems that ORU effects are more strongly driven by skills in countries with lower levels of CWB.[4] Figure 2 further suggests two things. First, the effects of

[4] In Appendix 6, we present figures on the country-level relationship between collective wage bargaining on the one hand, and GDP *per capita* and the proportion of higher status jobs on the other. We also

overeducation and undereducation are more strongly related to skills than is the case for required schooling, for both low- and high-CWB countries. Second, even in strong CWB countries some of the wage effects of required education are at least partly explained by underlying differences in skill levels. Taking into account that this is a conservative estimate of the effect of skills, the real explanatory effect of skills in these countries might be much higher. This could reflect the fact that in CWB one of the arguments for assigning higher wages to higher educational levels is based on the presumed higher skills levels.

5. Conclusions and discussion

In this article, we have aimed to shed further light on explanations for the well-established relationship between overeducation, undereducation, and earnings. Using new empirical data (OECD, 2013a), we were able to estimate the classical ORU-model whilst controlling for heterogeneity of observable skills. This allowed us to address four research questions.

First, we asked to what extent required education, overeducation, and undereducation are related to individual wages. Our findings are in line with earlier studies showing that the wage effects of overeducation are almost half of the wage effects of required education and that the (absolute) wage effect for undereducation is even lower than the wage effect for overeducation.

Second, we asked to what extent the effects of required education, overeducation, and undereducation on individual wages can be explained by individual differences in skills. Our analyses show that skills heterogeneity contributes considerably to the explanation of educational mismatch. The effect of numeracy skills on wages explains some 15% of the wage effect of required education, a quarter of the wage effect of overeducation, and over one third of the wage effect of undereducation. Considering that we only use one measure of one observable skill, these effects are in fact quite high. One can easily imagine that much more could be explained if we could have measured all relevant skills. At least we can conclude that part of the educational mismatches is just apparent and that mismatches do not necessarily imply that workers' skills are heavily underutilized or overutilized. The incidence of undereducation and overeducation in these cases can be interpreted as an adjustment by the market that shifts workers to jobs that in fact better match their capabilities than would jobs formally requiring their own level of education. The significance of skills is also illustrated by the fact that even in strong CWB countries some of the wage effects of required education are explained by underlying differences in skill levels. Again taking into account that this is a conservative estimate of the effect of skills, the real explanatory effect of skills in

relate it to a country's correlation between years of schooling and numeracy skills. The absence of a relationship makes it implausible that the results we present can be explained by country differences in productivity, the proportion of higher status jobs, or the extent to which a country's educational system is related to the accumulation of skills.

these countries is likely to be higher. This seems to suggest that even in a situation of collective wage bargaining one of the arguments for assigning higher wages to higher educational levels is because of the presumed higher skills levels.

In our third and fourth research questions, we asked to what extent there is cross-national variation in the extent to which the relationship between wages, on the one hand, and required education, overeducation, and undereducation, on the other hand, can be explained by skills heterogeneity and to what extent this cross-national variation is related to differences in labour market institutions. Although cross-national variation exists, we clearly observe that in all countries, a considerable part of the wage effects of over- and undereducation is explained by heterogeneous skills. Notwithstanding this clear support for the heterogeneous skills theory, we also find support for the institutional theory, which predicts that the extent to which skills explain the wage effects of required education, overeducation, and undereducation will depend strongly on the institutional context. In countries with weak collective bargaining coverage, we find stronger direct effects of skills on wages. Also, in these countries a larger proportion of the observed wage effects can be accounted for by skills. By contrast, where CWB is more prevalent, skills have a weaker direct effect on wages and account for relatively little of the wage effects of required education, overeducation, and undereducation. It is hard to find an alternative explanation for these observed effects of labour market institutions. All countries in question are highly developed, and although there may be differences in economic conditions, it is not immediately clear why numeracy skills affect wages strongly in countries like Canada, Japan, and the UK and so weakly in Italy or Cyprus. It is unlikely that some omitted skill variable might be responsible for this. That would assume that for example in country X wages are strongly related to skill A and in country Y it would be strongly related to skill B, with little or no correlation between skills A and B. That seems quite unlikely, and we think that it is plausible to infer from our findings that the extents to which individual skills affect wages is constrained by the institutional arrangements. We conclude that these observations make plausible that skills do matter in explaining wage effects of education and educational mismatches, but that the extent to which this is the case also depends on institutional contexts.

Our analyses have important policy implications. Policy makers often worry about high incidences of educational mismatches, but our study shows that at least part of the incidence of undereducation and overeducation should be interpreted as an adjustment by the market that shifts workers to jobs that in fact better match their capabilities than would jobs formally requiring their own level of education. Indirect evidence suggesting that this may be the case has already been provided by Allen and van der Velden (2001), who argued that educational mismatches do not necessarily imply skills mismatches and showed that the correlation between educational mismatches and subjective feelings of over- and underutilization are in fact quite weak. Our analyses now directly demonstrated this using proper indicators for educational mismatches and objective measures of skills. Nevertheless, in countries with strong CWB, these educational mismatches

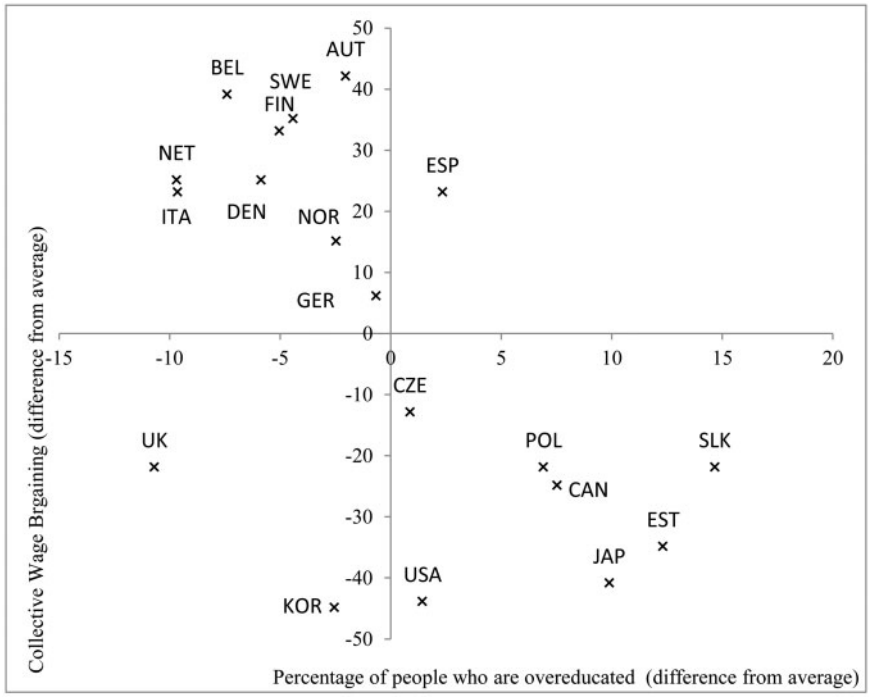


Fig. 3 Relationship between collective wage bargaining and the prevalence of overeducation.

probably do represent over- or underutilization of skills, and here policy makers should develop policies that allow for a better matching on the labour market. Figure 3 shows how countries compare on the measure of collective wage bargaining (*y*-axis) and the incidence of overeducation (*x*-axis). As expected we can clearly see a negative relationship between the incidence of overeducation and CWB. Most countries are located either in the upper left corner (combining a relatively high CWB with a relatively low incidence of overeducation), or in the lower right corner (combining a relatively low level of CWB with relatively high levels of overeducation). In the first group of countries, workers are less likely to be overeducated, as job allocation is often based on formal qualifications, but if they are overeducated, they will have a higher chance that their skills are underutilized. In the second group of countries, the reverse is true. Workers in these countries are more likely to end up in jobs for which they are formally overqualified, but it is relatively unlikely that their skills will be underutilized in those jobs. Institutional characteristics like CWB thus work in two different ways: on one hand they protect workers against the incidence of overeducation, but on the other hand they increase the likelihood of ending up in jobs where the actual skills do not fully pay off. The UK and South Korea stand out as countries where both the level of overeducation

and the likelihood of underutilization of skills is the lowest. The opposite is true for Spain, that represents the only country in the upper right corner, combining both high levels of overeducation and a high likelihood of underutilization of skills.

We analysed a unique and very rich data set to provide some answers to questions that were raised more than a decade ago but remained largely unanswered due to data limitations. This article is a first attempt to tackle this issue, but many questions remain. Due to its cross-sectional nature, the PIAAC data do not easily allow to derive causal explanations for the relations between education, mismatches, and skills. As previous research has shown, overeducation may also lead to cognitive decline, thus reversing the relation between skills and overeducation (Grip *et al.*, 2008). We need to look for proper indications in the data to explore these causalities. It is also important to explore how these mechanisms work for part-time employees. Most of the work on educational mismatches has been done for full-time working men and it is not obvious whether the same underlying mechanisms are at stake for part-time workers in general and female part-timers in particular. Although the robustness check in this analysis showed that the relations for full-time working women are not different, we still need to explore how mismatch works out for part-timers. Future research should explore this further.

Supplementary material

Supplementary material (the Appendix) is available online at the OUP website.

Acknowledgements

The authors thank Lex Borghans, Didier Fouarge, the participants of the 2014 ISA RC28 Spring meeting in Budapest, and the editor and anonymous reviewers for their valuable comments.

Funding

Programme Council for Fundamental Scientific Education Research of the Netherlands Initiative for Education Research (411-10-920 to RvdV).

References

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

Blau, F.D. and Kahn, L.M. (2005) Do cognitive test scores explain higher U.S. wage inequality? *Review of Economics and Statistics*, **87**, 184–93.

Chiswick, B.R. (1978) The effect of Americanization on the earnings of foreign-born men, *Journal of Political Economy*, **86**, 897–921.

Chiswick, B.R. and Miller, P.W. (2008) Why is the payoff to schooling smaller for immigrants? *Labour Economics*, **15**, 1317–40.

Dekker, R., De Grip, A., and Heijke, H. (2002) The effects of training and overeducation on career mobility in a segmented labour market, *International Journal of Manpower*, **23**, 106–25.

Denny, K., Harmon, C., and O'Sullivan, V. (2004) Education, earnings and skills: a multi-country comparison, IFS Working Papers W04/08. Institute for Fiscal Studies, London.

Duncan, G. and Hoffman, S.D. (1981) The incidence and wage effects of overeducation, *Economics of Education Review*, **1**, 75–86.

Fasih, T., Kingdon, G., Patrinos, H.A., Sakellariou, C., and Soderbom, M. (2012) Heterogeneous returns to education in the labor market, Policy Research Working Paper Series 6170. World Bank, Washington, DC.

García-Serrano, C. and Malo-Ocaña, M. (1996) Educational mismatch and internal labour markets: is there any relationship?, ISER Working Paper no. 1996-16. University of Essex.

Green, F. and McIntosh, S. (2007) Is there a genuine under-utilization of skills amongst the overqualified? *Applied Economics*, **39**, 427–39.

Green, F., McIntosh, S., and Vignoles, A. (2002) The utilization of education and skills: evidence from britain, *Manchester School*, **70**, 792–811.

Grip, A. de, Bosma, H., Willems, D., and van Boxtel, M. (2008) Job-worker mismatch and cognitive decline, *Oxford Economic Papers*, **60**, 237–54.

Groot, W. and Maassen van den Brink, H. (2000) Overeducation in the labour market, a meta-analysis, *Economics of Education Review*, **19**, 149–58.

Hanushek, E. and Woessmann, L. (2011) The economics of international differences in educational achievement, in E. Hanushek, S. Machin, and L. Woessmann (eds) *Handbook of the Economics of Education*, vol. 3, North-Holland, Amsterdam.

Hanushek, E. and Zhang, L. (2006) Quality consistent estimates of international returns to skill, NBER Working Paper 12664, NBER, Cambridge, MA.

Hanushek, E., Schwerdt, G., Wiederhold, S., and Woessmann, L. (2013) Returns to skills around the world: evidence from PIAAC, OECD Education Working Papers No. 101. OECD, Paris.

Hartog, J. (1977) On the multicapability theory of income distribution, *European Economic Review*, **10**, 157–71.

Hartog, J. (2000) Overeducation and earnings: where are we, where should we go? *Economics of Education Review*, **19**, 131–47.

Hartog, J. and Oosterbeek, H. (1988) Education, allocation and earnings in the Netherlands: overschooling? *Economics of Education Review*, **7**, 185–94.

Hersch, J. (1991) Education match and job match, *Review of Economics and Statistics*, **73**, 140–44.

McGuinness, S. (2006) Overeducation in the labour market, *Journal of Economic Surveys*, **20**, 387–418.

Mincer, J. (1974) *Schooling, Experience, and Earnings*, NBER Press, New York.

OECD (2013a) *Skills Outlook: First Results from the OECD Survey of Adult Skills* (Volume 1), OECD Publishing, Paris.

OECD (2013b) *Technical Report of the OECD Survey of Adult Skills (PIAAC)*, OECD Publishing, Paris.

Patrinos, H.A., Ridao-Cano, C., and Sakellariou, C. (2006) Estimating the returns to education: accounting for heterogeneity in ability, Policy Research Working Paper Series 4040. World Bank, Washington, DC.

Quintini, G. (2011) Over-qualified or under-skilled: a review of existing literature, OECD Social, Employment and Migration Working Papers No. 121. OECD, Paris.

Sattinger, M. (1993) Assignment models of the distribution of earnings, *Journal of Economic Literature*, **31**, 851–80.

Sattinger, M. (2012) Qualitative mismatches, *Foundations and Trends in Microeconomics*, **8**, 1–168.

Schneider, S. (2009) Confusing credentials: the cross-nationally comparable measurement of educational attainment, Ph.D. Thesis, University of Oxford.

Sicherman, N. (1991) Overeducation in the labour market, *Journal of Labour Economics*, **9**, 101–22.

Sloane, P. (2003) Much ado about nothing? What does the overeducation literature really tell us? in F. Büchel, A. de Grip, and A. Mertens (eds) *Over-Education in Europe: Current Issues in Theory and Policy*, Edward Elgar, Cheltenham.

Sloane, P.J., Battu, H.B., and Seaman, P. (1999) Overeducation, undereducation and the Britisch labour market, *Applied Economics*, **31**, 1437–53.

Spence, M. (1973) Job market signalling, *Quarterly Journal of Economics*, **87**, 355–74.

Venn, D. (2009) Legislation, collective bargaining and enforcement. Updating the OECD employment protection endicators, OECD Social, Employment and Migration Working Papers 99. OECD, Paris.