Great Recession and over-education among high skilled. The case of Italian Ph.D graduates.

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PRELIMINARY VERSION - DO NOT QUOTE

Abstract

This paper evaluates the impact of the Great Recession on over-education among Italian Ph.D graduates drawn from the four cohorts 2004, 2006, 2008, 2010 surveyed by the Italian National Institute of Statistics. Originally, regional resilience (Martin, 2012) is adopted, among other proxies, to assess the effect of the crisis. The paper also adds empirical evidence on the main determinants of over-education among the highest skilled workers as the literature has mainly focused on graduated. Over-education is examined through the definitions of over-skilling and over-qualification. The results show that economic crisis dampens the optimal skill job matching in early phd holders' careers; the evidence is less robust when over-qualification is examined. The impact is attenuated if the Ph.D holder works in more economic resilient areas and hold R&D based activities. Additionally, it emerges that socio-demographic variables do not exert a relevant influence on over-education. Conversely, job attributes such as working in academia or carrying out R&D activities reduce the likelihood of incurring into over-education. On the contrary, being self-employed increases the risk of over-education. Among Ph.D related features, visiting abroad is always a driver to overcome any kind of job mismatch.

Keywords: over-education, over-skilling, over-qualification, Ph.D graduates, crisis, economic resilience

JEL Classification: C2, I2, J24.

1 Introduction

A growing international consensus and a common vision on what a Ph.D program is supposed to encompass has emerged in recent years. The Ph.D should produce knowledge, not only

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developing original research and attributes subject-specific (hard skills), but also promoting both more general and transferable soft skills, as well as building up individuals with creative and inquisitive mindsets (EUA, 2005). All this should facilitate the entry of Ph.D graduates in the labor market recognizing the multiplicity of employment trajectories in addition to academia. The final goal is to favor the emergence and consolidation of the so-called knowledge economy and to promote the creation of a learning society.

In recognition of this crucial role of the very educated people, and on the basis of the presumption that market failure in learning might be pervasive in the society (Stiglitz and Greenwald, 2014), many countries have taken action expanding and reforming their Ph.D programs.

The result has been a widespread increase in the number of Ph.D students, well above the demand for academic positions, with Ph.D supply probably outstripping demand, despite the contribution of a growing technical progress in demanding skilled workers.

In the light of these dynamics, a possible consequence is the potential emergence of a widespread over-education at Ph.D level (Leuven et al., 2011; Quintini, 2011; Hartog, 2000). While over-education among samples of graduated has received great attention, investigation among Ph.D holders is still tiny (Enders, 2002; Gaeta, 2015; Di Paolo and Mañé, 2016) The current paper contributes to fill this gap examining four cohort of Ph.D recipients surveyed from 2004 to 2010 by the Italian National Institute of Statistics (hereafter, ISTAT). Focusing on this strand of high skilled workers is important to shed light on the return of public investment as Ph.D education is mostly publicy financed. Moreover, it helps to infer the capability of the economy to keep up with the pace of technological change - and thus to avoid the 'low skill, low technology trap' (Snower, 1996; Di Pietro, 2002) - that requires skilled workforce to be adopted at appropriate level.

Furthermore, as noted in Devillanova (2013), there is not a clearcut on the primary causes of this phenomenon. So far, the evidence on several relevant structural and individual factors (business cycle, educational system, gender, social or educational background and past experience) is still mixed, also because of sentitivity to measurement of educational mismatch (Verhaest and Omey, 2006; Groot and Van Den Brink, 2000; Quintini, 2011). Thus, this paper aims to add empirical evidence on the correlation between different definitions of over-education, i.e over-skilling or over-qualification, and a large set of individual and job characteristics taking advantage of the rich information set availabe in the ISTAT survey adopted to carry out this study. Since overeducation represents a source of individual, firm and societal costs expecially when very highly educated individuals, such as Ph.D holders, are concerned (Stiglitz and Greenwald, 2014), this explorative investigation offers valid suggestions to calibrate policy advise to ensure Ph.D graduated a well-positioned inclusion in the labour market in terms of skill-occupational match, also beyond Italy.

More over, based on the best of our knowledge, the effects of the ongoing severe economic crisis on the size of over-education have not been fully explored. The sample under observation includes graduates before and after 2008, the year of the wide-spreading international financial and economic downturn that exacerbated labour market prospects. Accordingly, we undertake an evaluation of the impact of the Great Recession on the probability of matching skills and educational level to occupational attainment among Ph.D graduates. Given polarization and strategic and opportunistic upskilling induced by downturns (Acemoglu and Autor, 2011; Di Pietro and

Urwin, 2006; Modestino et al., 2016), the crisis may have affected professional outcome of low and high-educated individuals in a different manner (Cockx and Ghirelli, 2016). Should this be the case, then stabilization policies should be pursed in order to avoid mismatch and persistent effect on worker's career even at the level of workers who held a Ph.D.

Within this framework, our study contributes to the existing literature on over-education of Ph.D graduates in several respects. First, focusing on the Italian case, we go beyond the analysis of business cycle, assessing the effect of the recent structural financial and economic crisis on mismatch in the labour market of the most skilled workers. Our dataset includes Ph.D graduate information before and after 2008. Consequently, we are able to undertake an evaluation of the impact of the Great Recession on the probability of matching skills and educational level to occupational attainment. In so doing, we adopt three different approaches to take into account the recession effect examining, for the first time to our knowledge, the nexus between over-education and economic resilience of local labor markets (Martin, 2012). Second, we add empirical evidence to the determinants of over-education, distinguishing over-qualification from over-skilling. Finally, we provide fresh evidence of the Italian Ph.D graduates' situation; based on our knowledge, our study is the first to use the recently issued survey of professional outcomes built on all Italian Ph.D graduates and carried out by ISTAT (2014). This recent survey of Ph.D graduates offers an in-depth and wide observation point allowing a valuable contribution to the growing, but still limited, international literature on Ph.D labour market perspectives. More precisely, we analyze the short term impact of getting a Ph.D on the career pattern of four cohorts of Ph.D recipients at about three and five years after graduation, including also the recent economic downturn.

Our main results confirm that the Great Recession increased the risk of over-skilling while the impact on over-qualification is less robust. Working in R&D based occupations, both within academic or other sectors of the economy, reduces the detrimental effect of the economic crisis on over-education in general. Ph.D recipients that are self employed are instead penalized in the labor market when job mismatch is examined. Among other determinants, and at odds with previous findings applicable to college graduates, it emerges that socio-demographic variables do not impact strongly on Ph.D over-education. Remarkably, among Ph.D workers education and social background seem do not affect significantly the likelihood of skill and title mismatch. Among Ph.D related features, the most striking driver of overeducation is the completion of an experience abroad.

The rest of the paper proceeds as follows. Section 2 reviews to the relevant literature on overeducation and effect of economic fluctuations on skill and education job mismatch. Section 3 presents the data and the econometric approach. It also introduces a distinction between two measures of over-education: over-skilling and over-qualification. Section 4 discusses the results of the empirical analysis focusing on the impact of the Great recession and other relevant drivers of over-education. Finally, concluding remarks follow in Section 5.

2 Literature background

Even if there is nowday a vast literature on over-skilling and over-qualification, a unifing theory on the relevant mechanism does not exist (Devillanova, 2013). Indeed, the economic

literature has proposed a combination of different approaches imported from labor market theories to interpret these two phenomena. First of all, from the point of view of Ph.D students and in line with the human capital theory (Becker, 1964; Mincer, 1974), entering a Ph.D program can be seen as a rational investment which should produce high level of future satisfaction. Satisfaction may have different dimensions, included a pecuniary premium. In relation to this approach, over-education should represent purely temporary and frictional mismatches between Ph.D graduates' human capital and firms' objectives (Leuven et al., 2011).

Similarly, according to the career mobility and search theory (Sicherman, 1991), over-education might be the result of Ph.D holders' search for professional experience considered as needed to get a job position more consistent with their education and skills in their near future. In this case as well, over-education should emerge as a short time phenomenon at the individual level, but, in aggregate, as a constant feature of today society.

On the other hand, the high number of over-educated Ph.D graduates could be related to a variety of labor market imperfections and to the imbalance between demand and supply of qualified labor. This is particularly relevant for Ph.D graduates in view of the widespread and growing saturation of academic positions. Moreover, as stated by the job competition theory (Thurow, 1975) - according to which job characteristics are the only element affecting earnings - in presence of poor employment prospects and rigidity of the demand for highly educated workers, individuals tend both to over-invest in education to enhance their position in the job market and to accept even a job for which they are overqualified. Similar to the job competition model is thus the signaling theory where education performs a mere signaling role (Spence, 1973). In both cases, qualifications become important for jobs allocation, but not for earnings, and significant and persistent over-education should be the result; consequently, we should observe Ph.D graduates partially under-employed with limited or no monetary premium, and hence the occurrence of structural and persistent over-education.

An intermediate explanation between the human capital theory and the job competition theory is provided by the so-called assignment model (Sattinger, 1993; Belman and Heywood, 1997) where both the characteristics of workers and those of jobs available in the economy explain the possible labor mismatches.

In fact, all these different approaches share the idea that whatever explanation is provided, over-education is a potential source of considerable individual, firm and societal costs. At the individual level, overqualified workers undergo salary penalties, and lower job satisfaction (Battu et al., 2000; Verhaest and Omey, 2006; Badillo-Amador and Vila, 2013). Overqualified workers also tend to show higher turnover and absenteeism (Allen and van der Velden, 2001), and lower participation in training (Hersch, 1995; Sloane et al., 1999; Buchel and Mertens, 2004). On the other side of the coin, these features and behaviors entail costs at the firm level, with repercussions in terms of lower productivity and product quality (Tsang, 1987; Kampelmann and Rycx, 2012) and constraints to technological change (Di Pietro and Urwin, 2006). At the societal level, given the high levels of public funding devoted to Ph.D programs in most countries, over-education is associated with a sub-optimal human resources allocation implying significant waste of public resources, higher unemployment (Jackman et al., 1991), lower tax revenues and national income (Mavromaras et al., 2007).

To limit these negative consequences, it becomes important to explore the main causes of

labor mismatch and identify effective policy actions to address them. By the same token, determinants of over-education have been targets of various studies producing mixed empirical evidence. Results are sensitive both to the definition of labor mismatch and also to many supply and demand side heterogeneities (see (Leuven et al., 2011; Quintini, 2011; Caroleo and Pastore, 2013) for recent in-depth reviews). Furthermore, the empirical literature comprises mainly studies applied to first university degree graduates whereas, by contrast, over-education among Ph.D recipients has received limited attention and only few recent empirical studies have investigated the issue.

As a matter of fact, measuring skill mismatch between Ph.D workers and job attributes is a complex issue. Detailed information on competencies and skills possessed by educated workers and those requested by their jobs is limited. Even Ph.D recipients' self-assessments of skill mismatch are quite rare. This is why most of the over-education academic literature focuses on qualification mismatch. While the number of years of education is undoubtedly a good proxy for skills, a small part of literature has investigated the difference between qualification and skill mismatch. Within this recent literature some studies have examined occupational outcomes and labor mismatches of Ph.D graduates in some countries. The US is the most analyzed case with papers on causes and consequences of educational mismatch (Bender and Heywood, 2011), on the adequacy of Ph.Ds supply (Stephan, 1996; Larson et al., 2014) and on the rewards of Ph.D programs (Stephan and Everhart, 1998). For Spain we refer to Di Paolo and Mañé (2016) who analyze which factors influence the qualification and skills mismatch among Ph.D holders and the relationship between mismatches on the one hand and wages and job satisfaction on the other. Returns of the Ph.D on the German labour market are examined by Enders (2002). Some recent papers have also investigated the Italian case drawing data from partial surveys covering only some subsets of Ph.D graduates (Ballarino and Colombo, 2010) and more often with data coming from a single university (Campostrini, 2011; D'Agostino and Ghellini, 2011). In this respect the only exception that we are aware of is Gaeta (2015) who however uses only the first Ph.D national survey published in 2009 by ISTAT.

Mixed results have also been produced by those studies that have analyzed the relationship between over-education and cyclical economic fluctuations; this literature has not focused specifically on Ph.D graduates and is primarily related to college graduates. Adopting a sample of European overeducated workers with a tertiary degree (or more), Croce and Ghignoni (2012) suggest that cyclical conditions matter with regard to over-education incidence from 1998 to 2006. They found that the percentage of overeducated graduates reacts significantly to cyclical movements in GDP and when a cyclical downturn hits the economy, an increase in the incidence of over-education can be expected. In a summary report for OECD, Quintini (2011) concludes that skill mismatch is procyclical with recession. Using individual data on Norwegian college graduates, Liu et al. (2016) find a countercyclical trend of skill mismatch; the correlation is more pronounced within private sector in constrast to public sector fields of study (i.e., health and education).They also show that labour market conditions have a declining but persisting effect on the likelihood of mismatch at early stages of working career. The paper of Altonji et al. (2016) documents that recessions affect labor market outcomes of graduates mainly in the form of earnings losses for the average major and, to a lesser extend, of worst occupation match quality. Similar evidence characterizes the working trajectory of young Canadian college

graduated examined by Oreopoulos et al. (2012). Interestingly, Altonji et al. (2016) report that the recent Great Recession strongly affected workers' perspective compared to the past because of higher cyclical sensitivity of demand for college graduates, in general, and for high-skilled majors relative to the average major. Finally, Cockx and Ghirelli (2016) highlight that during the recent downturn, high-educated youth are less affected in terms of employment and hours worked; however, no prediction is put forward with regards to mismatch. Indeed, because of job polarization characterizing modern economies over last decades Acemoglu and Autor (2011), we could expect relevant fluctuations also in skill mismatch over the business cycle. The recent downturn has hit the economy mainly at the expense of "middle-skill" jobs with middle skill workers during recession tend to be downgraded toward lower-skill job as well as nonparticipation(Foote and Ryan, 2015). At the same time, during recession it may well happen that jobs are re-categorized in terms of education level or skill requirement, that is employers adopt a strategic or opportunistic upskilling across occupations during recruitment in response to higher unemployment. Eventually, it changes the return to investment in higher education and overeducation is likely to emerge (Modestino et al., 2016; Valletta, 2016; Fogg and Harrington, 2011; Di Pietro and Urwin, 2006). The current paper attempts to empirically evaluate if this occurrence marks the early career pattern of the highly educated and skilled Italian Ph.D graduates entering the labour market before and after the Great Recession.

3 Data and empirical strategy

3.1 Data and overeducation measures

The data used in the analysis come from two cross-sectional surveys on the professional outcome of Italian Ph.D graduates carried out by ISTAT in 2009 and 2014[1]. The surveys are based on interviews directed to individuals who got a doctoral degree in Italy in 2004 and 2006 (first survey) and in 2008 and 2010 (second survey), for a total of 41,037 graduates. Among the recipients, the respondents are 12,964 (out of 18,568) in 2009 and 16,322 (out of 22,469) in 2014, with an average response rate of approximately 70%.

The surveys report information on four main issues: personal details and education; job and job search; mobility; family-related characteristics. Since the employment conditions of Ph.D holders are assessed some years after graduation (that is, in the years when the surveys are conducted), the present analysis focuses on the possible mismatch between education and professional outcome in the short medium-term[2].

As for the investigated years, almost 93% of the respondents are employed at the time of the survey and, among them, about 90% of them work in the services sector (which includes also the academic sector and other research-based occupations). Concerning the distribution of the graduates among the scientific fields of study, the highest number of titles was awarded in

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[1]Indagine sull'inserimento professionale dei dottori di ricerca (ISTAT, 2009, 2014). The present analysis uses the ISTAT Microdata for research purposes, available from ISTAT upon request.

[2]In the first survey the employment conditions of the respondents are assessed 3 and 5 years after Ph.D graduation (for those who were awarded the title in 2006 and 2004 respectively), while in the second survey the professional outcome is examined 4 and 6 years after graduation (for those who were awarded the title in 2010 and 2008 respectively).

Table 1: Over-education among Italian Ph.D graduates

Over-qualification	Over-skilling		Total
	Yes	No	
Yes	3,404	248	3,652
No	4,977	9,935	14,912
*Not applicable**	5,175	3450	8,625
Total	13,556	13,633	27,189

*Not entitled to answer about over-qualification as employed already before Ph.D attainment.

Medicine (more than 14% of the respondents), in Industrial and Information Engineering (more than 11%) and in Biology (10%), while the number of Ph.D holders in Math and Computer Sciences and in Earth Sciences are the lowest (3.1% and 2.6% respectively).

In the present analysis, over-education is measured in terms of both skill and qualification mismatch. It is noteworthy to stress that we derive over-education focusing on a subjective approach based on Ph.D graduates' self-assessment.[3] In particular, the first variable of interest, denoted as *over-skilling*, is defined on the basis of a question of the ISTAT survey asking about the utility of the competences acquired during the doctoral program to carry out the job. More specifically, the question is the following: "*According to you*, in order to carry out your current job is getting a Ph.D necessary in fact?"and the possible answers are: "Yes, it is"/"No, it isn't".

The question is asked to all the respondents who were employed at the time of the survey. On the basis of the 27,189 collected answers, a dummy variable has been defined and used as dependent variable in the present analysis: it is equal to one when respondents report that the skills and competences acquired during the Ph.D are not useful to perform the job, and zero otherwise.

The second definition of over-education, aims to assess the utility of the Ph.D title to get a job. In this case, respondents were asked the following question: "Was the Ph.D title an explicit requirement to get your current job?"and the possible answers: "explicitly required", "not required but useful", "neither required nor useful". Differently from the question about over-skilling, the latter is asked only to those individuals who got their job after the completion of their Ph.D. The relevant sample counts 18,564 respondents; they represent about 68% of the Ph.D graduates who are employed at the time of the survey. A dummy variable denoted as *over-qualification* has been defined, taking the value of one when respondents declare that the Ph.D title was neither required nor useful to get the current job and zero if the Ph.D was required or at least useful, even if not formally required.

The total distribution of over-skilling and over-qualification resulting from the two ISTAT surveys is presented in Table 1. About 50% of the respondents who were employed declare

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[3]Usually, the choice among objective, statistical or subjective approach for the measurement of overeducation is driven by data avalaibility as any method has advantages and drowbacks(Hartog, 2000). For instance, the subjective approach, here adopted, on the one hand is supposed to over report overeducation, but on the other, it allows to get updated estimates of the phenomenon (Verhaest and Omey, 2006; Capsada-Munsech, 2015) and it has been largely used in the literature (Capsada-Munsech, 2015; Gaeta, 2015; Di Paolo and Mañé, 2016; Di Pietro and Urwin, 2006)

Table 2: Over-education of workers in University or in R&D based occupations (%)

	University		R&D		Total (N)
	yes	no	yes	no	
Over-skilled	10.0	90.0	15.7	84.3	13556
Over-qualified	6.2	93.8	10.7	89.3	3652

Figure 1: Over-education by study field
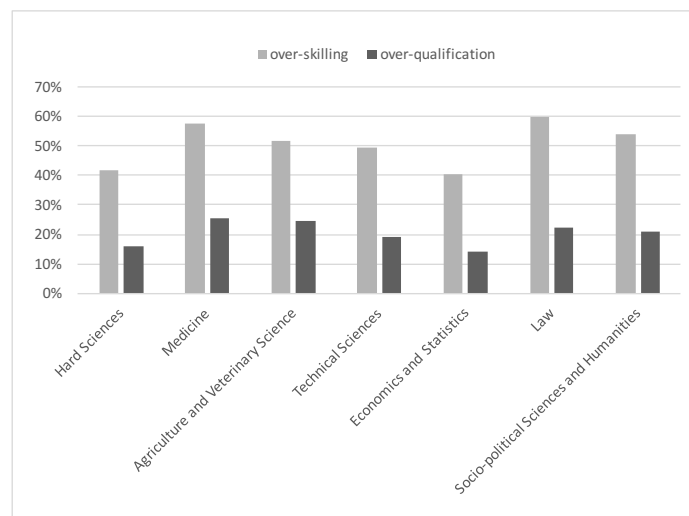
Source: ISTAT, 2009, 2014

to be over-skilled. As for those who got their job after the completion of the Ph.D program, about 20% refer that the Ph.D title was not required neither useful to get their job, thus resulting over-qualified. Moreover, among those who respond to the two questions, just over 53% are found to be adequately matched in terms of job entry requirements and skills required for the job, while 18% result both over-qualified and over-skilled (3,404 out of 18,564) signaling that in Italy over-education is a crucial concern also for the most educated workers[4], although some eterogeneity applies to different sectors. In particular, over-skilling and over-qualification are almost negligible in the academia and for those employed in on R&D activities (see table 2).

Finally, figure 1 illustrates the distribution of over-skilling and over-qualification among fields of study[5].

3.2 Empirical strategy

To evaluate the impact of the Great Recession and to explore the determinants of over-education, we use a probit model. Our dependent variable has a binary outcome, $y_i \in (0, 1)$, where y_i denotes over-skilling or over-qualification. The dependent variable assumes value equals to one when the worker is over-educated; it is zero otherwise. Therefore, given our set of regressors $\mathbf{x}_i$, our goal is to describe $Pr(y_i = 1|\mathbf{x}_i)$ through a function of the form $Pr(y_i = 1|\mathbf{x}_i) = F(\mathbf{x}_i'\boldsymbol{\beta})$, where $F(\cdot)$ is assumed to be normal.

As a binary outcome model, the probit model can be given a latent variable interpretation, by assuming that the variable y_i is linked to an unobserved variable y_i^* according to the following equations:

$$y_i^* = (\mathbf{x}_i'\boldsymbol{\beta}) + e_i \tag{1}$$
$$e_i \sim F(\cdot)$$

$$y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \\ 0 & otherwise \end{cases} \tag{2}$$

In addition, our sample is a non-random selection of potential observations, since the probability of being over-educated is assessed only for those who are employed at the time of the survey; it is unobserved otherwise. To correct for possible sample selection bias, we estimate a bivariate probit model with sample selection (Heckman, 1979; van de Ven and van Pragg, 1981) to ascertain if unobservable factors that affect the propensity to get a job also impact on over-education.[6] This approach yields consistent, asymptotically efficient estimates for all parameters

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[4]While these features resemble those emerged with reference to Spanish Ph.D (Di Paolo and Mañé, 2016), Croce and Ghignoni (2012) show that the average level of over-education among tertiary graduates in Italy over the period 1998-2006 is about 40%. By using the Survey on Adult Skills (OECD, 2012), McGowan and Andrews (2015) report that the proportion of workers aged 16-65 with skill mismatch in Italy for the years 2011-12 is slightly lower than 35%.

[5]As to the definition of the fields of study, *Hard Sciences* includes Mathematics and Computer Science, Physics, Chemistry, Earth Sciences, Biology; *Technical Sciences* includes Civil Engineering and Architecture, Industrial and IT Engineering; *Socio-political Science and Humanities* includes Philology and Literature, History Philosophy and Psychology, Political and Social Sciences.

[6]For example, if no matched job are available, unemployment is an option to avoid overeducation. Thus, the most likely to be overeducated are those least likely to enter employment (Büchel and Van Ham, 2003)

in the model when the correlation through the error terms of the main probit equation of determinants of overeducation and the probit selection equation of the probability of being employed is different from zero. Differently, ignoring the selection into the labour market by using a simple probit model would produce biased estimates of the determinants of the risk of over-education.

The main focus of ther paper is to assess the impact of the Great Recession on the risk of over-education among Ph.D. Starting in late 2007, the financial crisis rapidly propagated around the world. Its effects on economic performance, labour productivity and employment reached a peak in the big recession dated 2008-2009 but in the case of Italy many negative effects of the crisis are still ongoing because of its structural nature and hysteresis phenomena. In addition, in some European countries the financial crisis was followed by the sovereign debt crisis which first involved Greece and then affected Italy as well, assuming a systemic dimension with negative impact on the level of the economic activity.Eventually, these two crises worsened the performance of the national labour market in several ways: people worked fewer hours, the number of jobs available fell, unemployment rose, expectations deteriorated, wages hardly rises if not shrunk and labour market turnover slowed. In the current paper we attempt to evaluate the effects on skill and qualification job matching produced by a labour market that, before and after the economic crisis, operated in significantly different economic conditions and with different opportunities to the newcomer Ph.D holders. Given polarization and strategic and opportunistic upskilling induced by downturns (Acemoglu and Autor, 2011; Di Pietro and Urwin, 2006; Modestino et al., 2016), we expect to observe a stronger effect of the Great Recession on overskilling compared to over-qualification. Because of slack labour market, employers succed to raise education and experience requirements within occupations. Polarization took place at the expence, mainly, of "middle skill" workers and high-skill educated workers, to face the risk of unemployment, may have downgraded to perform also routine task with the risk of raising over-skilling. Nevertheless, we could not observe over-qualification as, because of up-skilling, the match is ensured by the fact that during recession a higher educational title is required to access occupation that previously necessitated a lower level qualification. Moreover, Ph.D course moulds individuals with a strong "taste for science" that, vocationally, are oriented toward careers in academic or research units (Roach and Sauermann, 2010). Usually, for these positions the Ph.D title is a substantial, if not mandatory[7], requirement to access job. This setting gives rise to the expectation that cyclycal fluctuations, and even more so heavy downturns as in the case of Italy, affect overqualification less severely compared to overskilling. In fact, as shown in Table 3, our data indicate that the incidence of over-skilling increases substantially during the crisis, while the proportion of over-qualified appears to be more stable across the two periods. Moreover, as Ph.D holders are concerned, we expect that the risk of overeducation because of an economic crisis are less dramatic for workers into academia or R&D based activities than elsewhere.

As to measurement issues, we first proxy the economic crisis by a dummy variable (*crisis*) that assumes value one if Ph.D graduates were awarded their degree during the Great Recession, that is from 2008, and zero otherwise. According to our sample, this cut off corresponds to separate respondents to first ISTAT survey (graduated in 2004 and 2006) versus respondents to second survey (graduated in 2008 and 2010). As a second indicator, we approximate pre- and after-crisis labour market prospects by computing the relative variation of the value added

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[7]This is particularly true for academic and public sector recruitment.

Table 3: Over-education before and after the crisis (%)

		Before the crisis	After the crisis	Total
Over-skilling	No	54.7	46.5	50.1
	Yes	45.3	53.5	49.9
	Total	100.0	100.0	100.0
Over-qualification	No	80.8	79.9	80.3
	Yes	19.2	20.1	19.7
	Total	100.0	100.0	100.0

Source: ISTAT 2009, 2014

registered in the provincial job area's of a Ph.D worker between 2006 and 2007, as to depict the local labour market economic situation of respondents graduated before the crisis, and between 2010 and 2011 for Ph.D graduated during downturn (*varVA*). Higher values denotes a lower exposure to the economic crisis pointing out a growth of value added across the two points of time. Finally, according to Martin (2012) we observe differences in region's sensitivity to a recession because of its resilience to recessionary shocks. Indeed, resilience denotes the real exposure of the local labour market to a crisis and its capability of economic restructuring to rebound in the face of a crisis. To our knowledge, this indicator has never been adopted before in the context of evaluating effects on overeducation among highly skilled workers. We think this indicator is appropriate given that more resilient labour markets, which are more able to drive regional transformation, to retain manufacturing and to innovate a high-tech economy, can offer more opportunities for skill matching. Accordingly, we use *resilience* as an additional proxy to evaluate the impact of the crisis on the risk of overeducation among Ph.D. This indicator is computed as the job provincial percentage decline in employment relative to the national percentage decline in employment computed in years preceding and during recession for, respectively, Ph.D graduated before and after 2008 in our sample. Values of *resilience* greater than unity reflect local labour markets that can be deemed less resistant to a national recessionary shock compared to local labour markets which report an index of less than unity.

We specify our empirical analysis of drivers of over-education by including three different categories of covariates (x_i) in the main equation: socio-demographic information, Ph.D features and job attributes.

In the first group we include dummy variables to control if the respondend is female (*female*) and Italian born citizen (*citizenship*). To investigate the impact of social mobility on labour market outcomes, the social background of the graduates' family of origin is proxied by parents' educational level (*parents edu*) and social class (*parents class*)[8]. The categorical variable (*province*) controls for the geographical origin of the graduated and possible unobserved heterogeneity. Definitions adopted to identify the categories of the latter variables are briefly illustrated in Table 4.

Features and performance related to the Ph.D educational course are examined by including

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[8]For the definition of the variable *parents class* we followed ISTAT (2003).

Table 4: Variables and summary statistics

Variable (label)	Description	Obs	Mean	Std. Dev.	Min	Max
DEPENDENT VARIABLES						
Over-skilling (oversk)	dummy=1 if over-skilled	27189	0.499	0.500	0	1
Over-qualification (overqual)	dummy=1 if over-qualified	18564	0.197	0.398	0	1
Employment (employm)	dummy=1 if employed	29286	0.928	0.258	0	1
Great Recession (crisis)	dummy=1 if awarded during Great Recession					
Value Added variation (varVA)	Variation of value added over					
Provincial Economic Resilience (resilience)	provincial labour market economic resilience					
SOCIO-DEMOGRAPHIC VARIABLES						
Gender (female)	dummy=1 if female	29286	0.521	0.500	0	1
Citizenship (citizenship)	dummy=1 if Italian	29286	0.984	0.126	0	1
Marital status (married)	dummy=1 if married or living together	29286	0.523	0.499	0	1
Children (children)	dummy=1 if having at least one child	29286	0.377	0.485	0	1
Parents education (parents edu_i)	Parents' highest educational level:					
	_1: junior high school diploma or lower*	29286	0.253	0.435	0	1
	_2: high school or post-high school diploma	29286	0.378	0.485	0	1
	_3: degree or post-graduate	29286	0.369	0.483	0	1
Parents class (parents class_i)	Parents' highest social class:					
	_1: bourgeoisie*	29286	0.301	0.459	0	1
	_2: middle class	29286	0.400	0.490	0	1
	_3: petite bourgeoisie	29286	0.170	0.376	0	1
	_4: working class	29286	0.101	0.301	0	1
	_5: other	29286	0.027	0.164	0	1
Province of residence before Ph.D	categorical variable, province of residence	29286			0	1
Ph.D-RELATED VARIABLES						
Recent cohort(s) (recent cohort)	dummy=1 if most recent cohort of graduates	29286	0.536	0.499	0	1
Age at graduation (Ph.D age)	dummy=1 if 29 (or younger)	29286	0.284	0.451	0	1
Ph.D end (Ph.D end)	dummy=1 if regular duration of Ph.D (3 years)	29286	0.860	0.347	0	1
Visiting abroad (visiting abroad)	dummy=1 if visiting abroad for at least 1 month	29286	0.350	0.477	0	1
Financial support (financial support)	dummy=1 if funding during Ph.D	29286	0.918	0.274	0	1
Study field (study field)	Ph.D scientific field of study:					
	- Hard sciences	29286	0.257	0.437	0	1
	- Medicine	29286	0.143	0.350	0	1
	- Agriculture and Veterinary sciences	29286	0.067	0.250	0	1
	- Technical Sciences	29286	0.191	0.393	0	1
	- Economics and Statistics*	29286	0.059	0.236	0	1
	- Law	29286	0.072	0.259	0	1
	- Socio-political sciences and humanities	29286	0.210	0.407	0	1
Province of Ph.D University	categorical variable, province of Ph.D University	29286			0	1
JOB-RELATED VARIABLES						
Self-employment (selfemployed)	dummy=1 if self-employed	27189	0.138	0.345	0	1
Informal access (informal access)	dummy=1 if informal channels to find job	27189	0.078	0.267	0	1
Academic (academic)	dummy=1 if academic sector	27189	0.342	0.474	0	1
R&D (R&D)	dummy=1 if R&D prevalent in job	27189	0.431	0.495	0	1
Part time (part time_i)	Part-/Full-time contract:					
	_0: Full-time*	27189	0.895	0.306	0	1
	_1: Part-time, no full-time opportunities	27189	0.063	0.244	0	1
	_2: Part-time, voluntary	27189	0.041	0.199	0	1
Job experience (jobexp_i)	Number of jobs:					
	_0: One job (current) started before Ph.D completion*	27189	0.317	0.465	0	1
	_1: One job (current) started after Ph.D completion	27189	0.299	0.458	0	1
	_2: More than one job after Ph.D completion	27189	0.384	0.486	0	1

* denotes the reference category in the estimation.

in the empirical regressions the scientific field of study (*study field*), the age at Ph.D awarding (*Ph.D age*)[9] and a dummy to signal if individuals attended a visiting period abroad (*visiting abroad*). By means of (*recent cohort*), that identifies the the distance between the year of the survey and the year of Ph.D title award, we identifies the most newcomer cohort of Ph.D graduated that entered the labour market. Specifically, *recent cohort* is equal to one for individuals who were awarded the title in 2006 and in 2010, and zero for the others. Finally, because of data limitations, we are able to capture effects related to institutional characteristics at university level, and mainly the Ph.D quality effect, only by including the province where the university awarding the Ph.D title is located (*province*).

As for the professional profile of Ph.D graduates, we include the variable (*sector*) to identify if the Ph.D worker is active in agriculture, industry or service sector. We also add a dummy taking value of one if the respondent works in the academic sector and zero otherwise (*academic*). Similarly, the dummy (*R&D*) signals if the Ph.D worker run a job mainly based on research and development activities. Furthermore, we take into account if Ph.D recipients work as employed or self-employed workers (*selfemployed*) and we include a variable describing whether the job is full or part-time (*part time*), distinguishing also if the part time is voluntary or compulsory. The variable (*jobexp*) registers the number of professional experiences between the year of Ph.D end and the year of the survey taking into account also if the actual job is held already before the Ph.D completion. We complete the set of job features by considering whether family networks or other informal channels helped in getting the job (*informal access*).

Concerning the selection equation adopted to correct for potential sample selection, the estimation procedure requires the inclusion in the selection equation of regressors that can be legitimately excluded from the set of the esplicative variable of the main model of the risk of over-education.[10] In other words, we need to select at least one instrument variable that influences the probability of being employed at the time of the survey, but not the probability of being over-educated. Following the reference literature, we used two variables pertaining to the graduate's own family as exclusion restrictions for the employment equation: marital status (*married*) and children (*children*). More specifically, studies on the reliance of wage premium for married men have confirmed that married men are, or are perceived to be, more valuable employees as more stable and committed workers (see de Linde Leonard and Stanley (2015) for a recent survey). This prejudice may help married men to outperform in employment selection. Additionally, it is well documented the inertia of sociological models such as "male bread winner", that assign more financial responsibility on man, within Italian families (Naldini and Jurado, 2013). Besides the marital status, also to have children may have some bearing on the motivation of the Ph.D graduate towards paid employment, as pointed out in Dolton and Vignoles (2000) and Di Pietro and Cutillo (2006) and, also in this case, the influence of childcare may be different between men and women. In the light of the arguments just illustrated, the variables chosen as

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[9]The format of microdata used in this analysis does not report the puntual age of respondents; it reports age by class at the time of Ph.D completion. Because of different coding of age classes across surveys, we have been only able to build a dummy variable taking value of one if the title has been obtained at the age of 29 or earlier and zero otherwise.

[10]Actually, model is basically identified by functional form because the bivariate probit model is non-linear. However, adopting a proper set of instruments allow us to avoid multicollinearity problems and insure a better identification of the model (Büchel and Van Ham, 2003).

exclusion restrictions have been included in the selection equation both directly and interacted with the variable *sex*. Additionally, socio-demographic information, Ph.D-related features and the variable on the area of residence are included among the regressors of the employment status in the selection equation.

All the dependent and independent variables outlined above are briefly defined in Table 4, which also reports the relevant summary statistics.

4   Results and discussion

This section presents the empirical results of the econometric model for over-education determinants with a focus on the impact of the Great Recession. Firstly, we comment results of the empirical model of over-skilling, then we move to analyze the drivers of over-qualification. As a general approach, we start estimating a baseline model which includes the whole set of assumed drivers of over-skilling and over-qualification excluding proxies for the Great Recession.Second, we examine the impact of the Great Recession adding our adopted proxies for the crisis.

4.1   Overskilling

Table 5 reports the estimates of the probability of being over-skilled for all Ph.D recipients. As the coefficients of the selection term are statistically different from zero, we rely on the estimates of the probit models with sample selection[11]. Table 5 show these estimates distinguishing results of the main model of determinants of over-skilling (columns 1, 3, 5 and 7) and results of the employment selection equation (columns 2, 4, 6 and 8). The variables chosen as instruments in the selection equation are significant and show the expected sign: having children and being married increase the probability of getting a job, denoting a relatively higher urgency to provide family sustenance. However, when also the sex variable is taken into account, a disadvantage for women emerges: being a woman with children or being a married woman reduces the probability of finding a job, confirming our theoretical predictions. Notably, the coefficient of the dummy *crisis* shows a negative and significant sign confirming our expectation that during a recession opportunities to find a job are relatively scarce and being unemployed is more likely. Overall, results of the whole selection model return to be almost stable across all the estimated models.

In column (1)-(2) of table 5, we report estimates of the baseline equation. The estimates of the empirical model of the impact of the Great Recession, that is of the three key regressors *crisis*, *varVA* and *resilience*, on over-skilling are reported through columns (3)-(8).

Before discussing the impact of Great Recession, we briefly comment the estimates reported in column (1) as to improve the general understanding of the drivers of over-skilling among Ph.D graduated. Our results report a weak impact of the socio-demographic characteristics of Ph.D holders, a piece of evidence already emerged in previous studies (Gaeta, 2015; Di Paolo and Mañé, 2016). As an exception, to confirm results obtained by Dell'Aringa and Pagani (2011)

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[11]Nevertheless, the probit models and the probit models with sample selection return similar estimated coefficients in terms of sign and significance of regressors. Results of the probit models are available upon request.

and Beckhusen et al. (2013) among others, we detect a significant higher probability of incurring into over-skilling for foreign Ph.D recipients.

Table 5: Determinants of over-skilling

VARIABLES	(1) oversk	(2) employm	(3) oversk	(4) employm	(5) oversk	(6) employm	(7) oversk	(8) employm
crisis	-	-0.166***	0.113***	-0.118***	-	-0.168***	-	-0.183***
		[0.026]	[0.018]	[0.026]		[0.024]		[0.024]
varVA	-	-	-	-	-1.410***	-	-	-
					[0.414]			
resilience	-	-	-	-	-	-	-0.006*	-
							[0.003]	
female	0.013	-0.012	0.014	-0.010	0.001	-0.006	-0.001	-0.012
	[0.018]	[0.033]	[0.018]	[0.033]	[0.019]	[0.034]	[0.019]	[0.034]
citizenship	0.237***	0.228**	0.238***	0.227**	0.312**	0.199	0.306**	0.203
	[0.091]	[0.115]	[0.091]	[0.115]	[0.124]	[0.145]	[0.124]	[0.145]
parents edu_2	-0.035	-0.049	-0.036	-0.049	-0.034	-0.049	-0.032	-0.047
	[0.026]	[0.035]	[0.026]	[0.035]	[0.027]	[0.035]	[0.027]	[0.035]
parents edu_3	0.007	0.013	0.005	0.012	-0.000	0.017	0.003	0.019
	[0.030]	[0.041]	[0.030]	[0.041]	[0.031]	[0.041]	[0.031]	[0.041]
parents class_2	0.020	-0.084***	0.018	-0.085***	0.007	-0.079***	0.005	-0.079***
	[0.022]	[0.030]	[0.022]	[0.030]	[0.023]	[0.031]	[0.023]	[0.031]
parents class_3	0.005	-0.160***	0.008	-0.161***	-0.009	-0.153***	-0.013	-0.152***
	[0.032]	[0.043]	[0.032]	[0.043]	[0.033]	[0.043]	[0.033]	[0.043]
parents class_4	-0.010	-0.107**	-0.014	-0.108**	-0.016	-0.096*	-0.017	-0.095*
	[0.038]	[0.051]	[0.039]	[0.051]	[0.039]	[0.051]	[0.039]	[0.051]
parents class_5	-0.036	-0.199***	-0.056	-0.212***	-0.058	-0.182***	-0.059	-0.173**
	[0.058]	[0.071]	[0.059]	[0.071]	[0.060]	[0.073]	[0.060]	[0.073]
Ph.D age	-0.021	0.070**	-0.027	0.070**	-0.005	0.042	-0.005	0.041
	[0.020]	[0.028]	[0.020]	[0.028]	[0.021]	[0.028]	[0.021]	[0.028]
recent cohort	-0.055***	-0.113***	-0.049***	-0.111***	-0.045**	-0.116***	-0.046**	-0.116***
	[0.018]	[0.024]	[0.018]	[0.024]	[0.018]	[0.024]	[0.018]	[0.024]
visiting abroad	-0.136***	0.084***	-0.151***	0.080***	-0.120***	0.035	-0.118***	0.037
	[0.019]	[0.026]	[0.019]	[0.026]	[0.020]	[0.026]	[0.020]	[0.026]
jobexp_1	0.104***		0.114***		0.127***		0.124***	
	[0.021]		[0.022]		[0.022]		[0.022]	
jobexp_2	0.019		0.019		0.047**		0.047**	
	[0.021]		[0.021]		[0.021]		[0.021]	
hard science	0.032	-0.165***	0.030	-0.167***	0.028	-0.173***	0.028	-0.175***
	[0.041]	[0.055]	[0.041]	[0.055]	[0.043]	[0.057]	[0.043]	[0.057]
medicine	0.203***	0.043	0.198***	0.037	0.192***	0.051	0.192***	0.050
	[0.044]	[0.061]	[0.044]	[0.061]	[0.045]	[0.063]	[0.046]	[0.063]
agric. and veter. sc.	0.120**	-0.190***	0.120**	-0.194***	0.085	-0.167**	0.091*	-0.166**
	[0.053]	[0.068]	[0.053]	[0.068]	[0.054]	[0.070]	[0.054]	[0.070]
technical sciences	0.106**	0.093	0.104**	0.090	0.084*	0.101*	0.086*	0.100
	[0.042]	[0.059]	[0.042]	[0.059]	[0.044]	[0.061]	[0.044]	[0.061]
law	0.220***	-0.135**	0.219***	-0.142**	0.196***	-0.124*	0.195***	-0.125*
	[0.049]	[0.066]	[0.050]	[0.066]	[0.051]	[0.067]	[0.050]	[0.067]
soc.-pol. sc. and hum.	0.048	-0.334***	0.051	-0.339***	0.004	-0.325***	0.005	-0.328***
	[0.042]	[0.055]	[0.042]	[0.055]	[0.043]	[0.057]	[0.043]	[0.057]
sector_2	-0.242***		-0.251***		-0.229***		-0.225***	
	[0.032]		[0.032]		[0.033]		[0.033]	
sector_3	-0.241***		-0.261***		-0.228***		-0.218***	
	[0.066]		[0.067]		[0.067]		[0.067]	
part time_1	0.229***		0.224***		0.201***		0.202***	
	[0.033]		[0.033]		[0.031]		[0.030]	
part time_2	0.218***		0.235***		0.205***		0.196***	
	[0.043]		[0.043]		[0.042]		[0.041]	
selfemployed	0.105***		0.110***		0.087***		0.089***	
	[0.025]		[0.025]		[0.025]		[0.024]	
informal access	0.028		0.030		0.029		0.023	
	[0.031]		[0.031]		[0.032]		[0.032]	
academic	-1.000***		-0.996***		-1.005***		-1.004***	
	[0.022]		[0.022]		[0.023]		[0.023]	
ReD_d	-1.092***		-1.084***		-1.040***		-1.041***	
	[0.019]		[0.020]		[0.020]		[0.020]	
children		0.200***		0.202***		0.219***		0.218***
		[0.052]		[0.052]		[0.053]		[0.053]
female*children		-0.371***		-0.373***		-0.375***		-0.373***
		[0.061]		[0.061]		[0.062]		[0.061]
married		0.280***		0.281***		0.276***		0.273***
		[0.045]		[0.045]		[0.046]		[0.046]

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female*married		-0.257***		-0.260***		-0.237***		-0.229***
		[0.056]		[0.056]		[0.056]		[0.056]
Constant	0.639***	1.732***	0.584***	1.715***	0.629***	1.718***	0.584***	1.722***
	[0.116]	[0.147]	[0.117]	[0.147]	[0.145]	[0.171]	[0.145]	[0.172]
Observations	29,286	29,286	29,286	29,286	26,543	26,543	26,361	26,361

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Social background, as proxied by parents' education and class, provides to be not significant in predicting over-skilling for the whole sample. This finding diverges from previous empirical evidence of positive correlation between higher socio-economic family endowment and job-education matching observed with regard to workers in general (Di Pietro and Cutillo, 2006). However, contrary to the general belief that intergenerational social mobility is persistently low in Italy (Checchi, 2010; Causa and Johansson, 2011) and more in line with our results, Capsada-Munsech (2015) highlights that parental background is pervasive for over-education exclusively for Italian graduates from fields of study that do not lead to a specific occupation while socio-economic origins does not influence the outcome of those who choose more occupationally targeted fields of study. We suspect that this effect is even stronger within our sample as professional specialization is further achieved throughout the Ph.D curse of study.[12].

Looking at the Ph.D-related features, it emerges that more recent cohorts of graduates have a higher probability to get a matched job. The labour market seems to reward those who are endowed with more updated skills. This result is at odds with studies that predict over-education as a temporary status (Rubb, 2003). Moreover, Ph.D graduates who have done experiences abroad are found to be at lower risk of mismatch relatively to their non-mobile peers. Even if we cannot disregard that this difference may depend on unobserved individual features, nevertheless the experience of a visiting abroad may integrate the educational training, therefore constituting a signal of a better-quality educational pattern. Among the scientific fields of study, Economics and Statistics (the reference category) turns out to be the discipline associated with the lowest probability of incurring in over-skilling in tandem with Hard Sciences and Socio-political Sciences and Humanities, whose coefficients are not statistically different from the reference field of study.

As for the job-related variables, doctoral courses confirm to be a forge of qualified human capital particularly tailored for research activity. Those who are employed in the academic sector or conduct R&D activity within other institutions or firms do report a lower risk to be over-skilled as they can entirely take advantage of the knowledge acquired during their doctoral studies. As in Bender and Roche (2013), self-employed workers are characterized by a higher risk of mismatch compared to those working as employees. This result casts doubt on the structural capability of the Italian economy of absorbing and exploiting fully the results of Ph.D higher education.More specifically, working in industry compared to services and agriculture is beneficial for a succesfull skill-job matching. Participation into the labour market as a part-time worker, both if it is voluntary or due to the lack of full-time opportunities, is characterized by

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[12]Nevertheless, we cannot exclude that socio-economic background influences labor market outcomes in a more indirect way. For example, by influencing the probability of getting a job as, according to our estimates, parents' social class is highly significant in the selection equation. In addition, the indirect impact of socio-economic background may reveal by the educational choice pattern starting already from high school (Brunello and Checchi, 2007; Caroleo and Pastore, 2013).

a higher risk of over-skilling compared to be a full-time worker. In addition, to start working after the completion of the Ph.D seems to increase the probability of incurring into over-skilling compared to start before the attainment of the doctoral title. The lack of statistical significance of the variable *informal access* adds robustness to the result that social networks do not impact on Ph.D over-skilling.

Moving to highlight possible differences in skill-job matching before and after the financial crisis, we examine the econometric results of columns (3)-(8). The coefficient of *crisis*, that is the main proxy of the Great Recession, is positive and significant. This result suggests that the Great Recession has deteriorated the probability of Ph.D holders to find the most appropriate job for their skills. The risk of over-skilling is more likely during downturn. In column (5) we report the estimated coefficient of *varVA*. The correlation among this variable and over-skilling is negative suggesting that as the index grows, signalling that the territory is less hit by the crisis, over-skilling is less likely. It reinforces the belief that recessions do not offer opportunities for adequate job matching. We then assess the predictable power of the variable *resilience* in column (7). As the coefficient is negative and statistically, even if weakly, significant, we can conclude that Ph.D holders working in areas with a higher level of market potential incurred in a reduced risk of over-skilling. Overall, the above evidence validates the hypothesis that the Great Recession brought about a deterioration of professional outcomes also in terms of over-skilling determining a waste of human capital as a possible outcome.

Table 6: Over-skilling and the Great Recession in R&D based occupations

VARIABLES	oversk
crisis	0.323***
	[0.026]
academic	-0.852***
	[0.031]
crisis*academic	-0.324***
	[0.043]
R&D	-0.930***
	[0.028]
crisis*R&D	-0.342***
	[0.038]
Constant	0.427***
	[0.122]
Observations	29,286

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

In an attempt to account for heterogeneous impact of the crisis across job characteristics of our sample of Ph.D holder, we extend the empirical model reported in column (3)-(4). Hence, we interact the *crisis* dummy with *academic* and *R&D*, that is those variables that best pick up the worker's taste for science which correspond to the primary vocational attitude of accademically trained Ph.D students. We expect that being occupied into such sectors could protect the workers from the devasting effect of the economic fluctuatuationn as these high-skilled performing jobs face a minior risk of downskilling and, more over, the higly qualified human capital holding such positions can be key factors to relief from an economic crisis by boosting the territorial competitiveness. We report the estimates of interest in table 6. Results are in line with our expectations as the coefficients of the interaction are negativee and stastically significant. Actually, the Ph.D

proves to be worthy for those who succeede to ended up working in academia or carrying on R&D based occupations, which can be intended as vocational jobs of Ph.D training courses, also in risky economic conditions such those related to downturns.

4.2 Over-qualification

Table 7 presents estimates of the predictors, including the impact of the Great Recession, of over-qualification as an alternative definition of over-education. According to the survey's design, this variable is defined only for those Ph.D graduates who found a job after the attainment of the doctoral title.

Table 7: Determinants of over-qualification.

VARIABLES	(1) overqual	(2) employm	(3) overqual	(4) employm	(5) overqual	(6) employm	(7) overqual	(8) employm
crisis	-	-0.150***	0.014	-0.152***	-	-0.174***	-	-0.177***
		[0.027]	[0.028]	[0.028]		[0.027]		[0.027]
varVA	-	-	-	-	0.267	-	-	-
					[0.648]			
resilience	-	-	-	-	-	-	0.000	-
							[0.005]	
female	0.080***	0.009	0.083***	0.008	0.060*	0.041	0.065**	0.039
	[0.030]	[0.036]	[0.030]	[0.036]	[0.032]	[0.037]	[0.031]	[0.037]
citizenship	-0.007	0.213*	-0.008	0.214*	-0.022	0.117	-0.025	0.120
	[0.134]	[0.124]	[0.133]	[0.124]	[0.171]	[0.157]	[0.171]	[0.157]
parents edu_2	0.001	-0.040	0.001	-0.040	0.002	-0.042	0.008	-0.042
	[0.038]	[0.038]	[0.038]	[0.038]	[0.039]	[0.039]	[0.039]	[0.039]
parents edu_3	0.009	0.011	0.008	0.011	-0.014	0.017	-0.011	0.018
	[0.044]	[0.045]	[0.043]	[0.045]	[0.045]	[0.046]	[0.045]	[0.046]
parents class_2	0.018	-0.077**	0.019	-0.077**	0.005	-0.068**	0.005	-0.070**
	[0.032]	[0.034]	[0.032]	[0.034]	[0.034]	[0.034]	[0.034]	[0.034]
parents class_3	0.066	-0.157***	0.067	-0.157***	0.032	-0.144***	0.038	-0.143***
	[0.046]	[0.047]	[0.046]	[0.047]	[0.048]	[0.048]	[0.048]	[0.048]
parents class_4	0.086	-0.094*	0.086	-0.093*	0.058	-0.076	0.059	-0.076
	[0.054]	[0.056]	[0.054]	[0.056]	[0.056]	[0.057]	[0.056]	[0.058]
parents class_5	0.024	-0.269***	0.024	-0.269***	0.007	-0.256***	0.024	-0.257***
	[0.084]	[0.079]	[0.083]	[0.079]	[0.088]	[0.082]	[0.087]	[0.082]
Ph.D age	-0.094***	0.204***	-0.097***	0.204***	-0.077**	0.180***	-0.081***	0.180***
	[0.030]	[0.030]	[0.030]	[0.030]	[0.031]	[0.030]	[0.031]	[0.030]
recent cohort	0.058**	-0.165***	0.061**	-0.165***	0.069**	-0.179***	0.075***	-0.179***
	[0.027]	[0.027]	[0.027]	[0.027]	[0.029]	[0.027]	[0.029]	[0.027]
visiting abroad	-0.151***	0.200***	-0.154***	0.200***	-0.112***	0.146***	-0.117***	0.146***
	[0.028]	[0.028]	[0.028]	[0.028]	[0.029]	[0.029]	[0.029]	[0.029]
jobexp_1	0.039		0.040		0.034		0.038	
	[0.025]		[0.025]		[0.026]		[0.026]	
hard sciences	0.013	-0.081	0.013	-0.081	0.040	-0.083	0.040	-0.086
	[0.060]	[0.061]	[0.060]	[0.061]	[0.063]	[0.063]	[0.063]	[0.063]
medicine	0.217***	0.015	0.215***	0.015	0.233***	0.035	0.237***	0.029
	[0.064]	[0.068]	[0.064]	[0.068]	[0.068]	[0.069]	[0.068]	[0.070]
agric. and veter. sc.	0.102	-0.166**	0.103	-0.166**	0.088	-0.134*	0.103	-0.135*
	[0.075]	[0.075]	[0.075]	[0.075]	[0.078]	[0.076]	[0.078]	[0.076]
technical sciences	-0.018	0.108*	-0.019	0.108*	-0.000	0.134**	-0.002	0.135**
	[0.062]	[0.066]	[0.062]	[0.066]	[0.066]	[0.067]	[0.066]	[0.067]
law	0.146*	-0.281***	0.148*	-0.281***	0.174**	-0.253***	0.179**	-0.254***
	[0.077]	[0.075]	[0.077]	[0.075]	[0.080]	[0.077]	[0.079]	[0.077]
soc.-pol. sc. and hum.	0.171***	-0.385***	0.175***	-0.385***	0.155**	-0.365***	0.174**	-0.368***
	[0.066]	[0.061]	[0.065]	[0.061]	[0.070]	[0.063]	[0.069]	[0.063]
sector_2	-0.379***		-0.378***		-0.383***		-0.389***	
	[0.040]		[0.040]		[0.043]		[0.043]	
sector_3	0.007		0.005		0.015		0.015	
	[0.087]		[0.087]		[0.091]		[0.090]	
part time_1	0.202***		0.200***		0.188***		0.181***	
	[0.042]		[0.042]		[0.043]		[0.043]	
part time_2	0.297***		0.298***		0.278***		0.279***	
	[0.056]		[0.056]		[0.058]		[0.057]	
selfemployed	0.478***		0.476***		0.470***		0.466***	
	[0.038]		[0.038]		[0.039]		[0.039]	
informal access	0.155***		0.155***		0.163***		0.150***	

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	[0.041]		[0.041]		[0.043]		[0.043]	
academic	-0.830***		-0.824***		-0.829***		-0.814***	
	[0.052]		[0.054]		[0.060]		[0.063]	
ReD_d	-0.931***		-0.924***		-0.894***		-0.881***	
	[0.044]		[0.046]		[0.051]		[0.053]	
children		0.140**		0.139**		0.169***		0.166***
		[0.059]		[0.058]		[0.060]		[0.060]
female*children		-0.368***		-0.367***		-0.386***		-0.382***
		[0.070]		[0.070]		[0.072]		[0.072]
married		0.284***		0.284***		0.295***		0.294***
		[0.050]		[0.050]		[0.051]		[0.051]
female*married		-0.289***		-0.287***		-0.286***		-0.286***
		[0.064]		[0.064]		[0.065]		[0.065]
Constant	-0.233	1.523***	-0.238	1.523***	-0.210	1.552***	-0.198	1.554***
	[0.171]	[0.161]	[0.170]	[0.161]	[0.206]	[0.191]	[0.204]	[0.191]
Observations	20,661	20,661	20,661	20,661	18,280	18,280	18,155	18,155

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Given the results of the selection mechanism, we assume as relevant econometric model the probit estimates with sample selection. For any of the emprical specifications, we report in separate columns the main model of over-qualification and the employment selection equation, respectively. We note that the excluded instruments perform as expected in predicting the probability of being employed: being married and having children prompt individuals to work but can be an obstacle if the worker is a woman. More over, bad economic conditions reduce the probability of being employed.

Considering first the baseline equation shown in column (1)-(2) of table 7, the estimates return results that almost replicate the evidence we found when over-skilling was examined: over-qualification is mainly driven by job characteristic and a minor role is played by socio-demographic characteristis of individuals. As exceptions, female Ph.D graduated incurr with higher probability in over-qualification compared to male and, while foreign Ph.D holders are more prone to over-skilling, they appear to not face over-qualification. Additionally, the variable *recent cohort* now provide to be positevely correlated with over-education showing that the mismatch regarding the required title to perform a job is less penalizing for more recent graduated, and possibly over-qualification is a temporary phenomenon. As the definition of over-qualification is focused on the relevance of the title, so that the title is a necessary condition to get the job and thus it is a yardstick to assess the job-education match, we see that features strictly pertaining the ease of the completion of educational career, such as *age at graduation*, matters revealing that younger Ph.D are less likely to suffer over-qualification. Conversely, this variable does not affect over-skilling.

Focusing on columns (3)-(8) to assess the impact of the recent downturn on over-qualification, we derive an absence of a significant correlation among the whole set of proxies of the Great Recession and title requirement mismatch at work; also, signs of the coefficients are in some cases counter-intuitive. This result was not completely unexpected. We prospected a reduced effect of the Great Recession on over-qualification compared to overskilling. Sectors where the title requirement is relevant or mandatory probably performed less opportunity in term of job position offered because of the crisis - as also revealed by the coeffcient of *crisis* of the selection equation - but it is more difficult that they underperform in term of over-qualification. Along this real title-job match, we observe a misleading outward match. Our definition of over-qualification is more picking up the employer perspective that adopt the title as a yardstick for human capital

selection. As the Great recession has induced a strategic behavoiur leading to upàskilling, the job match in term of title requirement is met even if it is substantial if we focus on skill job content.

Interestingly, consider results in table 8 of the estimates of the more structured model of over-qualification obtained by augmenting the model in column (3)-(4) with interactions terms of crisis and job characteristis. Once we control for sector and job peculiar respons to the Great Recession, it turns out that the variable *crisis* significantly increases the risk of over-qualification. At the same time, it is confirmed that working in academia or doing R&D based activity moderates the dampening effect of a recession.

Table 8: Over-qualification and the Great Recession in R&D occupations

VARIABLES	overqual
crisis	0.094***
	[0.032]
academic	-0.707***
	[0.061]
crisis*academic	-0.268***
	[0.074]
R&D	-0.857***
	[0.051]
crisis*R&D	-0.175***
	[0.061]
Constant	-0.308*
	[0.173]
Observations	20,661

Robust standard errors in brackets
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

5 Final remarks

We adopted data on Italian Ph.D holders, graduated from 2004 to 2010, to shed light on the impact of the Great Recession on over-skilling and over-qualification among higly skilled worker; in addition, we contribute to enrich the empirical evidence on main determinants of over-education. Qualification and skills mismatch emerges as a widespread phenomenon within our sample. Almost 50% of the respondents declare to be over-skilled, whereas about 20% result over-qualified. These percentages increase during the recession, markedly in the case of over-skilling.

According to these data, our estimates return a striking impact of the Great Recession on over-skilling. This effect is marked not only when the incidence of the crisis is measured throught a crude dummy that distinguish the years of pre and post crisis but also when we adopt more refined indicators that explicitly take into account local economic performance, such as value added growth, and provincial labour market dinamic, that is provincial resilience. Remarkably, to our knowledge this is the first paper to examine the correlation among over-skilling and the crisis by means of economic resilience as proxy. As expected, the impact of the crisis is more pronounced within more resilient labour markets. The effect of downturn on over-skilling is less marked among Ph.D working in the academia or performing R&D activities as main occupation at work. The protecting effect from the downturn disruptions played by these factors appears to be at work also when over-qualification is examined. Nevertheless, the direct impact of the

Great Recession on over-qualification is less robust. Infact, the adopted proxies of the crisis do not return significant coefficients in the estimated models, with the exception of the crisis dummy when we assume an empirical model with interactions aimed at capturing peculiarities of research oriented occupations. These results are in accordance with our expectations.

As to other drivers of over-education, socio-demographic variables do not seem to affect significantly the probability of being over-educated, at least not as much as they do in the case of graduates. Surprisingly, the family of origin of doctoral graduates does not influence over-education, a result that is encountered in other very recent emprical investigation (Capsada-Munsech, 2015) but that is at odd with general expectations about inter-generational mobility of graduates in Italy (Checchi, 2010). This evidence deserves major insights to evaluate if the relationship between socio-economic background and professional outcomes becomes looser as educational attainment increases or if other explanations, for example istitutional changes whitin the universtity system (Argentin and Triventi, 2011), are more likely to interpret this result. Internatioonalization turns out to be a key aspect of a Ph.D training course as attending a visiting period abroad turns out to be the characteristic that mostly affects a succesfull job matching. Additionally, the risk of over-education is not equally distributed across fields of study as Ph.D graduated in humanieties are more likely to be mismatched compared to peers gratuated in economics or science and tecnhology. Overall, the strong result of this paper is that job characteristis are the main drivers of the risk of mismatch among Ph.D holders; they exert similar impact on oversklilling and overqualification. Beside a preminent protective effect induced by holding position in University or R&D based centers, we stress that self-employers face a higher risk of incurring in overeducation.

In terms of policy implications, over-education is not only a problem for individuals (dissatisfied workers) and firms (declining productivity) but should be also a concern for policy makers. First, governments devote growing amount of financial resources to Ph.D initiatives; consequently they have the duty of monitoring the real effect and the return of public investment in doctorate programs. Shedding light about over-education makes the government (and the PhD market) better decision makers. Second, policy makers can affect the over-education phenomenon by influencing both the demand for and the supply of Ph.D graduates. For instance, demand policies might provide tax incentives for hiring skilled workers, whereas, on the other hand, governments could affect the supply of PhD, for example, reducing the private costs of doctorates, or, if necessary, taking into consideration the distributional heterogeneity of over-education among different subjects. If so, the government has to face the issue of how to re-orientate the Ph.D system away from those areas where over-education is higher. Our findings also provide a strong support to design Ph.D courses with powerful incentives to do research activity abroad, not only to improve employability, but also to reduce over-education. Third, the public sector is the largest employer of Ph.D graduates. Our results corroborate the idea that providing public support does not necessarily imply a waste of public resources, as, among other things, it can favor better results in terms of matching. This indication proves to be relevant especially in a time of shortage of public funding of the academic sector. Moreover, the impact of ensuring funding to Ph.D students may reinforce their probability to avoid over-education as it helps to achieve the graduation day without extra-time.

More in line with the assignment model approach, job-related characteristics are strong

drivers of over-education as well. The Italian Ph.D proves to be still a research oriented educational pattern, since working in academia or in research intensive sectors is a undeniable factor for a successful matching. This is partially due to the increasing competition in the academic job market which forces many good candidates to turn to positions outside the academia. In this respect if there is consensus that Ph.D programs should also favor the transfer of knowledge outside academia, our evidence calls out for more incisive policies to achieve such a mission. The current economic crisis makes this need even more urgent. Indeed our findings call for some policy actions also promoting a more applicable type of knowledge, such as general analytical skills and general problem solving attitude, which might be more valuable outside the academia and pure research sectors. At the same time, attention should be paid to promoting a more knowledge-based development absorbing more high-skilled Ph.D graduates to foster higher value-added productions and reinforcing links between universities and other productive sectors. Given the industrial structure of the Italian economy, strongly based on small enterprises, accommodating a higher number of Ph.D holders represents another reason for a move towards a larger average size of Italian firms. Besides as most of Ph.D holders are usually employees, it is not surprising that working as self-employed does not provide a positive outcome in terms of job-education matching. In fact, we observe that self-employed workers face significant obstacles to find a job that properly matches their education profile in recession times. It may happen because they encounter difficulties to start and/or run an activity at a scale adequate to their skills. Financial constraints, that become more severe during crises, offer a plausible explanation for this occurrence. This opens the route for policy measures, such as broader credit facilities or business incubators, facilitating better future job education matching. Finally, since those who get a job via informal channel incur more likely into over-skilling, an intervention on the placement side is also advisable. It may constitute a suggestion to strengthen the placement services offered by universities in order to increase the employment prospects/match each job candidate with the best possible opportunity to fit her study achievement.

However, as usual, further research is needed not only to better explain our findings about the determinants of over-education, but also to investigate at the Ph.level the role of other variables as for instance the academic standing of teaching and research quality of the university that granted the doctorate. Besides further research should be devoted to better understand the consequences of over-education analyzing, for instance, the relationship between over-education on the one side and earnings and worker satisfaction on the other. There is also a need to study over-education dynamics over time once the great recession will be over, a piece of research that unfortunately we cannot do yet.

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