Education Economics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cede20

The over-education wage penalty among PhD holders: a European perspective

Loredana Cultrera, François Rycx, Giulia Santosuosso & Guillaume Vermeylen

To cite this article: Loredana Cultrera, François Rycx, Giulia Santosuosso & Guillaume Vermeylen (06 Nov 2023): The over-education wage penalty among PhD holders: a European perspective, Education Economics, DOI: 10.1080/09645292.2023.2277120

To link to this article: https://doi.org/10.1080/09645292.2023.2277120

Published online: 06 Nov 2023.

EDUCATION ECONOMICS
https://doi.org/10.1080/09645292.2023.2277120

The over-education wage penalty among PhD holders: a European perspective

Loredana Cultrera [a], François Rycx [b,c,d,e], Giulia Santosuosso [f] and Guillaume Vermeylen [g]

[a]Université de Mons (Soci&ter and Risk), Mons, Belgium; [b]Université Libre de Bruxelles (Dulbea and Cebrig), Bruxelles, Belgium; [c]Université de Mons (Soci&ter), Mons, Belgium; [d]Université catholique de Louvain (IRES), Louvain, Belgium; [e]GLO and IZA, Germany; [f]Université libre de Bruxelles and E.CA Economics, Brussels, Belgium; [g]Université de Mons (Soci&ter), DULBEA and CEBRIG, Mons, Belgium

ABSTRACT

Using a unique pan-European dataset, we rely on two alternative measures of over-education and control stepwise for four groups of covariates in order to interpret the over-education wage penalty in light of theoretical models. Firstly, it appears that a significant fraction (i.e. between 1/5 and 1/3) of PhD holders in Europe are genuinely over-educated. Secondly, these genuinely over-educated PhD holders are found to face a substantial wage penalty (ranging from 15 to almost 30%) with respect to their well-matched counterparts. Finally, unconditional quantile regressions highlight that the over-education wage penalty among PhD holders increases greatly along the wage distribution.

ARTICLE HISTORY
Received 9 September 2022
Accepted 25 October 2023

KEYWORDS
Phd graduates; over-education; over-skilling; job satisfaction; wages; Europe

JEL CODES
J21; J24

1. Introduction

Doctoral education is at the heart of the innovation process and a key driver of economic growth (Bansak, Bender, and Coon 2021; OECD 2016). Through research, doctoral graduates produce the most advanced scientific knowledge, which is then used by companies to boost their production capacity. However, policymakers and public organisations also benefit greatly. Indeed, the dissemination of scientific insights goes far beyond the private sphere of the economy (Alfano, Geata, and Pinto 2021; Marini 2021). As a result, the strategic role of PhD holders is recognised in the promotion of a learning society and the expansion of the so-called 'knowledge economy' (Di Paolo and Mañé 2013; Ermini, Papi, and Scaturro 2017).

In recognition of this crucial function, many countries have started to reform their PhD programmes, resulting in a widespread increase in the number of PhD students, well above the demand for academic positions (Cruz-Castro and Sanz-Menéndez 2005; Cyranoski et al. 2011; Stiglitz and Greenwald 2014). Recent studies attest to this trend, showing, for example, that the number of new doctoral students in OECD countries almost doubled between 1998 and 2017 (from around 140,000 to almost 276,000 on an annual basis), and that the number of PhD graduates increased by 25% over the period 2014–2019 (OECD 2021). Moreover, while in the OECD around 1% of 25–64 year-olds had a doctorate in 2019, if current trends continue, according to the OECD (2019) this proportion could more than double in the decades to come.[1]

In comparison, it seems that research-related activities, which provide most of the traditional jobs held by doctorate holders, are progressing at a much slower rate (Sarrico 2022). It is therefore to be

CONTACT Guillaume Vermeylen Guillaume.vermeylen@umons.ac.be

feared that research-related activities do not develop fast enough to provide enough well-suited jobs for the many new PhD graduates (Hnatkova et al. 2022). Furthermore, according to the European Commission, the risk is that many new PhD holders 'are mostly prepared for a career in academia, whereas the need is for many of them to work in other sectors' (European Commission 2021, 50). In short, the increase in the number of doctoral degrees raises concerns about the employability of new doctorate graduates and, in particular, the availability of a sufficient number of suitable jobs enabling them to make full use of their skills.

The results of the survey on the Careers of Doctorate Holders (CDH) show that in 2006 a significant proportion (up to 30%) of doctoral recipients (who graduated between 1996 and 2006) in OECD countries were employed in jobs unrelated to their doctorate, or below their level of qualification. The study by Boman et al. (2021), based on a career survey of doctorate holders who graduated from nine European universities between 2006 and 2020, comes to an even stronger conclusion, namely that almost half of PhD graduates work in jobs that do not require a doctorate. The phenomenon of over-education among doctoral graduates, i.e. the situation where a doctorate holder has a higher level of education than that required for her/his job, has thus become widespread (Bender and Heywood 2009; 2011; Boman et al. 2017; Ermini, Papi, and Scaturro 2017; Gaeta, Lavadera, and Pastore 2022; Waaijer et al. 2016) and could even, given current trends (described above), continue to grow in the years to come.

At the economy-wide level, this situation is worrying because it leads to the under-utilisation of the productive capacities of PhDs (Schwabe 2011). Moreover, given the importance of doctoral graduates for economic development, but also the high cost of doctoral education and the large share of public funding that doctoral graduates receive, the efficiency loss due to mismatched PhD holders is probably higher than that for other educational groups (Gaeta 2015).

From the individual's point of view, the doctorate is expected to generate significant private returns such as better career opportunities, increased work satisfaction and higher pay. However, for PhDs who end up in jobs for which they are over-educated, the disappointment is likely to be considerable.[2] A large literature indeed shows that over-educated workers earn overall significantly less than their former classmates employed in jobs matching their education (Bender and Roche 2018; Dolton and Silles 2008; Leuven and Oosterbeek 2011). Yet, evidence on the specific wage penalty faced by over-educated PhDs is surprisingly scarce. In other words, little is known on the wage differential between over-educated PhD graduates and their well-matched counterparts (Bender and Heywood 2009; 2011; Canal Domínguez and Rodríguez Gutiérrez 2013; Caroleo and Pastore 2018; Gaeta, Lavadera, and Pastore 2017; 2022). This article aims to fill this gap. Specifically, we contribute to the existing literature, not only by measuring the incidence of over-educated PhD holders in the European Union, but also by estimating their wage penalty relative to what they could have earned in a job corresponding to their level of education. As far as we know, our study is one of the very few to address this issue in a cross-country perspective and the first to focus on all EU-27 Member States plus the UK.

To do this, we take advantage of access to a unique pan-European dataset, the European Skills and Jobs (ESJ) survey, a survey that was specifically conducted by CEDEFOP (2014) to collect detailed information on educational and skills mismatches in all EU-28 Member States (i.e. the current EU-27 countries plus the UK) and to enable a better understanding of the extent, determinants and consequences of these phenomena. In practice, we estimate wage equations according to the specification developed by Verdugo and Verdugo (1989), including a wide range of control variables (i.e. socio-demographic characteristics, skills needed for the job, other job-specific characteristics and employment expectations) step by step in order to interpret the wage penalty associated with over-education in light of the underlying theoretical models. This approach, combined with our rich set of covariates – which, among other things, allows us to account for a potential ability bias that could arise from an unobserved ability factor that would be correlated with both over-education and earnings – is a significant improvement over previous studies. The robustness of our results is also assessed through the use of two alternative measures of over-education.

Furthermore, we add to the existing literature by examining the interaction effects between over-education and over-skilling on the one hand, and between over-education and job satisfaction on the other. Since over-educated workers or not necessarily over-skilled (and vice versa), we first investigate whether and how the over-education wage penalty depends on the interaction between these two variables. Second, we also examine the moderating role of job satisfaction. The intuition is that over-educated PhD holders might have chosen (or at least accepted) to be over-educated in order to improve other aspects of their job, such as employment security, commuting time or work-life balance. Put differently, as Gaeta, Lavadera, and Pastore (2022) point out, the interaction with job satisfaction provides information on whether or not holding a job that does not require the acquired level of education represents a 'voluntary' status.[3] We expect the wage penalty of over-education to be the greatest among over-educated PhD holders who are over-skilled and/or dissatisfied with their jobs. Finally, we rely on the unconditional quantile regression (UQR) method, developed by Firpo, Fortin, and Lemieux (2009), to examine how the wage penalty evolves along the wage distribution. Put differently, we aim to assess whether the over-education wage penalty is more pronounced for low- or high-wage PhD graduates. To our knowledge, evidence on this issue is quite scarce for higher education graduates in general (Bender and Roche 2018), and even more so for PhDs (Gaeta, Lavadera, and Pastore 2017).

The remainder of this paper is organised as follows. Section 2 describes the wage consequences of over-education according to the main theoretical models (models whose hypotheses validity will be tested – to some extent – as part of our empirical analysis) and reviews the empirical results on the wage penalty of over-education among doctoral graduates. Our methodology, data set and descriptive statistics are described in sections 3 and 4. Econometric results are presented in section 5. The last section concludes.

2. Literature review

2.1. Theoretical background

In Becker's (1962) human capital theory, over-education is interpreted as a temporary mismatch between the human capital of workers and the technology of firms (Leuven and Oosterbeek 2011). In the longer term, over-education is seen as a statistical artefact consequent to omitted variable problems when the measurement of earnings and human capital accumulation is imperfect (McGuinness 2006). Put differently, the wage penalty associated with over-education would simply result from the fact that workers with higher degrees than those required for their jobs have less human capital overall (e.g. less work experience) than their properly matched counterparts. According to Becker's theory, obtaining a doctorate is therefore a rational investment to acquire additional skills and ultimately a higher salary.

Thurow's (1979) job competition theory sees over-education as a permanent phenomenon in the economy where there is over-investment in education and individuals have to defend their position in the job distribution queue. In the case of demand rigidity and poor job prospects for highly educated individuals, they are more likely to accept jobs for which they are over-skilled and to over-invest in education in order to strengthen their position in the labour market. According to this model, only job characteristics influence earnings.

Sattinger's (1993) assignment theory can be described as an intermediate explanation between the human capital and job competition theories, in which the characteristics of workers and the characteristics of the jobs available in the economy can explain labour mismatch. In the job allocation process, workers prefer some jobs to others when they maximise their utility, while wages are determined by a hedonic price equation that takes into account both job and worker characteristics.

Sicherman and Galor's (1990) occupational mobility theory argues that workers end up being over-educated because they try to acquire the right amount of work experience and skills in

order to improve future levels of mobility and income (Mavromaras et al. 2013). In other words, over-education is supposed to be a short-term phenomenon for the individual but a constant feature of the economy (Rubb 2003).

Finally, Jovanovic (1979), in his job search theory, describes the phenomenon of over-education as a consequence of the individual's lack of information and her/his need for time to find the right job. In addition, mismatch can also be voluntary (Mavromaras et al. 2013) and result from workers choosing to compensate for lower pay with other intrinsic aspects of the job that increase satisfaction, for example job security or work-life balance (Mavromaras et al. 2013).

By controlling stepwise for four groups of covariates (i.e. socio-demographic characteristics, skills needed for the job, other job-specific characteristics and employment expectations), our econometric analysis in Section 5 aims to test (at least in part) the validity of the theoretical assumptions of these different models to explain the wage penalty associated with over-education among PhD graduates.

2.2. Empirical findings

While the literature on the incidence and wage effects of over-education is substantial (Bender and Roche 2018; Cultrera et al. 2022; da Silva Marioni 2021; Davia, McGuinness, and Connell (2017); Eguia, Rodiguez Gonzalez, and Serrano 2023; Jacobs, Rycx, and Volral 2022; 2023; Leuven and Oosterbeek 2011; McGuinness, Pouliakas, and Redmond 2018a; McGuinness, Bergin, and Whelan 2018b; Verhaest and van der Velden 2013), specific results for doctoral graduates are surprisingly scarce. The main reason for this is probably that it is often quite difficult to obtain sufficiently comprehensive databases to study this issue in depth for doctoral graduates. As a result, only a limited number of studies provide empirical results on this issue, most often with data for a single country.

Bender and Heywood (2009) analysed the impact of over-education on wages of doctorates in science using US cross-sectional data. They estimated earnings equations and found that mismatch is associated with lower wages, decreased job satisfaction and a higher rate of turnover. Specifically, they found that doctoral graduates having a job not related to their PhD suffer a greater wage penalty in the academic sector (between −7.2 and −14.8% depending on the extent of the mismatch) than outside (between −4.8 and −10.3%). In terms of incidence, their estimates show that 16.5% of doctoral graduates working in the academic sector report some degree of mismatch, compared with 43.6% outside academia. In a more recent study, Bender and Heywood (2011) used a panel dataset of scientists in the US to provide estimates of the over-education wage penalty by field of study and at different career stages. Their fixed effects estimates show that the penalty is more pronounced for PhD holder workers in the hard and social sciences, as well as for those in the later stages of their careers.

The results of Canal Domínguez and Rodríguez Gutiérrez (2013) confirm that being over-educated leads to a wage penalty for Spanish PhDs. They estimated wage differentials by field of study and occupation using Heckman's (1979) correction method for self-selection problems alongside the Oaxaca (1973) and Blinder (1973) decomposition technique. Overall, they found that doctoral graduates in non-academic jobs requiring doctoral or post-doctoral training earned more than doctoral graduates in non-academic jobs requiring only professional training. Specifically, their results suggest that, all other things being equal, doctorate holders suffer a wage penalty of between 18 and 25% compared to matched doctorate holders. Di Paolo and Mañé (2016) examined the situation of doctoral graduates in Catalonia, considering not only over-education but also over-skilling as measures of mismatch. They estimated an extended wage equation according to a labour market view based on assignment theory, in which both the human capital of workers and the characteristics of jobs determine pay. Applying a bivariate probit estimator to seemingly unrelated regressions (SUR), they find a wage penalty that peaks at about 12% when PhD holders are both over-educated and over-skilled.

Gaeta, Lavadera, and Pastore (2017) studied the wage penalty associated with over-education among doctoral graduates in Italy using cross-sectional data for 2009. In essence, the authors

show that the wage penalty incurred by over-educated PhD holders is around 11% but that this penalty is significantly higher among doctoral graduates who are genuinely over-educated (i.e. either over-educated and over-skilled or over-educated and dissatisfied with their job). In a more recent paper, Gaeta, Lavadera, and Pastore (2022) used Italian cross-sectional data for 2009 to measure, through a recentered influence function (RIF), the effect of over-education at different points of the conditional wage distribution, as well as by field of study and sector of employment of doctorate holders. Overall, they report an over-education wage penalty of −13.7% for PhD holders employed in the academic sector (e.g. technicians working in laboratories, administrative staff, teaching positions that do not involve holding a PhD), while outside academia they find a penalty of −9.9% for those involved in non-R&D activities, and zero (i.e. an insignificant penalty) for those carrying out R&D tasks. However, the authors also show that the incidence of over-education among PhD holders is almost ten times lower in the academic sector than outside academia (3.7 vs. 35%). This finding is not surprising insofar as, with a few exceptions (e.g. administrative and technical jobs), jobs in academia are expected to require a doctorate.[4] Finally, Gaeta, Lavadera, and Pastore (2022) show that the over-education wage gap is very heterogeneous along the wage distribution and particularly high in the middle and upper part of the wage distribution, which seems to be consistent with the glass ceiling hypothesis.

3. Methodology

3.1. Measuring over-education and its impact on wages

Over-education is typically measured by comparing the level of education attained by workers with the level of education required for the job they hold. Three methods co-exist in the literature to measure the level of required education for a job (Hartog 2000; Verhaest and Omey 2010). These are respectively the job analysis (JA), the realised matches (RM) and the worker self-assessment (WA) methods.

So far, there has not been any single perfect indicator, as each measurement method has its advantages and shortcomings. The choice of one method over another is therefore mainly driven by data availability (Leuven and Oosterbeek 2011). Given the feature of ours, we use the WA method in this paper. The workers in our dataset were asked to self-assess the level of education needed *to do* as well as *to get* their job.[5] By comparing these levels of education with the highest level of education attained by each worker, we can then determine (based on each criteria separately, i.e. either the educational level *to do* or *to get* the job) whether respondents are working above their own level of education (see section 4.1 for more details).[6]

To estimate the effect of over-education on the wages of doctorate holders in Europe, we rely on the dummy specification (or VV specification) developed by Verdugo and Verdugo (1989) which improves the traditional Mincer wage equation by distinguishing between the educational level of workers and the educational requirements of the job. Accordingly, our benchmark equation is formulated as follows:

$$lnW_i = \gamma_0 + \gamma_1 OE_i + \gamma_2 UE_i + \gamma_3 X_i + u_i \quad (1)$$

where:

lnW_i denotes the logarithm of the gross hourly wage of worker i ;[7]

OE_i is a dummy variable taking the value 1 if the worker is over-educated, and 0 otherwise;

UE_i is a dummy variable taking the value 1 if the worker is under-educated, and 0 otherwise;[8]

X_i is a vector containing a set of detailed covariates that have been divided in four groups:

(i) Socio-demographic characteristics, which aim to take into account human capital theory arguments (Becker 1962). These characteristics include dummies regarding the PhD field of study

(teacher training and education sciences; humanities, languages and arts; economics, business, law and finance; other social sciences; natural sciences; mathematics and statistics; computing sciences; engineering sciences; agriculture and veterinary sciences; medicine and health-related sciences; security, transport or personal services); worker's age (in level and squared); worker's years of tenure (in level and squared); dummies defining the previous labour market status of the worker (i.e. in education or training, employed, unemployed, other e.g. child care, disability); dummies for participation in training courses in the last 12 months (i.e. courses attended during working hours, outside working hours, while performing the regular job); a dummy variable for gender (1 for men, 0 otherwise); and dummies specifying the living conditions of the individual (i.e. living alone, with parents, with partner, with children).

(ii) & (iii) Skills needed to do the job and other job-specific characteristics, which are intended to take account of arguments relating to the job competition model (Thurow 1979) and the assignment theory (Sattinger 1993). The characteristics of the skills needed to do the job include 5 dummy variables identifying whether the level of literacy, numeracy and ICT skills required for doing the job are basic, moderate or advanced respectively.[9] The job-specific characteristics comprise dummies for the type of employment contract (i.e. temporary/fixed-term, indefinite/permanent, no formal contract); dummies for the characteristics that the job involves, i.e. learning new things during daily work, choosing the way in which to do the work (autonomy), team working and responding to non-routine situations in daily work; a dummy equal to one if the individual has been promoted to a higher position since working for the current employer; dummies for the sectors of activity (i.e. science and engineering; health; teaching; business and administration; ICT; legal, social and cultural industries); a dummy equal to one if the employee works in the private sector; a dummy equal to one if the company has more than one workplace; and dummies for the size of the firm (i.e. number of full-time equivalent employees being 1–9, 10–49, 50–99, 100–249, 250–499, 500 and more).

(iv) Variables related to employment expectations (i.e. what workers were looking for in their jobs), which aim to capture the importance of the arguments put forward by theories of occupational mobility (Sicherman and Galor 1990) and job search (Jovanovic 1979). These variables indicate respectively whether the responds wanted: i) their job to suit their qualifications and skills, ii) to gain some work experience, iii) a job providing security, iv) a job offering good career progression/career development, v) to work in an company/organization that is well/known in its field, vi) a job with a good pay and package of benefits, vii) a job close to home, viii) an interesting job, and ix) a job with a good work-life balance.[10]

– u_i is the error term.

In Equation (1), γ_1 and γ_2 measure the returns of being over- and under-educated respectively. The level of attained education is controlled for in Equation (1), so that mismatched workers are compared directly to workers with the same level of attained education but in a job for which they are adequately educated. The existing literature suggests that γ_1 should take a negative value, over-educated workers being subject to a penalty compared to their former classmates employed in jobs that match their level of education, meaning that over-educated individuals earn less than their comparably educated counterparts who are well matched (McGuinness 2006).

3.3. Estimation techniques

Equation (1) has been estimated with two different methods: (i) ordinary least squares (OLS), and (ii) the unconditional quantile regression (UQR) approach. The OLS estimator, with heteroscedasticity-consistent standard errors, is based on the cross-section variability between workers in our sample.

OLS estimates may suffer from an omitted variable bias. This bias could arise in the presence of an unobserved ability factor that is correlated with both over-education and earnings. In other words, the omission of unobserved ability may overstate the pay penalty for the over-educated status

(Verhaest and Omey 2010). Among the different strategies adopted in the literature to address this issue, the inclusion of more precise control variables for the quality of workers' human capital (Kleibrink 2016) is the one chosen in this paper. More precisely, we include a large set of covariates that capture the heterogeneity of workers' abilities and expectations (cf. groups 1 and 4 of the control variables discussed above). We expect the OLS regression coefficient associated with the over-education dummy variable to decrease (in absolute value) when these covariates are included (Gaeta, Lavadera, and Pastore 2017).

Second, since we rely on the worker self-assessment (WA) approach to measure over-education, and workers tend to overestimate their likelihood of being over-educated, our estimates may suffer from a measurement error bias. Evidence suggests that this bias generally under-estimates the true wage penalty associated with over-education (Dolton and Silles 2008). Indeed, the wage penalty associated with over-education is expected to decrease (in absolute value) as more individuals believe to be over-educated when they are not (Caroleo and Pastore 2018). Therefore, the results presented in this paper should be interpreted with caution, bearing in mind that they are likely to be lower bound estimates, i.e. the true wage penalty for over-education is likely to be higher (Verhaest and Omey 2010).

Another limitation of the OLS estimator is that it only estimates the over-education wage penalty at the mean value of the dependent variable. However, the penalty is likely to be heterogeneous and to vary along the wage distribution (Bender and Roche 2018). To examine this issue, we re-estimated Equation (1) using the unconditional quantile regression (UQR) approach developed by Firpo, Fortin, and Lemieux (2009).

4. Data set and computation of mismatch variables

In spring 2014, the European Center for the Development of Vocational Training (CEDEFOP), commissioned Ipsos to carry out the first pan-European survey on skills mismatch. This European Skills and Jobs (ESJ) survey, at the basis of our analysis, was conducted by telephone and online on 48,676 employees aged between 24 and 65 in the 27 European Union Member States and the UK. It aims at assessing the extent to which respondents' qualifications and skills correspond to the level required to do their job. The survey has the advantage of providing a large number of educational and skill mismatch indicators. Another distinctive feature is the variety of moderating and/or control variables that can be included, thus improving the relevance and accuracy of the analysis.[11]

The analyses conducted in this article face some restrictions relating to the data. As this analysis focuses on European doctorate holders, only individuals with an educational level corresponding to ISCED 1997 level 8 (tertiary education-advanced level) were considered, representing 2,869 observations. The wage variable has been constructed from the following question: 'On average, how much is your gross monthly earnings from your job (before deductions or credits of tax and national insurance)?'. A significant portion of answers was missing (27.57%) because some individuals (i.e. 791 workers) either did not know their wage or refused to communicate it, and were therefore dropped from the sample. Furthermore, in order to analyse the relation between over-education and workers' wages, jobless individuals, consisting in a small portion of the initial sample (0.87% or 25 individuals), were dropped.[12] Our final sample is therefore made of 2,053 workers holding a PhD. Table A1 in the Appendix presents the descriptive statistics of our main regressors and selected covariates before and after restricting our sample to only those workers for whom wage information is available. It is interesting to note that the descriptive statistics remain fairly stable after applying this restriction.

4.1. Computing the main variables of interest

In order to measure over-education, two questions in our data set have been compared, namely: 'What are the educational qualifications, if any, that someone actually needs *to do* your job today?' and 'What is the highest level of education or training that you have completed?'. A worker was then classified as over-educated for her/his job if her/his level of education was

higher than that required *to do* the job. In the context of this research, and given the fact that all workers in the data hold a PhD degree, a worker was automatically considered over-educated (dummy variable equal to one) if her/his job did not require a doctorate qualification. According to this approach, 79% of the workers in our sample declared to be over-educated (see Appendix Table A2 for a presentation of the main descriptive statistics).[13,14,15]

As mentioned earlier, the WA method of measuring over-education is subjective and may therefore lead to over-estimation by respondents, which is possibly to be the case here as the portion of over-educated workers in our sample is quite large. Therefore, as a robustness test, an alternative measure of over-education has been used, namely over-education in order *to get* the job the individual currently holds. Specifically, to classify a worker as over-educated or not, we compared the following questions: 'What are the educational qualifications, if any, that someone actually needs *to get* your job today?' and 'What is the highest level of education or training that you have completed?'. A worker is then classified as over-educated for her/his job if her/his level of education is higher than that required *to get* the job. Following this alternative approach, 76% of workers in our sample stated that the doctorate was not useful for obtaining their current job.

As over-education usually comes with over-skilling, another measure of mismatch has been considered, namely the situation in which a worker feels that she/he makes little use of her/his past experience, skills and abilities in her/his current job (Chevalier 2003). In this paper, the measure of over-skilling is based on individuals' responses to the following question:

'Overall, how would you best describe your skills in relation to what is required to do your job?', with possible answers being 'My skills are higher than required by my job', 'My skills are matched to what is required by my job', and 'Some of my skills are lower than what is required by my job and need to be further developed'. Based on the answers to this question, it appears that 42.5% of the workers in the sample are over-skilled.

Another interesting variable is job satisfaction. Indeed, as suggested by Gaeta, Lavadera, and Pastore (2017), the interaction between over-education and job satisfaction makes it possible to distinguish between people who have voluntarily chosen to work in a job for which they are over-educated (or at least are satisfied with it) and those for whom this situation is clearly undesirable and unsatisfying. Therefore, a variable measuring the worker's satisfaction with her/his current job (which we will later interact with over-education) was constructed by considering the answer to the following question: 'On a scale from 0 to 10, where 0 means very dissatisfied, 5 means neither satisfied nor dissatisfied and 10 means very satisfied, how satisfied are you with your job?'. The satisfaction variable consists of a dummy that takes the value of 1 when the individual is satisfied with her/his job, 0 otherwise, and the individual is considered satisfied when her/his response takes values from 6 to 10. Based on this definition, 21% of the individuals in our sample are dissatisfied with their current job.

4.2. Interaction effects

An important part of our empirical analysis focuses on interaction effects. More specifically, we first considered the interaction between over-education and over-skilling. Following Mavromaras et al. (2013), Pecoraro (2014) and Di Paolo and Mañé (2016), four alternative situations have been considered: (1.i) genuine matching, which occurs when respondents report being neither over-educated nor over-skilled, (1.ii) apparent matching, which occurs when respondents report being over-skilled but not over-educated, (1.iii) apparent over-education, which occurs when respondents report being over-educated but not over-skilled, and (1.iv) genuine over-education, which occurs when respondents report being both over-educated and over-skilled. Looking at the data, it appears that 43% of PhD holders are over-educated but not over-skilled (i.e. apparently over-educated), while 36% declared to be both over-educated and over-skilled (i.e. genuinely over-educated). Only 7% of those who are not over-educated are over-skilled (i.e. apparently matched).

We also examined the interaction between over-education and workers' job satisfaction. Following Chevalier (2003), four alternative situations can be considered: (2.i) genuine matching, which

occurs when the doctorate holder is not over-educated and satisfied with her/his current job, (2.ii) apparent matching, which occurs when the PhD holder is not over-educated but dissatisfied with her/his job, (2.iii) apparent over-education, which occurs when the PhD holder is over-educated but satisfied with her/his job, and finally (2.iv) genuine over-education, which occurs when the PhD holder is both over-educated and unsatisfied with her/his job. In our sample, we find that 61% of PhD holders are overeducated but satisfied with their current job (i.e. apparently overeducated), while 18% report being both overeducated and dissatisfied with their current job (i.e. genuinely overeducated). Complementary descriptive statistics are provided in Appendix Table A2.

5. Econometric results

5.1. Stepwise OLS analysis

In order to analyse the relationship between over-education and wages, we first estimated Equation (1) by OLS. The dependent variable is the natural logarithm of the gross hourly wage. The over-education variable (OE_i) is a dummy that equals 1 when the individual is considered to be over-educated and its coefficient (γ_1) will be interpreted as a *ceteris paribus* correlation. Therefore, a negative relationship between the dependent variable and the variable of interest is expected, which means that being over-educated should be correlated with lower wages. To strengthen the robustness of our results, all regressions were run with two alternative definitions of over-education: one considering the educational qualification needed *to do* the job, the other based on the educational qualification needed *to get* the job (see section 4.1 for more details). Following McGuinness and Pouliakas (2017), four groups of covariates were included step-by-step in order determine how and to what extent the over-education wage penalty can be attributed to either human capital (i.e. socio-demographic) characteristics, specific skills needed to do the job, other job characteristics, and compensating job attributes.

The OLS estimates, with heteroscedasticity-consistent standard errors, are presented in Table 1. The results in columns (1) and (1′) show the effects of over-education on workers' wages using either measure of over-education while controlling only for country fixed effects.[16] As expected, regardless of the indicator of over-education used, we find that the regression coefficient associated with over-education is significant and negative. Specifically, in both cases, estimates indicate that the wage penalty for over-educated PhD holders is about 25% compared to their well-matched former classmates. Our results therefore suggest that over-educated PhDs could earn about a quarter more if they worked in jobs where their doctoral degree was required.

Columns (2) and (2′) of Table 1 show how differences in socio-demographic characteristics (e.g. PhD field of study, age, tenure, labour market status before the current job, participation in training courses in last 12 months)[17] contribute to the explanation of this wage penalty. For both over-education indicators, we find that the over-education wage penalty is reduced by almost one-third, from about 25% to slightly less than 17% after the inclusion of these covariates. Therefore, a significant fraction of the gross wage penalty of over-educated PhD holders appears to derive from their less favourable (i.e. rewarding) human capital attributes. That said, in light of the large residual wage penalty, other explanations deserve to be explored. In line with previous studies (e.g. Di Paolo and Mañé (2014) and Gaeta, Lavadera, and Pastore (2017; 2022), our results indeed suggest that arguments put forward by human capital theory (Becker 1962) only partially explain the wage gap between over-educated and well-matched PhDs.

Columns (3) and (3′) of Table 1 include additional controls respectively for the level of numeracy, literacy and ICT skills needed to do the job. In doing so, we test the hypothesis that part of the over-education wage penalty results from the fact that over-educated PhDs hold jobs with lower average requirements than those associated with jobs held by well-matched PhDs. Following the inclusion of these covariates, we find that the over-education wage penalty decreases by approximately 1.5% points to around 15% percent. Our results thus confirm the hypothesis under investigation.

Table 1. Stepwise OLS estimates.

Dependant variable: log of hourly wage	(1)	(1′)	(2)	(2′)	(3)	(3′)	(4)	(4′)	(5)	(5′)
Over-education	−0.249***		−0.167***		−0.152**		−0.142**		−0.135**	
to do the job	(−4.21)		(0.06)		(0.06)		(0.06)		(0.06)	
Over-education		−0.246***		−0.165***		−0.150**		−0.139**		−0.131**
to get the job		(−4.16)		(0.06)		(0.06)		(0.06)		(0.06)
Control variables:[a]										
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Socio-demographic characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Skills needed to do the job	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Other job-specific characteristics	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Employment expectations	No	No	No	No	No	No	No	No	Yes	Yes
Number of observations	2,053	2,053	2,053	2,053	2,053	2,053	2,053	2,053	2,053	2,053
R^2	0.063	0.063	0.112	0.112	0.117	0.117	0.159	0.159	0.163	0.163

Notes: [a]The precise description of the control variables is provided in Section 3.1 and in Appendix Table A2.
Weighted regressions. Robust standard errors are reported between parentheses. ***, **, *: significant at respectively 1%, 5% and 10% levels.

However, differences in the ICT, numeracy and literacy skills required for the jobs held by the over-educated and well-matched PhDs respectively appear to contribute rather modestly to the overall wage gap between them.

To further test the relevance of the arguments put forward by the job competition (Thurow 1979) and assignment (Sattinger 1993) models, we added various other controls for job-specific characteristics (e.g. type of contract, sector of activity, size of the workplace, job complexity, autonomy to do the work, ability to learn new things during daily work, working as part of a team). The results, presented in columns (4) and (4′) of Table 1, show that these characteristics also contribute to explaining the over-education wage penalty. However, their contribution is again relatively limited, as the penalty does not decrease by more than 1% point, to about 14%. Overall, our estimates in columns (3), (3′), (4) and (4′) support the theoretical arguments of the models that attribute a role to job characteristics that would limit the ability of over-educated PhDs to fully exploit their skills, reduce their productivity and thus also their wages. That said, in quantitative terms, our results suggest that the contribution of these arguments amounts to less than 10% of the gross wage penalty associated with over-education (i.e. contributes less than 3 percentage points).

Finally, we added several control variables related to job motives. These variables reflect, among other things, the importance that the worker places on the fact that the job suits his level of qualifications and skills, offers a good career progression and development, provides a good security, is interesting, is close to home, is well paid or allows a good work-life balance. Estimates, presented in columns (5) and (5′) of Table 1, show that job motives matter as the over-education wage penalty decreases further to about 13.5%. However, given that this decrease is less than 1% point, our results suggest that the argument of compensatory job attributes, put forward by career mobility (Sicherman and Galor 1990) and job search (Jovanovic 1979) theories, plays a rather limited role in explaining the over-education wage penalty among PhDs.

In sum, our stepwise OLS analysis reveals that, compared to their well-matched counterparts, over-educated PhDs in European countries suffer a wage penalty of between 25 and 13.5% depending on the specification adopted. This range for our results is in line with the few existing studies on the US, Spain and Italy (see e.g. Bender and Heywood 2009; Canal Domínguez and Rodríguez Gutiérrez 2013; Di Paolo and Mañé 2016; Gaeta, Lavadera, and Pastore 2022).[18,19] Moreover, consistent with these studies, we find that characteristics explain less than half of the unadjusted wage penalty associated with over-education among PhD holders. This result also corroborates the estimates of other studies of all higher education graduates, including Bender and Roche (2018) for the US in 2015.[20]

5.2. The moderating role of over-skilling and job satisfaction

Next, following Mavromaras et al. (2013), we tested the role of two moderating variables, namely over-skilling and job satisfaction, in the relationship between over-education and earnings of PhD holders.

Therefore, we have first re-estimated Equation (1) by distinguishing the following four situations in which PhD holders may find themselves, namely being: (1.i) genuinely matched (i.e. neither over-educated nor over-skilled), (1.ii) apparently matched (i.e. not over-educated but over-skilled), (1.iii) apparently over-educated (i.e. over-educated but not over-skilled), and (1.iv) genuinely over-educated (i.e. over-educated and over-skilled).

The OLS regression using these interaction terms was carried out following the same approach as for the regressions presented so far. For the sake of simplicity and clarity, Table 2 presents only the coefficients for these interaction variables. However, we controlled for exactly the same set of covariates as in Table 1. The regression coefficients for the apparently matched, apparently over-educated and genuinely over-educated are interpreted as the wage penalty faced by these different groups of PhD holders with respect to their genuinely matched counterparts (i.e. the reference category).

Our results first show, in line with earlier results obtained for Italy by Gaeta, Lavadera, and Pastore (2022), that the regression coefficients for apparently matched and apparently over-educated PhD

holders are not statistically significant. Therefore, we cannot reject the hypothesis that these two categories of PhD holders earn similar wages to their genuinely matched counterparts. If we consider PhD holders who are both over-educated and over-skilled, results are very different. Indeed, they show a significant wage penalty of 15,3% compared to genuinely matched PhD holders. As expected, this penalty is higher than the one estimated for over-educated PhDs, using our model *without* interaction effects (see Table 1). However, the differential wage gap does not exceed 2% points (15,3 vs 13,5%).

Next, we examined the moderating role of job satisfaction. To do so, as highlighted in Section 4.2, the four following situations in which PhD holders may find themselves have been considered, namely being: (2.i) genuinely matched (i.e. neither over-educated nor dissatisfied), (2.ii) apparently matched (i.e. not over-educated but dissatisfied), (2.iii) apparently over-educated (i.e. over-educated but not dissatisfied), and (2.iv) genuinely over-educated (i.e. over-educated and dissatisfied). These interaction effects provide some information on the potential voluntary status of over-education. More precisely, these interactions allow us to distinguish between people who have 'voluntarily' chosen to work in a job for which they are over-educated[21] (or at least are satisfied with it) and those for whom this is clearly an undesirable and unsatisfactory situation. Indeed, while some workers may give up a job corresponding to their level education and thus a higher wage in favour of other job characteristics (e.g. greater job security, shorter commuting time or a better work-life balance), for others, holding a job for which they are over-educated is by no means the result of a compensatory strategy that satisfies them (Jovanovic 1979).

The OLS regression results with the interaction variables between over-education and job satisfaction are presented in Table 3. They first show that PhD holders that are apparently matched or apparently over-educated do not experience a wage penalty compared to their genuinely matched counterparts. In contrast, genuinely over-educated PhDs are found to earn 28,1% less than the reference category. Doctoral graduates who are both over-educated and dissatisfied with their jobs therefore earn more than a quarter less than if they were in a job that matches their education and satisfies them. Moreover, we find that the over-education wage penalty (estimated at 13.5% in our specification *without* interaction effects, see Table 1), more than doubles when focusing on those who report being dissatisfied with their jobs.

Table 2. Interaction effects between over-education and over-skilling (to do the job), OLS estimates.

Dependant variable: log of hourly wage	(1)
Genuinely matched (i.e. neither over-educated nor over-skilled)	Reference category
Apparently matched (i.e. not over-educated but over-skilled)	0.17 (0.09)
Apparently over-educated (i.e. over-educated but not over-skilled)	−0.0019 (0.04)
Genuinely over-educated (i.e. over-educated and over-skilled)	−0.153*** (0.06)
Control variables:[a]	
Country fixed effects	Yes
Socio-demographic characteristics	Yes
Skills needed to do the job	Yes
Other job-specific characteristics	Yes
Employment expectations	Yes
Number of observations	2,053

Notes: [a]The precise description of the control variables is provided in Section 3.1 and in Appendix Table A2. Over-education and over-skilling refer to over-education and over-skilling *to do* the job. Weighted regressions. Robust standard errors are reported between parentheses. ***, **, *: significant at respectively 1%, 5% and 10% levels.

Table 3. Interaction effects between over-education and job satisfaction, OLS estimates.

Dependant variable: log of hourly wage	(1)
Genuinely matched (i.e. neither over-educated nor dissatisfied)	Reference category
Apparent matching (i.e. not over-educated but dissatisfied)	0.160 (0.10)
Apparent over-education (i.e. over-educated but not dissatisfied)	0.183 (0.14)
Genuine over-education (i.e. over-educated and dissatisfied)	−0.281*** (0.06)
Control variables:[a]	
Country fixed effects	Yes
Socio-demographic characteristics	Yes
Skills needed to do the job	Yes
Other job-specific characteristics	Yes
Employment expectations	Yes
Number of observations	2,053

Notes: [a]The precise description of the control variables is provided in Section 3.1 and in Appendix Table A2. Over-education refers to over-education *to do* the job. Weighted regressions. Robust standard errors are reported between parentheses. ***, **, *: significant at respectively 1%, 5% and 10% levels.

5.3. Analysis along the wage distribution

Finally, we analysed the heterogeneity of the over-education wage penalty and in particular its evolution along the wage distribution. To do so, we relied on the unconditional quantile regression approach, developed by Firpo, Fortin, and Lemieux (2009), using the same control variables as in Equation (1).

Figure 1 displays the estimates obtained for the over-education variable through a graphical representation where the horizontal axis represents the quantiles of the wage distribution, and the vertical axis represents the estimated over-education wage penalty.[22] Overall, we find that the detrimental effect of over-education on wages is highly heterogeneous throughout the wage

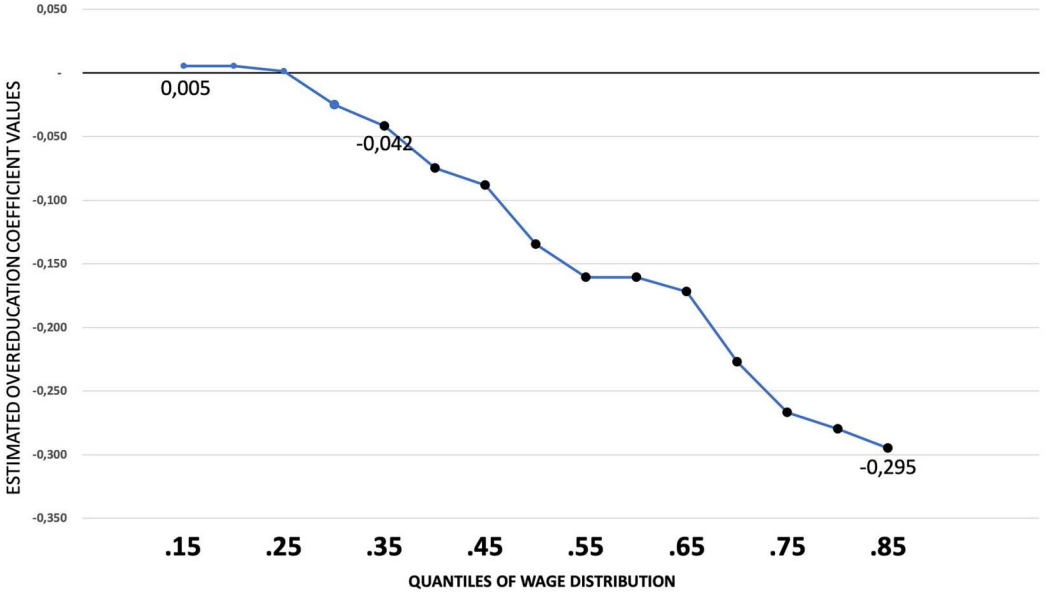

Figure 1. The over-education wage penalty along wage distribution, unconditionnel quantile estimates (Firpo, Fortin, and Lemieux 2009).

Notes: The blue (black) dots on the graph correspond to statistically non-significant (significant) regression coefficients at the 10% probability level. Detailed regression results, not reported here due to space constraints, are available on request.

distribution. More precisely, in the bottom part of the wage distribution, results show that the coefficient of over-education is small, close to zero and statistically non-significant. This suggests that, for low levels of wages, there is no correlation, *ceteris paribus,* between the over-education status of PhD holders and their earnings. The over-education coefficient becomes statistically significant starting from the 35th percentile, with a wage penalty of 4.2%. The coefficient then increases along the wage distribution and reaches the highest value at the 85th percentile. At that level, the over-education wage penalty for a doctorate holder is 29.5%.

To sum up, our results suggest that over-educated PhD graduates face a substantial wage penalty, especially when they are located in the middle-top of the earnings distribution. A similar outcome has been reported by Gaeta, Lavadera, and Pastore (2022) in the Italian context. The absence of a significant wage penalty at the bottom of the wage distribution can be interpreted in the light of the various labour market institutions in Europe (e.g. minimum wages, trade unions, unemployment benefits) that raise and compress the earnings of low-paid workers. As for the higher wage penalty at the middle-top of the distribution, it seems to be consistent with the existence of a glass ceiling, i.e. the fact that over-educated PhDs face invisible but real barriers preventing them from obtaining higher level positions.

6. Discussion

Over the past 15 years, the number of doctoral degrees awarded in European countries has increased very significantly. This has led to growing concerns about the career prospects of doctoral graduates (Gaeta, Lavadera, and Pastore 2022). The growth in the number of PhDs raises challenges when looking for a job in the labour market, especially outside academic institutions (Canal Domínguez and Rodríguez Gutiérrez 2013). Despite research demonstrating the costs associated with excess human capital (i.e. over-education and over-skilling), policies to address the problem are rarely visible, either at national or European level. McGuinness and Pouliakas (2017) suspect that policymakers do not see over-education as highly problematic, but simply as a short-term phenomenon.

While the literature on the incidence and wage effects of over-education is substantial (Bender and Roche 2018; Leuven and Oosterbeek 2011), specific results for doctoral graduates are surprisingly scarce. This paper aims to fill this gap, not only by measuring the prevalence of over-education among PhD holders in Europe (i.e. in EU Member States and the UK), but also by estimating their wage penalty relative to what they could have earned in a job corresponding to their level of education. Using a unique pan-European dataset (CEDEFOP 2014), we rely on two alternative measures of over-education and control stepwise for four groups of covariates (i.e. socio-demographic characteristics, skills needed to do the job, other job-specific characteristics and employment expectations) in order to interpret the over-education wage penalty in light of theoretical models.

Our descriptive statistics first show that while the share of over-educated PhD holders is around 75%, 'only' 42% of PhDs actually appear to be over-skilled. Moreover, we find that 36% of doctoral graduates are both over-educated and over-skilled, and 18% over-educated and dissatisfied with their jobs. Depending on the specification adopted, OLS estimates further indicate that the gross hourly wage penalty associated with over-education amounts to 25%, but decreases to 13.5% after including all covariates. As expected, *ceteris paribus*, our results also show that the wage penalty associated with over-education is higher (at around 15%) for doctoral graduates who are both over-educated and over-skilled, and particularly severe (at around 28%) for those who are both over-educated and dissatisfied with their jobs. Finally, unconditional quantile regressions suggest that over-educated PhD graduates face a substantial wage penalty, specifically when they are located in the middle-top of the earnings distribution. While the absence of a significant wage penalty at the bottom of the wage distribution can be interpreted in the light of the various labour market regulations in Europe that raise and compress the wages of low-paid workers, the higher penalty at the median (around 15%) and especially at the top of the distribution (around 30%) seems consistent with the existence of a glass ceiling.

In summary, the analysis carried out in this article – which should not be interpreted in a causal way – leads to a double conclusion. On the one hand, it appears that a significant fraction (i.e. between 1/5 and 1/3) of PhD holders in Europe are genuinely over-educated (i.e. they are either over-educated and over-skilled, or over-educated and dissatisfied with their jobs). On the other hand, these genuinely over-educated PhD holders are found to face a substantial wage penalty (ranging from 15 to almost 30%).

In many ways, these results are worrying. Firstly, given the extent of the phenomenon of over-education and its socio-economic consequences (Bender and Heywood 2017; Bender and Roche 2013; Leuven and Oosterbeek 2011), the incentive for individuals to undertake a PhD is likely to be dampened. Indeed, individuals may reconsider their investment in education, fearing that the time and effort spent on obtaining a PhD is not sufficiently rewarded (Gaeta, Lavadera, and Pastore 2022). This is a key issue as PhD holders are generally considered to play a strategic role in the expansion of the so-called 'knowledge economy' (Bansak, Bender, and Coon 2021; Ermini, Papi, and Scaturro 2017). Moreover, from a public finance perspective, the fact that many doctorate holders end up in jobs for which they are genuinely over-educated means that significant resources are wasted, especially as the cost of doctoral training is high and the share of public funding spent on doctorate holders is large (Caroleo and Pastore 2018).

That said, the evidence shows that many PhD holders, although employed in jobs for which a PhD is not required (and for which they are therefore likely to be over-educated), can take advantage of their degree to improve their career prospects. Indeed, as the extensive survey by Boman et al. (2021) shows, there are many jobs for which a doctorate is a desired and valued qualification, but not an essential one, so that the person with a doctorate is assigned to a more interesting and rewarding job, allowing easier access to responsibilities, promotions, and other benefits (monetary or non-monetary). Our estimates based on an ORU specification (see footnote 21) corroborate this by showing that over-educated doctorate holders earn a wage premium over their well-matched colleagues doing the same job. Overall, these results therefore suggest that the years of over-education of doctorate holders are not entirely unproductive (both for the company employing them and for the doctoral graduates themselves). However, further research is needed to determine precisely to what extent the knowledge and skills acquired with a doctorate are used in lower-skilled jobs during an episode of over-education, and to what extent a doctoral degree influences the employment prospects of over-educated PhD holders, relative to non-PhD holders, in jobs outside academia requiring a bachelor's or master's degree.[23]

Studies also point out that there is a relatively small proportion of doctoral graduates who have completed their doctoral programme specifically to become researchers in academia (Boman et al. 2021). This, combined with the fact that the number of publicly-funded academic posts is largely insufficient to provide employment for all newly graduated PhDs, reinforces the argument that universities should strive to offer PhD programmes that prepare graduates for a wider variety of future careers (particularly outside academia). The ability of an economy to create enough non-academic, research-prone jobs offering adequate opportunities to PhD graduates is therefore probably also a major issue.

Given that doctoral education is often described as central to the innovation process and a key driver of productivity growth (OECD 2016), the economic gains from improving the matching of PhD holders are likely to be large. Overall, this suggests that the problem of over-education of doctoral graduates should not be taken lightly and requires further attention from scientists (to better understand the phenomenon) and policy makers (to take appropriate action).

Notes

1. In the European Union, the statistics point in the same direction: the number of newly enrolled doctoral students aged between 24 and 35 increased by almost 27% between 2013 and 2018 (from around 71,000 to almost 90,000), while the number of doctoral students rose from around 735,000 to 779,000 between 2013 and 2019

(European Commission 2020; Eurostat, 2023). Furthermore, in 2019, the number of new doctorate holders was around 121,000 in the EU-28 (Eurostat, 2023).

2. This said, it should be noted that a significant number of people embark on a thesis for reasons other than obtaining a job requiring a PhD. Intrinsic motivation and intellectual development are also important drivers (Hnatkova et al. 2022). In addition, studies show that many PhD graduates, despite holding jobs for which a PhD is not essential (and for which they are therefore likely to be over-educated), can nevertheless leverage their degree to improve their career prospects. More specifically, as Boman et al. (2021) point out, in many jobs, a doctorate, even if not required, is desired or valued, so that the person with a doctorate has a more interesting and rewarding job, which also makes it easier to access more responsibility, promotion or other benefits (pecuniary or otherwise).
3. The term 'voluntary' should be interpreted with caution as it may obviously be a constrained choice.
4. The study by Ermini, Papi, and Scaturro (2017), based on four cohorts of Italian doctoral graduates (relating to the years 2004, 2006, 2008 and 2010), also finds that jobs held by doctoral graduates in academia and the research sector are more often associated with a successful match. The analysis by Boman et al. (2021), which is based on a career tracking survey of doctoral graduates between 2006 and 2020 in nine European universities, concludes that almost half of doctoral graduates are employed in jobs that do not require a doctorate, but also that overeducation is most prevalent outside universities and research institutions.
5. By relying on the WA method, over-education is constructed with replies from questions concerning the usefulness of the PhD. In this regards, it has been underlined how the exact phrasing varies substantially across studies: some interviews refer to recruiting standards (Duncan and Hoffman 1981), while others to the education needed to perform the job (Hartog and Oosterbeek 1988). Evidence also shows that the same person responds differently to similar questions, and it is not clear whether and to what extent these variations in framing and phrasing cause differences in the measured levels of required education (Green, Myerson, and Ostaszewski 1999). For these reasons, we calculated the over-education variable in two alternative ways, namely on the basis of the usefulness of the PhD title *to do* and *to get* the current job position respectively.
6. The over-education variable computed on the basis of the educational level *to get* the job is used as a robustness test. Estimates based on this alternative measure are very similar to those based on the educational level required *to do* the job. Therefore, the latter are only reported for the stepwise OLS analysis (without interaction effects). The results of other specifications, which corroborate our findings, are available on request.
7. To calculate the gross hourly wage, we first converted the variable Q50_X, i.e. the 'gross monthly earnings' of workers in the various countries analysed, into a common currency, namely the euro. To do this, we use the average exchange rate between national currencies and the euro in 2014. Next, we calculated the number of hours worked per month by multiplying the 'hours worked per week' (i.e. variable Q10_2) by 4.43 (as it is generally accepted that a month comprises an average of 4.33 weeks). Finally, by dividing the gross monthly wage (expressed in euros) by the hours worked per month, we obtain the gross hourly wage.
8. A worker is considered as under-educated if her/his level of education is lower than that required for her/his job.
9. Given the distribution of these variables, we have chosen to include 2 dummies for ICT skills (i.e. for moderate and advanced levels) and only 1 for numeracy and literacy skills respectively (i.e. for the advanced level).
10. This fourth group of variables refers to the career aspirations of employees before they started working for their current employer. In practice, it turns out that for many of these employees, these aspirations are not, or are no longer, being met. This is particularly the case if we focus on the desire of certain employees to have a job that corresponds to their qualifications. Indeed, when we calculate the correlation between this variable and the overeducation variable (our variable of interest), we find that it is very weak (equal to -0.04) and therefore that there is no systematic relationship between these two variables.
11. The European Skills and Jobs Survey relies on a quota approach. Quota sampling can achieve representativeness by using quotas and weights which align the sample with the population on key variables. This method ensures that the sample is representative for the key control variables and makes it likely for other variables that correlate with them. Consequently, we have used weights in our analysis. Specifically, we relied on variable 291 (i.e. 'Weight_Country_with_education'). For more details, see Ipsos MORI (2014).
12. Specifically, we excluded from our analysis individuals who answered 'no' to the following question from the ESJS: 'Did you do any paid work in the last 7 days, even if it was for one hour?'.
13. To examine whether over-education among PhD holders is a temporary phenomenon (i.e. whether it occurs more often just after the doctorate is obtained), we calculated the incidence of over-education according to the year in which doctoral graduates obtained their degree. We considered different thresholds. In all cases, the incidence remains very stable, close to its mean value. Our estimates (available on request) therefore suggest that over-education among PhD holders is fairly persistent and stable across cohorts of PhD holders.
14. We also examined the incidence of over-education, as well as the distribution of PhD graduates, by sector, occupation and field of study. Descriptive statistics presented in Appendix Table A-3 show that 46% of doctorate holders work in the private sector and that their probability of being over-educated there is 87%, i.e. 14% points higher than in the public sector (including other organisations, such as not-for-profit trusts, charities and non-governmental organisations). Furthermore, we note that almost all doctorate holders are either

managers (11%), professionals (56%), technicians and associate professionals (15%) or clerical support workers (13%). In these occupations, the incidence of over-education varies from 70% (among professionals) to 96% (among clerical support workers). As for the breakdown of doctorate holders by field of study, we find that 22% of them hold degrees in Economics, business, law and finance, 15% respectively in Natural sciences and Engineering sciences, 14% in Humanities, languages and arts, and 11% in Teacher training and education science. Other fields of study (e.g. Computer sciences or Medecine and health-related sciences) gather less than 10% of PhD holders in our sample. Finally, as regards the incidence of over-education among doctoral graduates by field of study, it fluctuates between 49% for graduates in Medecine and health-related sciences and 88% for graduates in Humanities, languages and arts.

15. The severity of over-education has also been investigated. Therefore, we classified over-educated PhD holders in three categories according to the degree required to do their jobs. We have qualified over-education as 'mild' when the level of education required for the job corresponds to ISCED 5 (i.e. tertiary education – first level), 'severe' when it corresponds to ISCED 3 or 4 (i.e. upper secondary education or pre-vocational post-secondary education), and 'very severe' when it corresponds to ISCED 1 or 2 (i.e. primary or lower secondary education at most). Unfortunately, when the level required to do a job corresponds to a tertiary diploma – first level (ISCED 5), our data do not allow us to have more details and in particular to identify whether it is a bachelor's or a master's degree that is needed. Clearly, having this additional information would have been a plus, as the consequences of over-education are probably most acute when only a bachelor's degree is required. Be that as it may, our results (available on request) show that in 80 to 86% of cases, depending on whether we consider our sample as a whole, the private or public sector, over-education can be described as mild, insofar as the PhD graduates actually do a job for which a tertiary degree is sufficient. Moreover, they suggest that the problem of over-education is somewhat less acute in the public sector than in the private sector. Indeed, while in the private sector over-education is severe or very severe for over 16% of over-educated PhDs, this is the case for less than 12% of over-educated PhDs in the public sector.
16. The complete set of regression results, not reported here due to space constraints, is available on request.
17. See Section 3.1 and Appendix Table A-2 for a detailed description of these characteristics.
18. As a sensitivity test, we re-estimated our benchmark equation, including all covariates, separately for PhD holders working in the private sector (i.e. private companies and partnerships), the public sector (i.e. national, regional and local public organisations) and other organisations (i.e. not-for-profit trusts, charities, non-governmental organisations and other organisations) respectively. Our estimates, available on request, show that the wage penalty associated with over-education is greatest in the private sector (-23.2%), lower in the public sector (-16.2%) and not significant in other organisations. The lower penalty in the public sector is probably due to the fact that, in this this sector, wages are generally based on fairly precise job classifications, where seniority-based pay often continues to play an important role, with little or no scope for individual wage negotiation. Overall, this results in a relatively compressed wage distribution, where low-skilled workers tend to earn more than their private sector counterparts, while the reverse is true for high-skilled workers, and therefore also for PhD holders (Bargain and Melly 2008; Lucifora and Meurs 2006). In the private sector, on the other hand, salary dispersion is typically greater and highly qualified positions (which in some cases require a doctorate) are generally much better paid than in the public sector (Giordano et al. 2011). As the academic sector represents only a small proportion of total public employment, our results are not directly comparable with those of previous studies (e.g. Bender and Heywood 2009; Gaeta, Lavadera, and Pastore 2022) comparing wage penalties of over-educated PhD holders inside and outside academia.
19. We also re-estimated our benchmark equation according to the severity of the over-education problem (e.g. qualified as mild, severe or very severe, see footnote 16 for the description of these categories). All sectors combined, our results (available on request) show that the wage penalty increases as the over-education problem worsens. The penalty is estimated at −24.9% and −34.5% in severe and very severe cases respectively. In mild cases, the penalty is not statistically significant. This non-significant outcome is likely to be at least partly driven by the fact that we are unable to distinguish PhD graduates in jobs requiring a bachelor's degree from those in jobs requiring a master's degree. Interestingly, though, if we turn to the estimates for the private sector, we find that the penalty is statistically significant and equal to −16.4% in mild cases and reaches −51.9% in more severe cases. In the public sector, the over-education wage penalty is estimated at −9.7 and −20.1% in mild and more severe cases respectively. However, none of these coefficients is statistically significant (again, probably because we can't distinguish between jobs requiring a bachelor's or a master's degree, but also because of a small sample issue, particularly for the more severe cases of over-education).
20. The ORU (Over-, Required, and Under-education) approach, suggested by Duncan and Hoffman (1981), enables to estimate the wage impact of over-education conditional on the level of education required to perform a job. The standard result from this literature is that over-educated workers earn a wage premium over their colleagues who do the same job but are adequately educated to do it (i.e. well-matched). In order to examine whether a similar result is obtained with our data, we re-estimated the over-education wage differential for doctoral graduates using an ORU approach. Our results, available on request, show that wages rise on average by 7.8% when the level of required education for a job increases by one year. Moreover, they indicate that a one-year increase

in over-education among PhD holders improves wages by 3.9%. These estimates, as expected, suggest that over-educated PhD holders earn a wage premium over their well-matched colleagues. They are also in line with previous evidence showing that over-educated PhD holders can nevertheless take advantage of their degree to improve their career prospects (see e.g. Boman et al. (2021)).

21. See footnote 4.
22. Detailed regression results, not reported here due to space constraints, are available on request.
23. We thank an anonymous referee for making these valuable comments.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Loredana Cultrera http://orcid.org/0000-0003-4400-4524
François Rycx http://orcid.org/0000-0003-0964-0939
Guillaume Vermeylen http://orcid.org/0000-0001-9641-060X

References

Alfano, V., G. Geata, and M. Pinto. 2021. "Non-academic Employment and Matching Satisfaction among PhD Graduates with High Intersectoral Mobility Potential." *International Journal of Manpower* 42 (7): 1202–1223. https://doi.org/10.1108/IJM-10-2020-0489.

Bansak, C., K. Bender, and M. Coon. 2021. "The Political Economy of Skilled Workers and Innovation." In *Handbook of Labor, Human Resources and Population Economics*, edited by K. F. Zimmerman, 1–33. New York: Springer.

Bargain, O., and B. Melly. 2008. "Public Sector Pay Gap in France: New Evidence using Panel Data." *Discussion Paper Series*, IZA Discussion Paper No 3427, Bonn.

Becker, G. 1962. "Investment in Human Capital. A Theoretical Analysis." *Journal of Political Economy* 70 (5): 9–49. https://doi.org/10.1086/258724.

Bender, K. A, and J. S. Heywood. 2017. "Educational Mismatch and Retirement." *Education Economics* 25 (4): 347–365.

Bender, K., and J. Heywood. 2009. "Educational Mismatch among PhDs: Determinants and Consequences." In *Science and Engineering Careers in the United States: An Analysis of Markets and Employment*, edited by R. Freeman, and D. Goroff, 229–255. Chicago, IL: University of Chicago Press.

Bender, K. A., and J. S. Heywood. 2009. "Educational Mismatch Among Ph. Ds: Determinants and Consequences." In *Science and Engineering Careers in the United States: An Analysis of Markets and Employment*, 229–255. University of Chicago Press.

Bender, K., and J. Heywood. 2011. "Educational Mismatch and the Careers of Scientists." *Education Economics* 19 (3): 253–274. https://doi.org/10.1080/09645292.2011.577555.

Bender, K. A., and K. Roche. 2013. "Educational Mismatch and Self-employment." *Economics of Education Review* 34: 85–95.

Bender, K., and K. Roche. 2018. "Educational Mismatch and the Earnings Distribution." *Southern Economic Journal* 85 (2): 441–456. https://doi.org/10.1002/soej.12282.

Blinder, A. 1973. "Wage Discrimination: Reduced Form and Structural Estimates." *Journal of Human Resources* 8 (4): 436–455. https://doi.org/10.2307/144855.

Boman, J., J. Baginskaite, T. Sturtz, E. De Young, B. Becker, and Berzelak. Brecko. 2017. "2017 career tracking survey of doctorate holders." Project report. Strasbourg.: European Science Foundation.

Boman, J., H. Beeson, M. Sanchez Barrioluengo, and M. Ristoru. 2021. *What Comes After a PhD? Findings from the DocEnhance Survey of Doctorate Holders on Their Employment Situation, Skills Match, and the Value of the Doctorate*. Strasbourg: European Science Foundation.

Canal Domínguez, J., and C. Rodríguez Gutiérrez. 2013. "Wage Differences among PhDs by Area of Knowledge: Are Science Areas Better Paid Than Humanities and Social Ones? The Spanish Case." *Journal of Education and Work* 26 (2): 187–218. https://doi.org/10.1080/13639080.2011.638623.

Caroleo, F., and F. Pastore. 2018. "Overeducation at a Glance: Determinants and Wage Effects of the Educational Mismatch, Looking at the Alma Laurea Data." *Social Indicators Research* 137 (3): 999–1032. https://doi.org/10.1007/s11205-017-1641-1.

CEDEFOP. 2014. "CEDEFOP European Skills Survey. Data collection and quality report." European Centre for the development of Vocational Training, Thessaloniki, Greece, October.

Chevalier, A. 2003. "Measuring Over-Education." *Economica* 70: 509–531. https://doi.org/10.1111/1468-0335.t01-1-00296.

Cruz-Castro, L., and L. Sanz-Menéndez. 2005. "The Employment of PhDs in Firms: Trajectories, Mobility and Innovation." *Research Evaluation* 14 (1): 57–69. https://doi.org/10.3152/147154405781776292.
Cultrera, L., B. Mahy, F. Rycx, and G. Vermeylen. 2022. "Educational and Skill Mismatches: Unravelling Their Effects on Wages Across Europe." *Education Economics* 30 (6): 561–573. https://doi.org/10.1080/09645292.2022.2050995.
Cyranoski, D., N. Gilbert, H. Ledford, A. Nayar, and M. Yahia. 2011. "The PhD Factory." *Nature* 472: 276–279. https://doi.org/10.1038/472276a.
da Silva Marioni, L. 2021. "Overeducation in the Labour Market: Evidence from Brazil." *Education Economics* 29 (1): 53–72. https://doi.org/10.1080/09645292.2020.1832201.
Davia, M., S. McGuinness, and O. Connell. 2017. "Determinants of Regional Differences in Rates of Overeducation in Europe." *Social Science Research* 63: 67–80. https://doi.org/10.1016/j.ssresearch.2016.09.009.
Di Paolo, A., and F. Mañé. 2013. "Determinants and Consequences of Qualification and Skills Mismatch Among Recent PhD Graduates." Draft Paper.
Di Paolo, A., and F. Mañé. 2014. "Are We Wasting our Talent? Overqualification and Overskilling among PhD Graduates. Overqualification and Overskilling Among PhD Graduates." *XREAP Document de Treball* 2014–06. Cataluña.
Di Paolo, A., and F. Mané. 2016. "Misusing our Talent? Overeducation, Overskilling and Skill Underutilisation among Spanish PhD Graduates." *Economic and Labour Relations Review* 17 (4): 432–452. https://doi.org/10.1177/1035304616657479.
Dolton, P., and M. Silles. 2008. "The Effects of Over-Education on Earnings in the Graduate Labour Market." *Economics of Education Review* 27 (2): 125–139. https://doi.org/10.1016/j.econedurev.2006.08.008.
Duncan, G., and S. Hoffman. 1981. "The Incidence and Wage Effects of Over-Education." *Economics of Education Review* 1 (1): 75–86. https://doi.org/10.1016/0272-7757(81)90028-5.
Eguia, B., C. Rodiguez Gonzalez, and F. Serrano. 2023. "Overeducation and Scarring Effects on the Wages of Young Graduates." *International Journal of Manpower* 44 (4): 755–771. https://doi.org/10.1108/IJM-02-2022-0075.
Ermini, B., L. Papi, and F. Scaturro. 2017. "An Analysis of the Determinants of Overeducation among Italian PhD Graduates." *Italian Economic Journal* 3 (2): 167–207. https://doi.org/10.1007/s40797-017-0053-3.
European Commission. 2020. Research and Innovation Observatory – Horizon 2020 Policy Support Facility, Statistics.
European Commission. 2021. *Taking Stock, Evaluating the Achievements and Identifying the Way Forward for the ERA Priority 3 Policy Measures. Final Report*. European Union: Brussels.
Eurostat. 2023. *Education and Training Outcomes (educ-outc)*. Luxembourg: Online Statistics.
Firpo, S., N. Fortin, and T. Lemieux. 2009. "Unconditional Quantile Regressions." *Econometrica* 77 (3): 953–973. https://doi.org/10.3982/ECTA6822.
Gaeta, G. 2015. "Was it Worth it? An Empirical Analysis of Over-Education among PhD Recipients in Italy." *International Journal of Social Economics* 42 (3): 222–238. https://doi.org/10.1108/IJSE-08-2013-0186.
Gaeta, G., G. Lavadera, and F. Pastore. 2017. "Much ado About Nothing? The Wage Penalty of Holding a PhD Degree but not a PhD Job Position." In *Skill Mismatch in Labor Markets*, edited by S. Polachek, and K. Pouliakas, 243–277. Bingley: Research in Labor Economics, Emerald Publishing.
Gaeta, G., G. Lavadera, and F. Pastore. 2022. "Overeducation Wage Penalty among PhD Holders: An Unconditional Quantile Regression Analysis on Italian Data." *International Journal of Manpower*. forthcoming.
Giordano, R., D. Depalo, M. Pereira, B. Eugène, E. Papapetrou, J. Perez, L. Reiss, and M. Roter. 2011. "The Public Sector Pay Gap in a Selection of Euro Area Countries." ECB Working Paper No 1406, Frankfurt.
Green, L., J. Myerson, and P. Ostaszewski. 1999. "Amount of Reward has Opposite Effects on the Discounting of Delayed and Probabilistic Outcomes." *Journal of Experimental Psychology: Learning, Memory, and Cognition* 25: 418–427. https://doi.org/10.1037/0278-7393.25.2.418.
Hartog, J. 2000. "Over-education and Earnings: Where are we, Where Should We Go?" *Economics of Education Review* 19: 131–147. https://doi.org/10.1016/S0272-7757(99)00050-3.
Hartog, J., and H. Oosterbeek. 1988. "Education, Allocation and Earnings in the Netherlands: Overschooling?" *Economics of Education Review* 7 (2): 185–194. https://doi.org/10.1016/0272-7757(88)90043-X.
Heckman, J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47 (1): 153–162. https://doi.org/10.2307/1912352.
Hnatkova, E., I. Degtyarova, M. Kersschot, and J. Boman. 2022. "Labour Market Perspectives for PhD Graduates in Europe." *European Journal of Education* 57: 395–409. https://doi.org/10.1111/ejed.12514.
Ipsos MORI. 2014. *Cedefop European Skills Survey: Technical Report*. London: CEDEFOP.
Jacobs, V., K. Pineda-Hernandez, F. Rycx, and M. Volral. 2023. "Does Over-Education Raise Productivity and Wages Equally? The Moderating Role of Workers' Origin and Immigrants' Background." *Education Economics*, forthcoming.
Jacobs, V., F. Rycx, and M. Volral. 2022. "Wage Effects of Educational Mismatch According to Worker's Origin: The Role of Demographics and Firm Characteristics." *De Economist* 170 (4): 459–501. https://doi.org/10.1007/s10645-022-09413-9.
Jovanovic, B. 1979. "Job Matching and the Theory of Turnover." *Journal of Political Economy* 87 (3): 972–990. https://doi.org/10.1086/260808.
Kleibrink, J. 2016. "Inept or Badly Matched? Effects of Educational Mismatch in the Labor Market." *Labour (Committee. on Canadian Labour History)* 30 (1): 88–108. https://doi.org/10.1111/labr.12065.

Leuven, E., and H. Oosterbeek. 2011. "Overeducation and Mismatch in the Labor Market." In *Handbook of the Economics of Education 4*, edited by E. Hanushek, S. Machin, and L. Woesmann, 283–326, Chapter 3. Amsterdam: Elsevier.
Lucifora, C., and D. Meurs. 2006. "The Public Sector pay gap in France, Great Britain and Italy." *Review of Income and Wealth* 52 (1): 43–59. https://doi.org/10.1111/j.1475-4991.2006.00175.x.
Marini, G. 2021. "The Employment Destination of PhD-Holders in Italy: Non-Academic Funded Projects as Drivers of Successful Segmentation." *European Journal of Education* 57 (2): 289–305. https://doi.org/10.1111/ejed.12495.
Mavromaras, K., S. McGuinness, N. O'Leary, P. Sloane, and Z. Wei. 2013. "Job Mismatches and Labour Market Outcomes: Panel Evidence on University Graduates." *Economic Record* 89 (286): 382–395. https://doi.org/10.1111/1475-4932.12054.
McGuinness, S. 2006. "Overeducation in the Labour Market." *Journal of Economic Surveys* 20 (3): 387–418. https://doi.org/10.1111/j.0950-0804.2006.00284.x.
McGuinness, S., A. Bergin, and A. Whelan. 2018b. "Over-education in Europe: Trends, Convergence and Drivers." *Oxford Economic Papers* 70 (4): 994–1015. https://doi.org/10.1093/oep/gpy022.
McGuinness, S., and K. Pouliakas. 2017. "Deconstructing Theories of Overeducation in Europe: A Wage Decomposition Approach." In *Research in Labor Economics 45*, edited by S. Polachek, K. Pouliakas, and K. Tatsiramos, 91–127. Bingley: Emerald Publishing Limited.
McGuinness, S., K. Pouliakas, and P. Redmond. 2018a. "Skills Mismatch: Concepts, Measurement and Policy Approaches." *Journal of Economic Surveys* 32 (4): 985–1015. https://doi.org/10.1111/joes.12254.
Oaxaca, R. 1973. "Male-Female Wage Differentials in Urban Labor Markets." *International Economic Review* 14 (3): 693–709. https://doi.org/10.2307/2525981.
OECD. 2016. *OECD Science, Technology and Innovation Outlook 2016*. Paris: OECD Publishing.
OECD. 2019. "What are the Characteristics and Outcomes of Doctoral Graduates?" In *Education at a Glance 2019: OECD Indicators*, 497 pp. Paris: OECD Publishing.
OECD. 2021. "Challenges and new Demands on the Academic Research Workforce." In *OECD Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity*, 18 pp. Paris: OECD Publishing.
Paolo, Di, A. Mañé. 2014. *Are we wasting our talent? Overqualification and overskilling among PhD graduates. Overqualification and Overskilling Among PhD Graduates*. XREAP Document de Treball 2014-06. Cataluña.
Pecoraro, M. 2014. "Is There Still a Wage Penalty for Being Overeducated but Well-Matched in Skills? A Panel Data Analysis of a Swiss Graduate Cohort." *Labour* 28 (3): 309–337. https://doi.org/10.1111/labr.12031.
Rubb, S. 2003. "Overeducation: A Short or Long run Phenomenon for Individuals?" *Economics of Education Review* 22 (4): 389–394. https://doi.org/10.1016/S0272-7757(02)00052-3.
Sarrico, C. 2022. "The Expansion of Doctoral Education and the Changing Nature and Purpose of the Doctorate." *Higher Education* 84: 1299–1315. https://doi.org/10.1007/s10734-022-00946-1.
Sattinger, M. 1993. "Assignment Models of the Distribution of Earnings." *Journal of Economic Literature* 31: 851–880.
Schwabe, M. 2011. "The Career Paths of Doctoral Graduates in Austria." *European Journal of Education, Research, Development and Policy* 46 (1): 153–168.
Sicherman, N., and O. Galor. 1990. "A Theory of Career Mobility." *Journal of Political Economy* 98 (1): 169–192. https://doi.org/10.1086/261674.
Stiglitz, J., and B. Greenwald. 2014. *Creating a Learning Society: A New Approach to Growth, Development, and Social Progress*. New York: Columbia University Press.
Thurow, L. 1979. "A job-Competition Model." In *Unemployment and Inflation, White Plains, ME Sharpe*, edited by M. Piore, 17–32. New York: ME Sharpe.
Verdugo, R., and N. Verdugo. 1989. "The Impact of Surplus Schooling on Earnings: Some Additional Findings." *Journal of Human Resources* 24 (4): 629–643. https://doi.org/10.2307/145998.
Verhaest, D., and E. Omey. 2010. "The Determinants of Overeducation: Different Measures, Different Outcomes?" *International Journal of Manpower* 31 (6): 608–625. https://doi.org/10.1108/01437721011073337.
Verhaest, D., and R. van der Velden. 2013. "Cross-country Differences in Graduate Overeducation." *European Sociological Review* 29 (3): 642–653. https://doi.org/10.1093/esr/jcs044.
Waaijer, C., H. Sonneveld, S. Buitendijk, C. van Bochove, and I. van der Weijden. 2016. "The Role of Gender in the Employment, Career Perception and Research Performance of Recent PhD Graduates from Dutch Universities." *PLoS One* 11 (10): e0164784. https://doi.org/10.1371/journal.pone.0164784.

Appendices

Table A1. Selected descriptive statistics based on sample before and after excluding individuals with no information on wages

% of sample	Sample including all workers (also those for whom there is no information on their wages but without those with no job) (1)	Sample including only workers for whom wage information is available (2)
Over-educated (to do the job)	79.2	79.5
Over-skilled (to do the job)	42.1	42.5
Unsatisfied with the job	21.2	21.0
Over-educated (to do the job) and over-skilled	34.7	35.8
Over-educated (to do the job) and unsatisfied with the job	18.1	18.3
Age categories:		
24–35	28.8	30.3
36–45	39.1	38.8
46–55	23.5	22.1
56–64	8.6	8.8
Tenure > 10 years	37.3	36.7
Men	54.3	55.6
Type of contract:		
Indefinite	86.2	86.3
Temporary	12.0	12.5
No formal work contract	1.8	1.2
Sector of activity:		
Science and engineering	18.9	19.5
Health	9.1	8.5
Teaching	19.6	19.3
Business and administration	10.7	11.1
ICT	7.4	7.7
Legal, social and cultural	4.9	5.0
Size of the workplace (FTE employees):		
1–9	12.5	12.1
10–49	23.2	23.0
50–99	14.9	14.5
100–249	15.4	15.6
250–499	7.9	8.2
>500	26.1	26.6
Number of observations	2,821	2,053

Table A2. Descriptive statistics, overall sample.

Variables	Share of sample (%)
Main explanatory variables and moderators:	
Over-educated (to do the job)	79.5
Over-skilled (to do the job)	42.5
Unsatisfied with the job	21.0
Over-educated and over-skilled (to do the job)	35.8
Over-educated (to do the job) and unsatisfied with the job	18.3
Control variables:	
a) Socio-demographic characteristics	
PhD field of study:	
Teacher training and education sciences	11.1
Humanities, languages and arts	14.0
Economics, business, law and finance	22.7
Other social sciences	6.7
Natural sciences	15.1
Mathematics and statistics	4.7
Computing sciences	9.4

(*Continued*)

Table A2. Continued.

Variables	Share of sample (%)
Engineering sciences	15.0
Agriculture and veterinary sciences	1.9
Medicine and health-related sciences	7.7
Security, transport or personal services	2.1
Age categories:	
24–35	30.3
36–45	38.8
46–55	22.1
56–64	8.8
Tenure > 10 years	36.7
Status before current job:	
Education or training	28.9
Employed	55.0
Unemployed	10.8
Other (not working, e.g. child care, disability)	2.9
Training courses attended in the last 12 months:	
Courses attended during working hours	49.3
Courses attended outside working hours	25.0
Courses attended while performing regular job	41.0
Men	55.6
Living conditions:	
Alone	19.1
With parents	3.2
With partner	68.6
With children	42.3
With friends	1.7
b) Skills needed to do the job	
Level of ICT skills to do the job: advanced	25.0
Level of ICT skills to do the job: moderate	62.1
Level of ICT skills to do the job: basic	8.6
Level of literacy skills to do the job: advanced	78.8
Level of numeracy skills to do the job: advanced	46.1
c) Other job-specific characteristics	
Type of contract:	
Indefinite	86.3
Temporary	12.5
No formal work contract	1.2
Characteristics that the job involves:	
Responding to non-routine situations during the course of the daily work	97.5
Choosing the way in which to do the work	96.8
Learning new things during daily work	98.7
Working as part of a team	97.8
Individual has been promoted to a higher position since working for the current employer	39.1
Sector of activity:	
Science and engineering	19.5
Health	8.5
Teaching	19.3
Business and administration	11.1
ICT	7.7
Legal, social and cultural	5.0
Company with more than 1 workplace	68.8
Size of the workplace (FTE number of employees):	
1–9	12.1
10–49	23.0
50–99	14.5
100–249	15.3
250–499	8.2
>500	26.6

(*Continued*)

Table A2. Continued.

Variables	Share of sample (%)
d) Employment expectations[a]	
Willingness that job suits qualifications and skills	98.3
Willingness to gain work experience	96.2
Good job security	98.2
Good career progression and development	97.1
Company well known in the field	97.3
Good pay and package of fringe benefits	95.3
Close to home	90.7
Interested in nature of the job itself	98.6
Good work-life balance	97.3
Number of observations	2,053

[a]These variables indicate the professional expectations of the doctorate holders surveyed. In practice, these expectations are not necessarily met.

Table A3. Distribution of doctoral graduates and incidence of over-education by sector, occupation and field of study

Variables	Share of sample (%)	Incidence of over-education (%)
Sector:		
Private sector[a]	46.0	87.3
Public sector[b] (including other organisations)[c]	54.0	72.9
Occupation:		
Plant and Machine Operator and Assemblers	0.4	88.9
Building, Crafts or a Related trade Persons	0.4	100
Skilled Agricultural, Forestry and Fishery Workers	0.2	75.0
Sales, Customer or Personal Service Workers	3.0	98.4
Clerical Support	12.5	96.5
Technician or Associate Professionals	15.3	93.0
Professionals	56.2	70.3
Managers	11.4	83.0
Elementary occupations	0.4	100
None of the above/no answer/don't know	0.3	50.0
Field of study:		
Teacher training and education sciences	11.1	78.1
Humanities, languages and arts	14.0	88.2
Economics, business, law and finance	22.7	87.3
Other social sciences	6.7	77.5
Natural sciences	15.1	61.9
Mathematics and statistics	4.8	69.4
Computing sciences	9.5	80.4
Engineering sciences	15.1	80.6
Agriculture and veterinary sciences	2.0	53.7
Medicine and health-related sciences	7.8	48.8
Security, transport or personal services	2.1	84.1
Others	7.7	91.1

Notes: [a]private companies and partnerships [b]national, regional and local public organisations [c]not-for-profit trusts, charities, non-governmental organisations and other organisations.