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PhD holders propensity to work in research-intensive sectors: evidence from Italy

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Abstract

The present study aims at estimating the probability of PhD holders to work in research- intensive sectors in Italy. We use data available from the National Institute of Statistics for the year 2018, to estimate a probit model with the Heckman correction for the sample selection bias. The novelty of this paper is the broad analysis done to all the entire population of Italian PhD holders and also the informative richness of the dataset employed. Our results document a negative association between age, being female, and a positive association between STEM areas and the estimated probability. Moreover, one result that emerges from the analysis is a lack of capacity of Italy's research institutions to retain Italian researchers in their own country. In this respect, the study has political consequences related to PhD holders career orientation.

Keywords: Doctoral degree; Job choice; Career attainment; Labor market.
JEL Classification Codes: I21, I23, J21, J24, M54.

1. Introduction

Doctorates play an important role in exploring new research areas relevant to the development of knowledge-based economies, and the investment in PhD education is seen as part of a strategy for tomorrows' society and future innovation (Costley & Lester, 2012; Hancock, 2020). Investment in doctoral studies is huge and governments develop growing political interests to attract students to scientific research careers. If, historically, doctorates aimed at and were absorbed by an academic career dedicated to teaching and research (Jones, 2018), nowadays it is a key task to prepare them to the labor market in different sectors and for a diversity of careers. In fact, the number of doctorates is far beyond the academic vacancies available (Hnatkova et al., 2022; Lin & Chiu, 2016; Yang et al., 2022). Looking at the two last decades, 154,000 new doctorates were registered in 2000 (OECD, 2001), reaching an estimated 651,000 in 2019 (Eurostat, 2022). Moreover, the mission of Higher Education Institutions (HEI) today includes co-

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operation and transferability of knowledge to society, with doctorates being the ones best qualified for production and dissemination of that same knowledge. This is challenging to tackle and cope with new societal challenges (Lešer et al., 2018).

Although doctorates may have different career paths in the perspective of the focus of our work, we will consider two main trajectories. On the one hand, a more traditional one related to research-intensive sectors (e.g., academia, research centers and similar), within a sharp contrast to the restricted number of places available and, on the other hand, a career outside research-intensive sectors at the risk of a significant proportion of PhDs occupying positions for which they are overqualified or outside their areas of expertise (Germain-Alamartine et al., 2021). However, some problems arise. On the one side is the fact that the traditional training of doctorates focusses on the preparation for an academic career and seems to neglect, according to some authors (e.g., Caparros-Ruiz, 2019), a whole set of personal and social skills essential for the job market outside HEI. On the other side, other authors (e.g., McCarthy & Wienk, 2019, p. 2) defend that "If there is a gap that needs bridging, it could be a lack of understanding on the part of employers outside academia of the value of engaging a PhD scholar or graduate to meet these needs".

The debate surrounding these two main objectives of doctoral programs (research and non-research) is not new and includes some questions about the relevance of writing a thesis or about the relevance of the generic competences expected to be developed within a doctoral (Kyvik & Olsen, 2012). According to Kyvik and Olsen (2012, p.221), this "trigger the question whether PhD training still should be common to all PhD students, or whether this training to a larger extent should be tailor-made to meet the various needs of doctorates and employers in different labour markets". Other studies, (e.g., Haapalorpi, 2017) also question the relationship between the labor market and organizational policies outside academia, where doctorates hired to work outside research-intensive sectors, performed special tasks, or played a specific role related to their academic status. Related to this, Barge-Gil et al. (2021) claim that doctorates significantly influence firms' Research and Development (R&D) strategy, mainly at an upstream level. However, other factors, such as firm's connectivity to a science-based perspective or tolerance to risk and failure, also play an important role (Barge-Gil et al., 2021). Other authors also mention other possible socioeconomic impacts and effects (e.g., Degani et al., 2021). Regarding job searching, the report by Ribeiro et al, (2019), which analyzes, among other issues, the career prospects of postdoctoral researchers in Europe in 2017, is somehow surprising. In fact, it indicates that "Although the majority of respondents would like to work in academia (68.3%, cf. question 48), 21.1% of these were also looking for jobs outside academia. Conversely, of the ones who would like to work outside academia, 31.9% were searching for jobs both in and outside academia".

Taking these points as drivers, a rise of doctorates has already begun with a focus on embedding research into professional practices, leading to a first generation of what is known as professional doctorates. Dyrenfurth et al. (2017), within the concept of an industry 4.0 society, outlined a model for a professional doctoral program in technology, aimed to increase the effectiveness of industry by providing high-performing leaders who possess an in-depth set of technological research skills. Yet, the practices regarding PhD careers in and outside research-intensive centers, are different among continents, namely between Europe and North America. In fact, having PhDs working in a more applied research context like in the industry, is a well know practice in North America, with some authors clamming (e.g., Dyrenfurth, 2017) that professional doctoral programs, as applied research contexts, are more fruitful for nations.

Jones (2018) lists a set of differences that distinguish these professionals: (i) career focus – designed to meet the needs of the industry; (ii) domain of research – starting from a practical problem and striving to find solutions; (iii) admission requirements – prerequisite of profes-

sional experience; (iv) mode of study – teaching given in blocks after working hours; (v) socialization – strong component of team work and communities of practice; and (vi) breath of focus – broad knowledge base in the area. According to Marini (2022) this brings political consequences (e.g., doctorates will have to obtain secure positions in any economic sector, incomes will have to be adjusted to their level of specialization).

The need for changing from a more traditional career in research-intensive sectors to a career outside research-intensive ones can also be analyzed by the light of the concept of Self-Determination Theory (SDT), understood as "a broad theoretical framework for the study of human motivation and personality in organizations and society" (Coccia, 2018, p. 3). In fact, and regarding scientific productivity, SDT seems to explain that, although some political changes and fund constrains, productivity is growing (Pagliaro & Coccia, 2021). This raises the idea that SDT may also explain some results related to the shift of PhD graduates' propensities towards industries.

Recent studies (e.g., Tocchioni & Petrucci, 2021) have documented that, in recent years, there has been a significant increase in migration of highly educated Italians, a phenomenon known as the "fuga dei cervelli" (brain drain), probably also considering that, in Italy, PhD students' mobility has become a fundamental step during doctoral studies.

Furthermore, certain family characteristics appear to play a role in both educational success and selection for academic careers, with Bredtmann and Smith (2018) suggesting that regarding educational achievement more than a third of the variation can be explained by family history, and with Helin et al., (2022) referring that family background explains more than a third of the overall variation in becoming a PhD and, then, an academic. This may be related in some way to the fact that people with advanced qualifications, such as doctoral studies, generally have better job prospects (OECD, 2020).

Another issue regards gender opportunities at labour market entry level, with several authors (e.g., Chung & Lippe, 2020) referring to gender inequalities and some others (e.g., Rosa & Clavero, 2021) mentioning that gender matters when we talk about the lack of integration of gender in research activities. Regarding tuition fees, the reduction of their value at the doctoral level aims to attract the best doctoral student. Another interesting point is that the field of research is an item that must be considered when assessing the labor market perspectives of doctorates, as emphasized by Hnatkova et al. (2022).

This work focuses on the case of Italy, where the PhD degree was introduced in 1980, later than other European countries (Alberti, 2015). Italy has a high rate (23%) of young adults (aged 25 – 34 years old) leaving school without an upper secondary qualification and is one of the OECD countries with a low rate of less than 30% of tertiary attainment among younger adults. On the other hand, Italy (together with Brazil, Greece, and south Africa) also has the highest share of long-term unemployed young people and features strong regional disparities.

Regarding inactivity rates of tertiary-educated young adults, in 2021 Italy had a share of 20%, that is more than twice the OECD average (OECD, 2022). Data from 2020, show that while 25% of new entrants at all higher education levels chose to study business, administration, and law, those in Italy chose arts and humanities. Furthermore, Italy was one of the 40% of countries where men outnumber women among new entrants, where at least 50% of doctoral students entered a Science, Technology, Engineering and Mathematics (STEM) related field and the completion rates difference between men and women is less than 7 percentual points.

In this paper, we use data collected through the National Institute of Statistics of Italy (ISTAT) for the year 2018 to estimate the likelihood of PhD holders to be employed in research-related fields, including academia, research centres, and industry. At the same time, the study aims to highlight which characteristics considering individual ones, those related to the course of study and research undertaken, and those related to family background, most affect this probability.

Following this introduction that also includes the literature review, the materials and methods used are presented. Then, the next section provides a critical analysis of the empirical contribution based on the case of Italy and, the last section, concludes the study.

2. Materials and Methods

2.1.Sample and data

Our analysis uses data of the "Indagine sull'inserimento professionale dei dottori di ricerca" (Job placement survey of PhD holders) available from the National Institute of Statistics (ISTAT, 2018). Data refer to 2018 and cover individuals who obtained their PhD in Italy between 2012 and 2014. Response rates of these three surveys were around 70%.

Our information source reports several variables related to the educational and research path followed by the individual during the course, on his or her scientific production, information on the individual's characteristics and employment status at the time of the interview as well as related to income.

2.2.Measures of variables

Table 1 reports the main descriptive statistics of applied variables along with a short description of the variables. For expository convenience, the table does not tabulate the percentage breakdown for the various categories. Here we just note that our dataset includes 15,092 doctorates, of whom 14,488 are Italian citizens and just 604 foreign citizens. Furthermore, 10,664 (70.7%) are employed in research intensive sectors, and 4,428 (29.3%) are not.

2.3. Models and data analysis procedure

The aim of our paper is to estimate the probability of PhD holders to work in research intensive sectors. The dependent variable is a dummy that equals 1 if the individual works in such sectors, and 0 otherwise. Specifically, this variable indicates whether the individual predominantly carries out research activities in his or her work. This includes academic work in the narrow sense, work at research institutions, and employment in research and development-related fields.

To this end, we estimate a probit model with the Heckman correction for sample selection given that the outcome variable is not observed for individuals who do not work.

The probit model with sample selection assumes that for individual *j* there exists a relationship:

$$y_j^* = \boldsymbol{x}_j \boldsymbol{\beta} + u_{ij} \quad (1)$$

such that we observe only the binary outcome:

$$y_j = \left(y_j^* > 0\right) \quad (2)$$

The dependent variable y_j is observed only if:

$$y_j = \left(\boldsymbol{z}_j \boldsymbol{\gamma} + u_{2j} > 0\right) \quad (3)$$

Eq. 2 identifies the probit equation, Eq.3 the selection equation.

In the model, we control for: gender, age at the time the individual received the PhD, whether the individual is an Italian citizen, the area in which the individual did the PhD work, whether the individual received research training abroad during the PhD, the self-reported satisfaction over the quality of teaching and research training of the PhD program, if the individual participated in research projects (within universities, firms, international organizations), and, lastly, whether the individual published paper or whether patents have been recognized after having received the PhD. In addition, we control for the role of the socioeconomic background in educational and employment outcomes, captured by the fact that his or her father has a university or post-university degree (Crawford et al., 2016).

Overall, these variables capture individual characteristics and family background on the one hand, and factors that may directly affect an individual's aptitude for working in research-related fields, on the other.

In the selection equation, we use two exclusion restrictions, the marital status and whether the individual has dependent children. The key intuition is that both the type and the composition of the family have a direct impact on the selection probability.

To account for unobserved geographical heterogeneity, in both equations, we control for the region in which the university where the individual received the PhD is located.

Table 1. Descriptive statistics and definition of applied variables

Variable	Mean	Min	Max	Description
Age at PhD	2.65	1	4	1=up to 28 years; 2=29-30 years; 3=31-34 years
Gender	1.53	1	2	Dummy that equals 1 if female, 0 if male
Italian citizen	0.96	0	1	Dummy that equals 1 if Italian citizen, 0 otherwise
Subject area	3.62	1	8	1 = Maths, informatics, physics, chemistry; 2 = Medicine, biology; 3 = Agricultural sciences; 4 = Engineering, architecture; 5 = Humanities, psychology; 6 = Law; 7 = Economics, statistics; 8 = Political science
Training abroad	0.43	0	1	Dummy that equals 1 if received research training abroad, 0 otherwise
Satisfaction (research training)	6.42	1	10	Self-reported satisfaction over research training received during PhD. Score varies between 1 and 10
Research projects after PhD	0.47	0	1	Dummy that equals 1 if the individual carried out research projects after PhD, 0 otherwise
Published scientific papers after PhD	0.78	0	1	Dummy that equals 1 if the individual published scientific articles after PhD, 0 otherwise
Patents after PhD	0.05	0	1	Dummy that equals 1 if the individual obtained recognized patents after PhD, 0 otherwise
Father's education	0.31	0	1	Dummy that equals 1 if the father has a university or post-university degree, 0 otherwise
Marital status	1,54	1	3	1 = Single; 2 = Married, cohabiting; 3 = Separated, divorced
Dependent children	1,62	1	2	Dummy that equals 1 if the individual has dependent children, 0 otherwise

3. Results and Discussion

Table 2 reports the results of our estimations expressed in terms of marginal effects.

Table 2. Probit estimates with Heckman correction for the selection bias. Dependent variable: probability of working in research intensive sectors by PhD holders. Marginal effects.

	Outcome equation	**Selection equation**
Age at PhD (default up to 28 years)		
29-30	-0.035***	-0.008
	(0.010)	(0.005)
31-34	-0.076***	-0.019***
	(0.011)	(0.006)
more than 35 years	-0.109***	-0.021***
	(0.012)	(0.006)
Gender (default male)	-0.055***	-0.029***
	(0.007)	(0.004)
Italian citizen	-0.051***	0.047***
	(0.017)	(0.008)
Subject area (default: humanities, psychology)		
Maths, informatics, physics, chemistry	0.106***	0.028***
	(0.012)	(0.007)
Medicine, biology	0.068***	0.030***
	(0.010)	(0.006)
Agricultural sciences	0.028*	0.027***
	(0.016)	(0.009)
Engineering, architecture	0.080***	0.046***
	(0.011)	(0.006)
Law	0.003	0.020**
	(0.015)	(0.009)
Economics, statistics	0.079***	0.034***
	(0.017)	(0.009)
Political science	0.037*	-0.014
	(0.020)	(0.013)
Training abroad	0.053***	0.006
	(0.007)	(0.004)
Satisfaction (research training)	0.016***	0.005***
	(0.001)	(0.001)
Participated in research projects	0.235***	0.010**
	(0.007)	(0.004)
Published papers	0.176***	0.004
	(0.010)	(0.005)
Patents	0.146***	0.026**
	(0.015)	(0.012)
Father's education (university degree)	0.019**	0.006
	(0.008)	(0.004)
Marital status (default: single)		
Married, cohabiting		0.019***
		(0.005)
Separated, divorced, widow		0.028***
		(0.008)
Dependent children		0.007
		(0.005)
Fixed effects	Region	Region

Note: Wald test of independent equations (rho = 0): $\chi2(1) = 6.65$ Prob > $\chi2 = 0.009$. This table reports the estimates (marginal effects) of the probit model with Heckman correction for the sample selection bias. See equation [1], [2] and [3]. We also control for the region in which the university where the individual received the PhD is located. Robust standard errors are in parenthesis; *p<0.10; **p<0.05; ***p<0.01.

First, the Wald test which tests the hypothesis of independence of errors of the two models demonstrates that the hypothesis that the two equations are independent can be rejected, thus providing evidence of the selection bias. We can conclude that there is a selection bias on unobserved characteristics that turns the sample of those doctorates for whom we observe the outcome variable different from the remaining ones. Moreover, we observe how for many of the selected variables the estimated coefficients are significant at the 1% level.

The likelihood of working in research-related fields decreases as the age at which the individual obtained his or her PhD increases. This is, somehow, aligned with the literature (e.g., Ribeiro et al, 2019) as, in general, researchers currently working in Southern and Eastern Europe were awarded their PhD at an older age than researchers working in Western countries.

Females with doctoral degree are less likely to work in research-related fields than their counterparts[1]. Not surprisingly, as aligned with the literature (e.g., Chung & Lippe, 2020), gender does not only matter at labour market entry level (considering that the coefficient of the selection equation is negative) but also on the likelihood of working in research activities (e.g., Rosa & Clavero, 2021).

The coefficient for Italian citizen is negative and statistically significant at the 1% level, indicating that Italian doctorates, compared with foreigners, show a negative propensity to work in research[2]. Results show a lack of capacity of Italy's research institutions to retain Italian researchers in their own country. This result can be interpreted in light of the fact that most likely Italian researchers look for research opportunities abroad, as aligned with the "fuga dei cervelli" phenomenon documented by the studies of Tocchioni and Petrucci (2021).

If we now consider the area in which the doctoral course was conducted, we observe that, compared with humanities and psychology, the coefficients are positive and significant at the 1% level for all subject areas, except for agricultural sciences and political science, for which the coefficient is significant at the 10% level, and law, whose coefficient is not significant. These results are somewhat predictable. If we then compare the marginal effects for the subject areas with the coefficients significant at the 1% level, we can infer that the largest impact on the outcome probability is for mathematics, informatics, physics, chemistry, while the smallest impact is for medicine and biology. The latter result can be interpreted in light of the continuing migration, for Italy, of the most qualified medical personnel as evidenced by La Colla (2019).

Obviously, having received research training abroad, having participated in research projects, having published scientific papers, having had patents, are factors that increase the outcome probability.

Satisfaction can be understood as a proxy for perceived quality on the individual's research training and, therefore, to some extent, individual skills. Higher satisfaction increases the likelihood of working in the research field, as is reasonable to expect.

The literature documents that the family background is an important determinant of educational attainment both at lower levels of education (Bredtmann & Smith, 2018) and for the attainment of PhDs (Helin et al., 2022). The results show a positive association between the father's undergraduate or postgraduate degree and the likelihood of outcome, as discussed in the literature.

Lastly, we turn to the exclusion restrictions. Both instrumental variables are statistically significant at the 1% level and with the expected sign, thus supporting the choice of these instruments in the selection model.

For better comprehension, table 3 summarizes the statistical association between the factors the main results of our analysis.

[1] Although the overall representation of women in research has increased over time, the gender gap in research systems seems to be a common feature of many OECD-area countries (2020).

[2] Data indicate a small number of foreign students pursuing doctoral studies in Italy, 625 this just 3.9% of the total.

Table 3. Probability of working in research intensive sectors by PhD holders: main results

Factor	Statistical association
Age	-
Gender (female)	-
Italian citizenship	-
Area of study (humanities, psychology)	-
Area of study (maths, science, medical, engineering, economics)	+
Internationalization	+
Perceived quality of research training (skills)	+
Participation in research projects, publication of articles, patents recognized	+
Father's education (family background)	+

4. Concluding Remarks

In this study, we estimate the probability of PhD holders to work in research-intensive sectors, among the Italian population. The novelty of this paper is the broad analysis done to all the entire population of doctorates, thus providing policy makers with fact material to shape the future from here.

This analysis has some limitations, namely because it is performed in a cross-section setting. As for future work, we consider it important to extend the study by applying panel data regressions (thus covering a longer period) and considering additional variables that may help the analysis.

The findings call for a further investigation in the topic. Regarding the fact that Italy struggles to retain its doctorates, policy makers should consider addressing some vital issues to prevent a brain drain. Based on SDT, we suggest that the lack of financial resources to do research, the low salaries, and the long-time of wait before PhD holders have a permanent contract, can push Italian doctorates to a career outside research-intensive sectors. This is true as high-tech industries and emerging Artificial Intelligence steadily increase job opportunities, the offer of higher salaries and better careers.

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