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Satisfaction of the doctorate degree as a determinant of the PhD holders' migration

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ABSTRACT

The migration of highly skilled individuals is widely recognised as a fundamental factor in regional development. Extant studies mainly focus on graduates, while limited attention has been paid to doctoral graduates. This paper investigates the determinants of Italian PhD holders' migration, distinguishing between interregional migration and abroad migration, on three levels: *micro, meso,* and *macro*. The *micro level* refers to individual characteristics; the *meso level* is related to the PhD course and the university attended; and the *macro level* refers to regional characteristics. Data are retrieved from the 2018 retrospective ISTAT national survey. We implement an econometric approach based on a probit model (PM) and a conditional (recursive) mixed process on a multinomial probit regression model (cmp-MPM) à la Heckman, used to contemplate the specific conditions of respondents that migrate (PM) and migrate domestically and abroad (cmp-MPM), where the non-migrant category represents the base category that migrants confront. We contribute to the extant literature by highlighting the role of doctoral pathways, the completion of the doctorate and the quality of the university (*meso level*) in explaining PhD holder mobility, relevant for policymakers and universities.

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Interregional migration; abroad migration; PhD satisfaction; Italy

1. Introduction

This paper focuses on PhD holders, a category of highly skilled individuals only recently focused on in the extant literature (see, e.g., Aronica et al. 2023; Mathies and Cantwell 2022; Tocchioni and Petrucci 2021) and relevant from various perspectives. From a labour market perspective, existing studies reveal that, for certain cohorts, it is increasingly difficult to find an academic job after PhD completion (Mewburn et al. 2020; Parenti, Pinto, and Sarno 2022); consequently, academia is no longer a unique reference

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labour market for PhD holders (Adenijia, Adeniyib, and Shatalova 2023; Alfano et al. 2025; Alfano, Gaeta, and Pinto 2021; Cavallone, Manna, and Palumbo 2024; Tocchioni and Petrucci 2021). Second, from an economic development perspective, highly educated individuals are expected to produce positive externalities in the place where they work and live (Bratti and Conti 2018; Mathies and Cantwell 2022; Ruiu et al. 2019), thereby encouraging the development of new ideas and, thus, supporting innovation and economic development. Lastly, from a regional perspective, it is acknowledged that highly educated individuals are the most mobile (Faggian, Rajbhandari, and Dotzel 2018) and, as such, they can contribute to the economic development of destination places, which in turn may reduce or exacerbate social and economic inequalities among territories (Fratesi and Percoco 2014; Fratesi and Riggi 2007).

When studying the interregional migration of highly skilled individuals, the extant literature – mainly based on graduates' – mostly focuses on individual characteristics (Caragliu et al. 2013a; Faggian, McCann, and Sheppard 2006) and the regional and territorial ones (Faggian and McCann 2006; Fratesi and Percoco 2014; Ruiu et al. 2019). However, and particularly in the case of PhD holders, universities and their doctoral pathways (i.e. PhD course characteristics and students' satisfaction) emerge as important variables to be considered (Aronica et al. 2023; Mathies and Cantwell 2022). Moreover, within the limited literature focusing on PhD holders' migration, major attention has been paid to their job satisfaction, overeducation, and overskilling (see, e.g. Aronica et al. 2023; Gaeta 2015; Parenti, Pinto, and Sarno 2022).

Beginning from these premises, this paper aims to analyse the determinants of PhD holders' migration, distinguishing also between interregional mobility and abroad migration, and considering three different levels: (*i*) 'micro' – that is, their individual characteristics; (*ii*) 'meso' – that is, their doctoral pathway and university quality; and (*iii*) 'macro' – that is, the territorial characteristics.

In pursuing this research objective, we focus on the case of Italy, using data related to the 2018 retrospective national survey provided by the Italian National Institute of Statistics (Istituto Nazionale di Statistica, ISTAT). Italy represents an interesting case since it is very well recognised that its internal migration pattern is significantly characterised by the presence of students who decide to move, especially in the South–North direction (Piras 2021). In this way, their migration choice among regions, rather than acting as equilibrating mechanisms, exacerbates the well-known historical North–South divide that characterises the country (Bacci and Bertaccini 2021; Basile et al. 2019; Iammarino and Marinelli 2015).

We implement an econometric approach based on a probit model (PM) and a conditional (recursive) mixed process on a multinomial probit regression model (cmp-MPM) à la Heckman, which is used to discuss the specific conditions of respondents who migrate both domestically and abroad, where the non-migrant category represents the base outcome that migrants confront.

This study differs from the extant literature for two reasons. First, it considers the university level (i.e. the *meso level*), which has been scantly addressed in previous literature on PhD holders. Second, existing studies often treat migration as an exploratory variable, while this study considers it as the dependent variable. In this way, this paper provides a comprehensive picture of the push and pull factors that affect migration both interregionally and abroad of doctorate graduates, whose decision to relocate is a crucial indicator of knowledge flows and the future socio-economic development of destination countries.

Results of this study contribute to the increasing literature on PhD students and their migration status by highlighting the relevant role that the doctoral pathways, completion of the doctorate, and university quality can play in explaining the mobility of PhD holders. In this respect, results show that the degree of satisfaction with the doctoral pathway has proven to be a relevant factor in explaining the decision to stay or to move after graduation (both in Italy and abroad). Moreover, university quality emerges as an important factor not only in attracting human capital but also in retaining talent, as it is negatively correlated with the propensity to move. These results, particularly those related to the meso level of analysis (i.e. doctoral pathways and university quality), are relevant for policymakers and universities. The results of our study highlight the relevance of the PhD programme, particularly its teaching activities and collaboration with faculty members, as a valuable tool for retaining talent. At the same time, university quality is a fundamental driver of not only attracting students but also of limiting the brain drain of PhD holders.

The remainder of the paper is organised as follows. Section 2 provides an overview of the extant literature and Section 3 presents the data and methods. Section 4 discusses the results and Section 5 concludes the paper.

2. Background studies

The relevance of human capital for economic growth has been widely recognised in the literature (Faggian, Comunian, and Li 2014; Faggian, Modrego, and McCann 2019), particularly when selective migration – that is, migration of highly skilled individuals – is concerned (Faggian, Rajbhandari, and Dotzel 2018; Fratesi and Percoco 2014; Granato et al. 2015). For these reasons, the migration behaviour of graduates has attracted scholars' attention, mainly to understand its determinants (Caragliu et al. 2013a; Faggian, McCann, and Sheppard 2007) and its effect on the destination, both at the regional or country level (Bratti and Conti 2018; Faggian and McCann 2009; Faggian, Rajbhandari, and Dotzel 2018; Karahasan and Bilgel 2021).

Looking specifically at the push factors of migration, individual characteristics prove to be an important component (Corcoran, Faggian, and McCann 2010; Faggian, McCann, and Sheppard 2006), as well as the individual previous history of migration (Newbold 1997), family social and cultural background (Galos 2022; Tosi, Impicciatore, and Rettaroli 2019), and expectations regarding future returns in terms of employment opportunities (Columbu et al. 2021; Di Cintio and Grassi 2017; Ermini, Papi, and Scaturro 2019; Galos 2022). At the regional level, wages, regional GDP, and employment opportunities are positively related to individual migration propensity (Faggian and McCann 2006; Fratesi and Percoco 2014; Ruiu et al. 2019).

When dealing with the selective migration of highly skilled individuals, the extant literature has only recently addressed PhD holders. With regard to micro-level studies in Italy, Ruiu et al. (2019) – based on the 2014 ISTAT professional survey – clearly confirm the existence of a self-selection mechanism in mobility propensity, which is also demonstrated by Faggian, McCann, and Sheppard (2007) in the case of graduates. Further, Tocchioni and Petrucci 2021 – investigating the relationship between family background and international mobility – found a positive impact of high parental education on the propensity to migrate and study abroad. At the same time, the authors

found a moderate effect of parental social class in PhD students' international mobility (Tocchioni and Petrucci 2021). Recently, Aronica et al. (2023) addressed the role of migration on the education–job match and found that individual characteristics affect the decision to move; moreover, they found that females are less likely to move as well as PhD holders who obtain their degree later in life, while the propensity to move is positively affected by a higher parental education level.

Further, certain studies also consider the characteristics of both universities and the doctoral pathway PhD students attended (i.e. the meso level). In Italy, Cavallone, Manna, and Palumbo (2024) found that the perceived quality of the educational service affects students' employability in the Italian labour market, both within and beyond academia. Specifically, these authors found that satisfaction regarding both methodological courses and the digital resources of the university has a positive effect on finding a job in academia. In contrast, satisfaction with the quality of teaching activities is positively correlated with job placement beyond academia (Cavallone, Manna, and Palumbo 2024). Although not explicitly addressing PhD satisfaction, certain university-related variables have been considered in studies of PhD holder migration. Furthermore, PhD holders' migration behaviour has been at the heart of two other studies based in Italy: Cattaneo, Malighetti, and Paleari (2019) and, more recently, Aronica et al. (2023). In 2019, the former study investigated the relationship between scientific performance and PhD holder migration for those who received their doctorates between 2008 and 2010 in the fields of economics, finance, and business management. They found interesting results, highlighting that the relationship between migration abroad and scientific performance is U-shaped. Specifically, they found that the likelihood of international migration declines as scientific performance increases to a certain threshold, but at very high levels of research performance, the relationship reverses (Cattaneo, Malighetti, and Paleari 2019). In their study, Aronica et al. (2023) argue that certain educational variables explain the relationship between migration and overeducation, finding that doctoral degrees in social science disciplines are more likely to be overeducated. These authors also found that good grades and spending time abroad reduce the probability of overeducation (Aronica et al. 2023).

When considering macro and regional characteristics, the migration behaviour of PhD holders is comparable to that of graduates. With regard to job market characteristics, Di Cintio and Grassi (2017) found a positive relationship between wage performance and international migration of PhD holders after graduation; they also highlight that international migration itself is a strategy to capitalise on the personal investment in education.

Recent studies have also examined the migration behaviour of PhD holders in other European countries, highlighting similar drivers related to academic opportunities, research conditions and labour market expectations. By way of example, research on Greek PhD holders shows that they tend to migrate to global cities and to places where international collaborations are stronger (Lois et al. 2022). Similarly, the European study conducted by Mathies and Cantwell (2022) emphasises the role that academic conditions play in shaping PhD holders' migration propensity across Europe. These European findings suggest that the doctoral migration decision is influenced not only by individual characteristics, but also by the structure and the attractiveness of the higher education system.

3. Data, variables, and methods

3.1. Data

The dataset

Our data source relies on the latest edition of the 'Survey on the employability of PhD holders' (*Indagine sull'inserimento professionale dei dottori di ricerca)* carried out by ISTAT in 2018 and referring to PhD holders who obtained their degrees in 2012 and 2014. A total of 15,407 observations[1] were collected. For the econometric analysis, the survey is matched with macro-level regional data collected from ISTAT.

3.2. Variables

Dependent variable

As we are interested in the determinants of the decision to migrate among PhD holders, we account for the migration decision from the moment they complete the doctorate. Thus, in our analysis, we distinguished between those who migrate after the PhD (i.e. the declared region/country of residence differs from where they obtained their doctorate) and those who do not migrate (i.e. those who, after the PhD, reside in the same region in which they obtained their doctorate). The variable takes the value 1 for a migration event and 0 otherwise. Subsequently, migrants were distinguished into those who migrate internally (interregional migration,[2] i.e. from one region to another within the country) and those who migrate abroad. The variable takes the value 1 if the respondent resides in a region different from the one in which he/she obtained their PhD (interregional migration); 2 if the respondent resides in another country (abroad migration); and 0 if he/she did not migrate (i.e. the base outcome) (see Table 3 for variable construction). This distinction follows Marinelli (2013), who focuses on interregional migration of graduates in Italy, and distinguishes between those who do not migrate (i.e. reside in the same region where they studied 'stayers') and those who migrate internally.

We found that 38.1 percent of Italian PhD holders migrate after graduation; of these, 65.3 percent migrate within the country (interregional), and 34.7 percent migrate abroad, the latter corresponding to 13.2 percent of all PhD students (see Table 1). With regard to migration patterns by macro-area of study (Table 2), almost 41 percent of those who obtained their doctorate in the North migrated, and almost half of them (41.1 percent) did so outside Italy, which corresponds to more than half of all PhD students who decided to migrate abroad (54.1 percent). If, on the other hand, we look at those who obtained their doctorate in the south of the country, we see that only a small percentage of them migrate (33.2 percent) and move within the country (interregional migration) (75.7 percent), with the remaining percentage going abroad (abroad migration) (17.4 percent). Lastly, for the PhD holders who obtained their doctorate from the centre of

Table 1. Migration patterns of Italian PhD holders.

	No migrants	Migrants	Interregional	Abroad
% over tot PhD	61.9	38.1	24.9	13.2
% over tot migrants			65.3	34.7

Note: Percentage. *Source*: Author's elaboration on ISTAT data survey, 2018.

Table 2. Migration patterns of Italian PhD holders by macro area of study.

Macro area of study	Freq.	Migrants	Interregional	Abroad
North	6561			
% of tot of migrants by macro area		40.9	58.9	41.1
% of tot of migrants by category (domestic or foreign)		45.7	41.2	54.1
Centre	4465			
		38.8	66.5	33.5
		29.5	30.0	28.5
South	4381			
		33.2	75.7	24.3
		24.8	28.7	17.4

Source: Author's elaboration on ISTAT data survey, 2018.

the country, almost 39 percent moved once they acquired their doctorate, with a majority of them (66.5 percent) tending to migrate within the country.

Regarding the regional spatial distribution, we mapped the percentage of PhD holders in a region who migrate after receiving their doctorate (Figure 1a), within the country (Figure 1b) (i.e. interregional migrants) and abroad (Figure 1c) (i.e. abroad migrants). The map reveals that the majority of human capital loss is in the centre and northeast of the country (between 42 and 59 percent of those who graduate) and in the southern regions of Molise and Basilicata. Conversely, regions experiencing relatively lower loss of high-skilled human capital include Piemonte (in the north), Lazio (in the centre), and the regions of Apulia, Sicily, and Sardinia (in the south). Considering the percentage of doctorates who migrate within the country or abroad, a marked difference between the northern and southern regions is evident. While the majority of PhD holders obtaining their doctorate in the South migrate within the country (Figure 1b), those who obtained their degrees in the northern region migrate abroad (Figure 1c). Sardinia shows a different trend: although it is a southern region, PhD holders who studied there mainly decide to migrate abroad.

Variables and descriptive statistics

The model includes a set of predetermined variables at the time individuals complete their PhD. These variables, entering the model gradually (as in Parenti, Pinto, and Sarno 2022), are distinguished into the three levels: (i) *micro level*, individual characteristics of the PhD holders; (ii) *meso level*, doctoral pathway and the quality of the university; and (*iii) macro level*, regional variables. Descriptive and detailed statistics, along with the corresponding survey questions, are presented in Table 3. The absence of multicollinearity (see correlation matrix, Appendix 1) enables us to include all the variables in the same regression model (the variance inflation factor VIF is consistently below 2).

At the *micro level*, we include a set of variables commonly used as controls: a dummy for sex (*female)*, for civil status (*married/cohabiting*) and for having offspring (*children*).[3] As a proxy of economic conditions and, consequently, a greater likelihood of mobility and study in a different region, we also take into account the social background of the family of origin as indicated by the parents' educational level (*parents' education*) and parents' working occupation (*parents' occupation*) (Aronica et al. 2023; Ermini, Papi, and Scaturro 2019; Ruiu et al. 2019). In our sample, half of the PhDs are female (53.7 percent), of whom 35.7 percent are migrants, compared to males, who have a migration

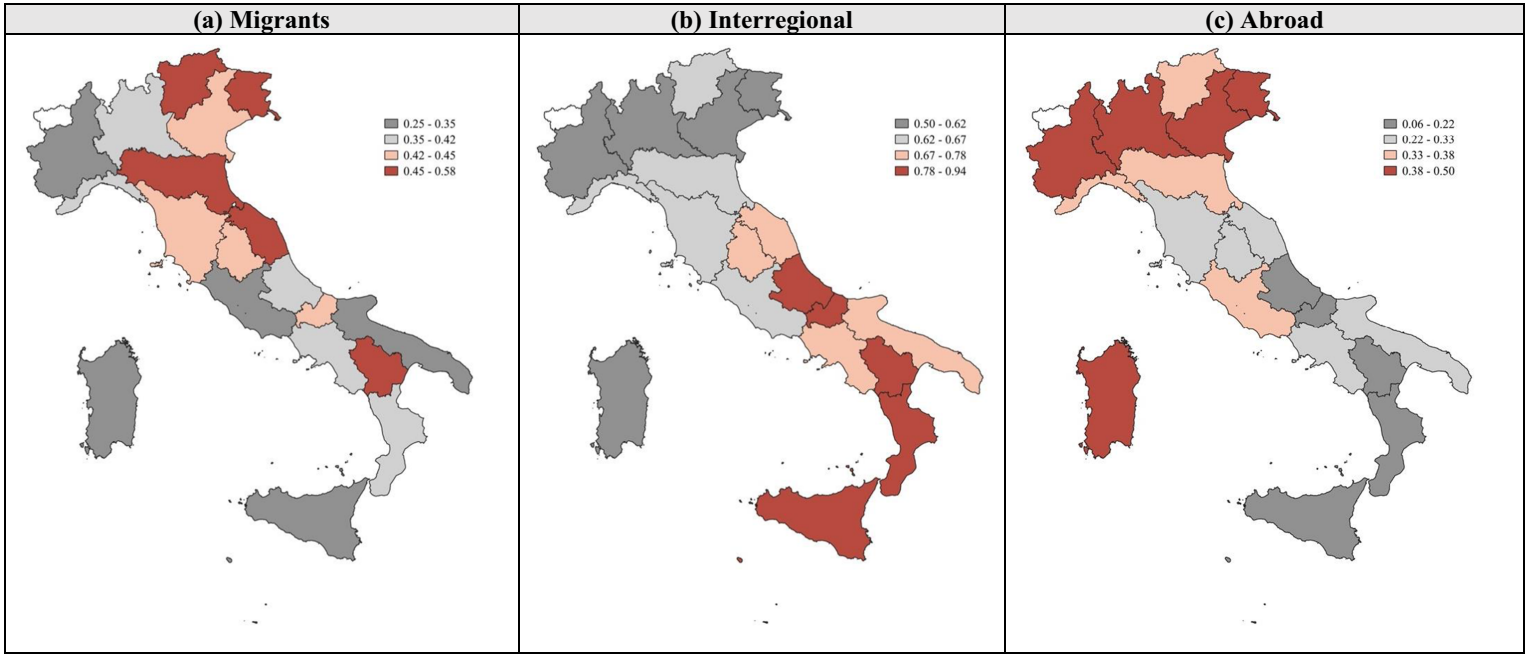

Figure 1. Patterns of migration of PhD holders in Italy (NUTS-2).

Note: Panel (a) percentage of migrants over the total of PhD graduates by region; (b) percentage of interregional migrants over the total of migrants (by region); (c) percentage of abroad migrants over the total of migrants (by region). Source: Author's elaboration on ISTAT data survey, 2018.

Table 3. Descriptive statistics of the sample.

Measure	Freq.	Mean | Std.	Migration Freq.	Interreg Freq.	Notes on variable construction
Dependent variable					
Migration	5871	0.38 | 0.49			Dichotomous variable equal to 1 if the respondent does not reside in the same region where they obtained their PhD, and 0 otherwise (i.e. no migration)
Interregional Migration	3834	0.51 | 0.72			Categorical variable equal to 1 if the respondent resides in a region different from the one in which they obtained their PhD; 2 if the respondent resides in another country; and 0 reside in the same region where they obtain their PhD (i.e. no migration)
Abroad Migration	2037				
Micro level	Freq.	Mean	Migration Freq.	Interreg Freq.	
Female	8176	0.53	2918	2045	Dichotomous variable equal to 1 if the respondent is a female, and 0 otherwise
Married/cohabiting	7031	0.46	2423	1662	Dichotomous variable equal to 1 if the respondent is married or is cohabiting, and 0 otherwise
Children	5772	0.37	1787	1361	Dichotomous variable equal to 1 if the respondent has at least one child, and 0 otherwise
Parents' education	6445	0.42	2634	1670	Dichotomous variable equal to 1 if parents' educational level is tertiary degree or more, and 0 otherwise
Parents' occupation	3701	0.24	3167	2488	Dummy variable equal to 1 if both parents are Employed, and 0 otherwise
Past migration	3701	0.24	3167	2488	Dichotomous variable equal to 1 if the region before enrolled at the university is different from the one they obtain their PhD, and 0 otherwise
Meso level	Freq.	Mean	Migration Freq.	Interreg Freq.	
Macro-area of study					
North (reference)	6561	0.46	2684	1581	Categorical variable indicating the macro-area of PhD study
Centre	4465	0.29	1731	1151	
South	4381	0.28	1456	1102	
Field of specialisation					
SM: Science and Medicine (reference)	5551	0.36	1899	1272	Categorical variable indicating the PhD area of specialisation
PE: Physics and Engineering	4526	0.29	1791	922	
SS: Social Sciences	5330	0.35	2181	1640	
Under 30	6926	0.45	2954	1593	Dichotomous variable equal to 1 if the age at completion of the doctorate was less than or equal to 30 years, and 0 otherwise
In time	12,644	0.82	4782	3083	Dichotomous variable equal to 1 if the PhD was completed in time, and 0 otherwise
Teaching	6491	0.42	2599	1484	Dichotomous variable equal to 1 if the respondent engaged in any teaching activities throughout their PhD, and 0 otherwise
Visiting	6629	0.43	3093	1637	Dichotomous variable equal to 1 if respondent spent a research period abroad during their PhD, and 0 otherwise
Academic career	8024	0.52	3169	1842	Dichotomous variable equal to 1 if has an academic job, and 0 otherwise

(*Continued*)

Table 3. Continued.

Measure	Freq.	Mean | Std.			Notes on variable construction
Degree of Satisfaction	Freq.	Mean	No Mig. | Mig. Mean	Interreg | Abroad Mean	
teaching_satisfaction	15,407	5.87	5.98 | 5.81	6.15 | 5.66	Continuous variable denoting satisfaction from 1 to 10. For all, the minimum was 2 and maximum 10*quality_satisfaction*: the quality of teaching (level of detail of courses, updating of content, adequacy of teaching methods, etc.)
collaboration_satisfaction	15,407	6.76	6.67 | 6.81	6.75 | 6.52	*collab_satisfaction*: collaboration with researchers and professors
resource_satisfaction	15,407	6.18	6.20 | 6.17	6.31 | 5.98	*resource_satisfaction*: the quality of the resources and services available at the host university (equipment, space, and instrumentation)
University Quality	Freq	Mean | Std.	Min	Max	
FFO [a]	14,586	1.96 | 1.35	0.036	5.267	Fondo di Finanziamento Ordinario (100 millions) Continuous variable, mean of three years of study for each cohort: 2010-11-12 for 2012 and 2012-13-14 for 2014. Database: ANVUR
Macro level	Freq	Mean | Std.	Min	Max	
Popdensity	15,407	2..66 | 1.14	0.59	4.38	Number of individuals per square kilometre by one hundred at NUTS-2 level. Database: Eurostat
Employment	15,407	17.58 | 3.98	12.11	25.33	Employees in knowledge-intensive sectors (manufacturing and services) over total of employees at NUTS-2 level. Database: Innovation Istat
Innovation	15,407	1.29 | 0.35	0.43	2.21	Intramural R&D expenditure over gross domestic product (GDP) NUTS-2 level. Database: Eurostat

Note: The total of observations for the micro- and meso-variables is 15,407, and all were retrieved from the ISTAT 'Survey on the employability of PhD holders'. Macro-territorial variables enter the model by graduation year (2012 and 2014). The FFO is not available for the Bolzano and Trento regions.

rate of 40.9 percent. Among *females* who migrate, only 10.7 percent move abroad (males: 16.1 percent). Those who move show a tendency not to have *children* (69.6 percent), not to be married/cohabiting (58.73 percent), and to have both parents employed (89.7 percent) but less educated (44.9 percent have at least one parent who holds a degree or has achieved a higher level of education). These characteristics are more pronounced among those who migrate abroad. We also control whether the past migration, i.e. the individual migrated for their PhD (*past migration*),[4] influences their decision to migrate. In our sample, 24.02 percent of individuals who had migrated after completing their PhD reported having previously migrated (see descriptive statistics in Table 3), in line with the previous findings of Ruiu et al. (2019). Regarding this matter, we conducted a check by omitting international students who completed their PhD in Italy from the model, as we anticipate that they were more likely to return to their home country (refer to the robustness check 4.3 section for details).

The *meso level* focuses on the doctoral pathway and university quality. The doctoral pathway includes a set of variables referring to the scientific area of specialisation

(*Physics and Engineering, Social Science and Science and Medicine)*,[5] which are considered important determinants of PhD mobility (Ruiu et al. 2019); a dummy variable indicating the age at completion of the doctorate (*under 30*), relevant since the probability of migration decreases as individuals get older (Ermini, Papi, and Scaturro 2017; Greenwood 1997); a dummy variable if the PhD has been completed without extending the duration (*in time*), if teaching activity has been conducted during the PhD (*teaching*), and, lastly, if the individual has spent a visiting period abroad (*visiting*). In fact, doctoral studies typically involve opportunities for teaching and international experiences, which can serve as valuable pathways for career advancement after completing the degree (Børing et al. 2015). We also include a control on the macro-area where they obtained their PhD (North: 42.58 percent, Centre: 28.98 percent, and South: 28.44 percent). In our sample, those who hold a PhD in physics and engineering (PE) are the ones who migrate less (34 percent), representing 30.5 percent of total migrants. The percentage increased to 40 percent for those who obtained a PhD in Social Science (SS) and/or science and medicine (SM), representing 37 and 32 percent of total migrants, respectively. Interestingly, these migration behaviours change between interregional and abroad migration. Most PhD holders in the *SS* and *MS* migrate internally (75.2 and 67 percent, respectively), and half of those with a PhD in the areas of *PE* migrate abroad (48.5 percent). Regarding the other characteristics considered at the *meso level* for doctoral graduates who migrate, the majority completed their degrees before the age of 30 (50.3 percent vs. 41.6 percent among those who do not migrate) or visited another country for a certain period (52.7 percent vs. 37.1 percent). However, no difference in percentage terms was found when distinguishing between interregional and abroad migration. Regarding the other variables, the majority of doctorates completed their studies on time (82.1 percent), a proportion that remains identical among those who migrate and those who do not. Unlike the individual 'micro-level' variables, these characteristics are more pronounced among interregional migrants (64.5). Interestingly, in contrast, those who carried out teaching activities during their PhD tend not to migrate (60 percent remain in the region where they obtained their doctorate).

On the doctoral pathway, at the *meso level*, we also included a set of novel variables on perceived satisfaction with the doctorate course, recognised as an important factor for students' learning outcomes, employment prospects, and overall experience. Only recently, Palumbo and Cavallone (2023) and Cavallone, Manna, and Palumbo (2024) examined the effect of doctoral students' satisfaction with educational services on their job prospects, finding a positive correlation between the perceived quality of learning experiences and employability. Accordingly, we argue that PhDs' satisfaction with educational services can be one of the main predictors of doctoral retention. In the ISTAT survey,[6] PhD graduates were asked to indicate their degree of satisfaction – with a score from '1' (lowest level) to '10' (highest level) – regarding the quality of teaching offered (*teaching_satisfaction*), related to the level of detail of courses, updating of content, adequacy of teaching methods; the collaboration with researchers and professors (*collaboration_satisfaction)*, and the quality of the resources and services available at the host university (*resource_satisfaction*) in terms of equipment, space, and instrumentation. In this regard, 59.8 percent of PhD holders declared that they are satisfied with the quality of the teaching (perceived satisfaction valued '6' or more). The level of satisfaction was slightly higher among those who migrated (61.2 percent, sp. corr. = 0.023, p

= 0.005) than among those who do not migrate (59 percent). In terms of collaboration with researchers and professors, most doctorates declared that they were satisfied (72.9 percent rated '6' or more), a mean that was, interestingly, slightly higher among those who do not migrate (mean = 6.81, Std. = 2.51) in comparison with those who do not (mean = 6.67, Std. = 2.58), with a negative correlation regarding migration (sp. corr. = −0.02, $p = 0.008$). This suggests that satisfactory and fruitful collaboration with faculty is a factor that deters the decision to migrate. With regard to the conditional value used to measure satisfaction with the quality of the giving of resources and services, PhD holders also appear to be overall satisfied (65.1 percent). However, no significant dependency appears on the migration decision (sp. corr. = −0.006, $p = 0.44$).

Lastly, at the *meso level*, we included a measure of university research quality. Research quality was assessed based on funding level, measured through the Ordinary Financing Fund (FFO, Fondo di Finanziamento Ordinario),[7] one of the primary sources of revenue for Italian universities. Evidence from Italy indicates that FFO is positively related to productivity and efficiency in public universities, including PhD students and research quality (Nobili and Turri 2025). At this level, we also included a control on the job status. While universities remain the primary employer for PhD holders, those working outside academia often earn higher wages (Ballarino and Colombo 2010). Following the literature on intersectoral mobility in the Italian context (Argentin, Ballarino, and Colombo 2014; Gaeta 2015), we account for the distinct career paths of PhD holders by including a variable to differentiate between those who entered an academic career (52.08 percent of PhD holders) to those who moved to the non-academic sector (42.06 percent) or those who do not have a job (only 5.86 percent). The ISTAT survey includes a question on the sector in which they work, with seven options – four of which correspond to academic sectors (university education, non-university education, and training, research activity conducted by a public entity, and research activity conducted by a private company).

The *macro level* refers to the regional characteristics, and we included a set of well-known local indicators to control for economic drivers of the migration of PhD holders: control on the level of urbanisation (*propensity*), employment in knowledge-intensive sectors (*employment*), and a measure of intramural R&D expenditure over GDP (*innovation*). The regional variables correspond to the specific NUTS-2 region where the university is situated, and the year the degree was granted (2012 or 2014).[8]

3.3. Method

A PhD holder's decision to migrate is influenced by employment opportunities in the destination region. Causal inferences for endogenous explanatory variables might be biased, and control for hidden bias must be engaged. To overcome this, a Heckman correction is used to contemplate the specific conditions of respondents who migrate and their choice(s) within the country or abroad. The Heckman correction, or Heckman two-step procedure, is widely used in econometrics to address selection bias (Heckman 1979). It involves the interaction of two equations: the first equation addresses the mechanisms that determine the outcome variable of interest, while the second equation – known as the selection equation – considers the sample in which the desired result is observed and the mechanisms that determine this selection. In migration

literature, Heckman's correction is often applied to address the endogeneity of employment when analysing the decision to migrate (e.g. see Nifo and Vecchione 2014). Thus, a bivariate probit model conditional à la Heckman is implemented, which simultaneously estimates two equations for every k PhD holder in the j region (NUTS2): one for the employment condition (Equation 1) and one for migration choice (Equation 2).

$$Pr(L_{kj} = 1 \mid Z_{kj}) = \alpha + \gamma Z_{kj} + \varepsilon_{kj}, \tag{1}$$

$$Pr(Y_{kj} = 1 \mid X_{kj}) = \alpha + \beta X_{kj} + \lambda_{kj} + \mu_{kj} \tag{2}$$

where L_{kj} is the dichotomous variable (1, if employed) of the first stage; Z_{kj} is the set of covariates of the employment equation; Y_{kj} is the dependent variable of the model (1 in the event of migration and 0 otherwise); X_{kj} is the set of covariates of the equation of the migration choice (*micro, meso, and macro levels* explained in the previous section).

Once the decision to migrate is divided into interregional and abroad, a multinomial probit model à la Heckman can be estimated using the conditional (recursive) mixed-process model[9] (Roodman 2011). This enables discrete choices (e.g. employment status) and continuous outcomes, thereby accounting for correlations among errors while addressing selection bias. As with the bivariate probit model, the correction term derived from the first stage is included in the second stage of the multinomial-probit mixed-process model (Equation 3) to account for non-random selection into the employment status.

$$Pr(A_{kji} = 1 \mid X_{kj}) = \alpha + \beta X_{kj} + \lambda_{kj} + \mu_{kj} \tag{3}$$

where A_{kji} is the dependent variable of the multinomial probit model represented by the i mobility categories ($I = \text{NoMigrate}_{\text{baseline}}$; Migrate Interregional, and Migrate Abroad). X_{kj} is the set of covariates of the equation of the migration choice, which is the same as those used in Equation (2).

The covariates included in the employment equation Z_{kj} are certain key individual characteristics (*female, marital status, parents' occupation and past migration*) and education-related variables (*ended before 30, field of study, and scholarship*).[10] The first set of variables serves as a proxy of individuals' abilities (Clark and Lisowski 2019; Labrianidis and Vogiatzis 2013), while the second set of variables measures the role of the PhD pathway on the holder's employment status. Previous studies have found that females are more likely to experience an education–job mismatch, while older and more experienced individuals report a lower education–job mismatch (Aronica et al. 2023; Di Paolo and Mañé 2016), with Ph.D. doctors in social sciences being more prone to experiencing overeducation (Aronica et al. 2023; Di Paolo and Mañé 2016). In our data, the former represents the population that declared a higher percentage of unemployment (sp. corr. = −0.06, p = 0.00). We also included a variable indicating whether they received a scholarship during their doctoral programme as a covariate in the selection equation, but not in the main equation X_{kj} (exclusion restriction), since this variable is likely to be correlated with labour market participation but not directly with migration. Our choice is both theoretically and empirically justified. In Italy, receiving a *scholarship* comes with contractual and normative restrictions, such as a time for completing the PhD and also the necessity of focusing on research during that period, which can implicitly shape the immediate post-graduation career expectations and search intensity. Aronica

et al. (2023) find that PhD holders who benefit from a scholarship experience less over-education when they get a job. In contrast, the migration decision is not driven by whether the PhD was supported by a scholarship. In our empirical analysis, being funded during a PhD is a statistically significant predictor of post-PhD employment (sp. corr. = −0.03, $p = 0.00$) but doesn't influence migration (sp. corr. = 0.01, $p = 0.20$), confirming exogeneity.

For the robustness of the analysis, we run a sensitivity check on unobservable variables (see Appendix 2). A linear probability regression was run with meso-level variables and another without (Diegert, Masten, and Poirier 2024). The difference in beta (β) coefficients of the micro level indicates that these variables were correlated with the omitted meso-level factors. The smaller coefficients, lower in magnitude and closer to zero for the combined model, indicate that the treatment variables are almost uncorrelated with the unobserved variables and represent a more accurate and reliable estimation. A delta (δ) was also calculated; it reveals that the combined model significantly reduces the potential bias from unobserved variables, thereby making the coefficients far more robust.

4. Results

The results of the regressions are presented in Tables 4 and 5. The variables are progressively included in the model. Each column corresponds to a level: *micro*, *meso*, and *macro*. Table 4 displays the probit model, where the non-migrant category represents the base outcome that migrants confront. Table 5 presents the mixed process in a multinomial probit regression for those who migrated domestically and abroad, with the non-migrant category as the reference group. Both tables include marginal effects and robust standard errors (see Appendices 4 and 5 for coefficients). With regard to the marginals, dummy variables reflect changes in predicted probabilities when transitioning from status 0 to status 1. In contrast, the marginal effects of continuous variables are interpreted as elasticities – that is, the difference in the predicted probabilities for cases in one category relative to the reference category. In all the regressions, we reject the hypothesis H_0 that the two errors are not related (H_0: $\rho = 0$) using a Wald test. Thus it can be stated that, in the model, there is no self-selection problem, and the estimators are unbiased. Following Heckman (1976), an endogeneity test is also conducted on atanhrho (the arc-hyperbolic tangent) by evaluating the null hypothesis (H0: atanhrho = 0). In the case of the probit model (Table 4), no evidence of sample selection bias is found (columns 2–4), which suggests that the unobserved factors affecting migration and employment are not statistically correlated. Accordingly, a joint estimation is not necessary, and a simple probit model is sufficient.[11] However, when we divide migration by type (Table 5), the null hypothesis of exogeneity is rejected between internal migration and employment (columns 1[a–d]), with a significant Wald test in both models; hence, it is accurate to estimate the two-equation system comprising Equations (1) and (3) à la Heckman rather than separately (Roodman 2011). We also control for Akaike's information criterion (AIC) for each model (Akaike 2015); the result suggests that the model with all levels included – '*micro-meso-macro*' – is preferred (Table 4, column 4; Table 5, columns 1–2 [d]).[12]

Table 4. Migration – probit models à la Heckman.

	Migration			
Baseline: No migration	(1)	(2)	(3)	(4)
Micro level				
Female	**−0.013****	**−0.033*****	**−0.033*****	**−0.033*****
	[0.007]	[0.007]	[0.007]	[0.007]
Married/cohabiting	**−0.015****	−0.007	−0.007	−0.006
	[0.008]	[0.008]	[0.008]	[0.008]
Children	**−0.097*****	**−0.082*****	**−0.082*****	**−0.082*****
	[0.008]	[0.008]	[0.008]	[0.008]
Parent's education	**0.025*****	**0.018****	**0.018****	**0.018****
	[0.006]	[0.007]	[0.007]	[0.007]
Parent's occupation	0.003	0.007	0.007	0.006
	[0.011]	[0.011]	[0.011]	[0.011]
Past migration	**0.516*****	**0.502*****	**0.502*****	**0.501*****
	[0.005]	[0.007]	[0.007]	[0.008]
Meso level				
Centre		**0.022*****	**0.022*****	**0.035*****
		[0.008]	[0.008]	[0.010]
South		**0.035*****	**0.035*****	**0.029*****
		[0.008]	[0.008]	[0.010]
PhysicsEng		**0.025*****	**0.025*****	**0.026*****
		[0.009]	[0.009]	[0.009]
SocialScience		**−0.025*****	**−0.026*****	**−0.025*****
		[0.009]	[0.009]	[0.009]
Under 30		**0.069*****	**0.069*****	**0.069*****
		[0.007]	[0.007]	[0.007]
In time		−0.007	−0.007	−0.006
		[0.009]	[0.009]	[0.009]
Teaching		**−0.016****	**−0.016****	**−0.014***
		[0.008]	[0.008]	[0.008]
Visiting		**0.108*****	**0.107*****	**0.105*****
		[0.008]	[0.008]	[0.008]
teaching_satisfaction		**0.003***	**0.003***	**0.003***
		[0.002]	[0.002]	[0.002]
collaboration_satisfaction		**−0.006*****	**−0.006*****	**−0.006*****
		[0.002]	[0.002]	[0.002]
resource_satisfaction		−0.002	−0.002	−0.002
		[0.002]	[0.002]	[0.002]
FFO		0.001	0.001	0.004
		[0.003]	[0.003]	[0.003]
Academic career			0.006	0.005
			[0.007]	[0.007]
Macro level				
Popdensity				0.002
				[0.004]
Employment				**−0.005*****
				[0.002]
Innovation				0.014
				[0.014]
Observations	15,407	14,586	14,586	14,586
Log-likelihood	−10578	−10003	−10003	−9996
Wald test (*p*-value)	0.000	0.176	0.216	0.296
Atanhrho	−1.819***	0.203	0.193	0.187
AIC	21188.26	20062.78	20064.14	20056.98
First stage				
Female	−0.244***	−0.260***	−0.260***	**−0.260*****

(*Continued*)

Table 4. Continued.

	Migration			
Baseline: No migration	(1)	(2)	(3)	(4)
	[0.034]	[0.035]	[0.035]	[0.035]
Married/cohabiting	0.074**	0.077**	0.077**	**0.077****
	[0.033]	[0.034]	[0.034]	[0.034]
Parent's occupation	0.137***	0.149***	0.149***	**0.149*****
	[0.050]	[0.050]	[0.050]	[0.050]
PhysicsEng	0.175***	0.152***	0.152***	**0.152*****
	[0.043]	[0.046]	[0.046]	[0.046]
SocialScience	−0.171***	−0.207***	−0.207***	**−0.207*****
	[0.035]	[0.038]	[0.038]	[0.038]
Under 30	0.290***	0.207***	0.206***	**0.207*****
	[0.033]	[0.036]	[0.036]	[0.036]
Scholarship	−0.126***	−0.217***	−0.217***	**−0.217*****
	[0.038]	[0.041]	[0.042]	[0.042]

Note: The values reported are the average marginal effects (dy/dx) of the probit regression à la Heckman (coefficients in Appendix 4; probit model in Appendix 3). The number of observations decreases across specifications due to data availability; see Table 3 for descriptive statistics. Estimates are robust to heteroskedasticity. Standard errors are given in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.01$.

4.1. Determinants of migration

Micro level. Beginning with the individual characteristics (Table 4, column 1), they appear significant to explain migration choices: (*i)* being *female* negatively impacts the probability of migrating (both in Italy and abroad) as do (*ii)* having *children*, while (*iii)* the economic background of the family (*parent tertiary education*) and a previous experience of migration (*past migration*) are positively correlated with the probability of being a migrant. All these results are in line with the current literature (Faggian, Corcoran, and McCann 2013; Galos 2022; Tocchioni and Petrucci 2021; Tosi, Impicciatore, and Rettaroli 2019). Being *married or cohabiting* does not have any significant correlation with migration.

Meso level. Beginning with the first set of characteristics related to the doctoral pathway (Table 4, column 2), the decision to migrate is positively affected by several variables. First, the geographical location is significant: PhD holders who have held their doctorate at a university in the south or the centre of Italy are more likely to migrate. Second, specialising in PE and completing a doctorate before the age of 30 positively influences the propensity to migrate. On the contrary, PhD holders in social sciences disciplines are less likely to migrate. Third, specifically regarding the characteristics of the doctoral pathways, having spent time visiting another university (*visiting*) and satisfaction with the course (*teaching_satisfaction*) have a significant positive effect. Moreover, having previous teaching experience (*teaching*) during the doctorate and being satisfied with the collaboration with faculty members (*collaboration_satisfaction*) are disincentives to migrate. The university resources and equipment (*resource_satisfaction*) as well as the economic resources of the university (*FFO*) do not appear significant. Finally, the control for distinct career paths (*academic career*, column 3) does not highlight any significance in the decision to migrate after obtaining the PhD.

Macro level. With regard to the three regional variables considered (Table 4, column 4) – *population density*, knowledge-based *employment*, and innovation measure through *R&D* expenditures – we found that regions with a higher percentage of employees in knowledge-intensive sectors are a pull factor in the decision to migrate.

Table 5. Interregional and abroad migration – multinomial probit à la Heckman.

	Migration							
	Interreg	Abroad	Interreg	Abroad	Interreg	Abroad	Interreg	Abroad
Baseline: No migration	(1a)	(2a)	(1b)	(2b)	(1c)	(2c)	(1d)	(2d)
Micro level								
Female	−0.010	**−0.059*** **	−0.014	**−0.046*** **	−0.011	**−0.048*** **	−0.010	**−0.047*** **
	[0.009]	[0.007]	[0.010]	[0.008]	[0.010]	[0.008]	[0.010]	[0.008]
Married/cohabiting	−0.016	0.009	−0.016	0.013	**−0.019***	**0.015***	**−0.019***	**0.015***
	[0.011]	[0.008]	[0.011]	[0.009]	[0.011]	[0.009]	[0.011]	[0.009]
children	**−0.080*** **	**−0.143*** **	**−0.073*** **	**−0.108*** **	**−0.071*** **	**−0.108*** **	**−0.069*** **	**−0.107*** **
	[0.012]	[0.010]	[0.012]	[0.010]	[0.012]	[0.010]	[0.012]	[0.010]
Parent's education	**0.019***	**0.033*** **	0.012	**0.022*** **	0.009	**0.023*** **	0.009	**0.023*** **
	[0.010]	[0.007]	[0.010]	[0.007]	[0.010]	[0.007]	[0.010]	[0.007]
Parent's occupation	0.013	**0.024** **	0.010	−0.001	0.010	−0.002	0.009	−0.003
	[0.015]	[0.012]	[0.015]	[0.012]	[0.015]	[0.012]	[0.015]	[0.012]
Past migration	**0.726*** **	**0.319*** **	**0.696*** **	**0.320*** **	**0.698*** **	**0.315*** **	**0.697*** **	**0.315*** **
	[0.014]	[0.014]	[0.015]	[0.014]	[0.015]	[0.014]	[0.015]	[0.014]
Meso level								
Centre			**0.046*** **	0.007	**0.047*** **	0.005	**0.075*** **	0.013
			[0.011]	[0.009]	[0.011]	[0.009]	[0.014]	[0.012]
South			**0.096*** **	**−0.041*** **	**0.098*** **	**−0.043*** **	**0.085*** **	**−0.040*** **
			[0.012]	[0.008]	[0.012]	[0.008]	[0.015]	[0.010]
PhysicsEng			−0.002	**0.040*** **	−0.001	**0.040*** **	0.000	**0.042*** **
			[0.012]	[0.009]	[0.012]	[0.009]	[0.012]	[0.009]
SocialScience			−0.003	**−0.053*** **	−0.002	**−0.053*** **	−0.003	**−0.052*** **
			[0.012]	[0.010]	[0.012]	[0.010]	[0.012]	[0.010]
Under 30			**0.040*** **	**0.104*** **	**0.042*** **	**0.102*** **	**0.041*** **	**0.103*** **
			[0.010]	[0.008]	[0.010]	[0.008]	[0.010]	[0.008]
In time			−0.006	**−0.018***	−0.006	**−0.021** **	−0.006	**−0.023** **
			[0.013]	[0.010]	[0.013]	[0.010]	[0.013]	[0.010]
Teaching			**−0.020***	**−0.018** **	**−0.019***	**−0.019** **	−0.016	**−0.018** **
			[0.011]	[0.008]	[0.011]	[0.008]	[0.011]	[0.008]
Visiting			**0.056*** **	**0.170*** **	**0.058*** **	**0.165*** **	**0.054*** **	**0.165*** **
			[0.011]	[0.009]	[0.011]	[0.009]	[0.011]	[0.009]
teaching_satisfaction			**0.005** **	0.000	**0.004***	0.001	**0.005***	0.001
			[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]

collaboration_satisfaction			−0.004	**−0.009*** **	−0.003	**−0.009*** **	−0.003	**−0.009*** **
			[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
resource_satisfaction			0.001	**−0.003***	0.002	**−0.004****	0.001	**−0.004****
			[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
FFO			−0.001	0.003	−0.002	0.003	0.003	0.004
			[0.004]	[0.003]	[0.004]	[0.003]	[0.004]	[0.003]
Academic career					**−0.048*** **	**0.061*** **	**−0.048*** **	**0.061*** **
					[0.010]	[0.008]	[0.010]	[0.008]
Macro level								
Popdensity							0.006	0.002
							[0.006]	[0.005]
Employment							**−0.009*** **	−0.002
							[0.002]	[0.002]
Innovation							0.026	0.014
							[0.019]	[0.015]
Observations	15,407	15,407	14,586	14,586	14,586	14,586	14,586	14,586
Log-likelihood	−14473		−13278		−13212		−13199	
Wald test (*p*-value)	0.000		0.000		0.000		0.000	
Atanhrho	0.037	0.029	0.064*	0.033	0.117***	−0.065	0.122***	−0.059
AIC	28994.98		26651.88		26523.55		26509.45	
First stage								
Female	−0.246***		−0.247***		−0.246***		−0.247***	
	[0.032]		[0.032]		[0.032]		[0.032]	
Married/cohabiting	0.072**		0.073**		0.074**		0.073**	
	[0.031]		[0.031]		[0.031]		[0.031]	
Parent's occupation	0.142***		0.142***		0.142***		0.142***	
	[0.047]		[0.047]		[0.047]		[0.047]	
PhysicsEng	0.130***		0.127***		0.130***		0.125***	
	[0.043]		[0.043]		[0.043]		[0.043]	
SocialScience	−0.173***		−0.176***		−0.171***		−0.176***	
	[0.035]		[0.035]		[0.035]		[0.036]	
Under 30	0.192***		0.194***		0.192***		0.192***	
	[0.034]		[0.034]		[0.034]		[0.034]	
Scholarship	−0.206***		−0.209***		−0.201***		−0.204***	
	[0.038]		[0.038]		[0.038]		[0.038]	

Note: The values reported are the average marginal effects (d*y*/d*x*) of the multinomial probit-cmp model à la Heckman of interregional and abroad migration (coefficients in Appendix 5). The number of observations decreases across specifications due to data availability; see Table 3 for descriptive statistics. Standard errors are given in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.01$.

4.2. Interregional and abroad migration

Table 5 presents the results obtained by differentiating between interregional (columns 1[a–d]) and abroad migration (columns 2[a–d]), with the non-migrant category as the reference group.

Micro level. When the destination is considered – that is, interregional versus abroad migration – our results reveal that female PhD holders are less likely to migrate abroad than their male counterparts. Moreover, being a parent negatively affects the propensity to migrate, particularly when migration abroad is concerned. In contrast, *parents' education* positively affects the decision to migrate abroad, but it is not significant for interregional migration. Third, previous personal history of migration positively affects the decision to migrate, both interregional and abroad.

Meso level. At the meso level, interesting results emerge when considering the geographical location related to the place where the PhD degree was obtained. We found that the positive effects when migration is considered as a whole are limited to the interregional one. Interestingly, a negative effect was found when abroad migration is concerned for those who obtained their PhD degrees in the south, a significant effect that can perhaps be explained by the fact that fewer international students do a PhD in southern regions; in fact, the coefficients increase in magnitude when we exclude students from abroad. With regard to the field of specialisation, we found that it affects solely the decision to migrate abroad and, more interestingly, with the opposite sign: PhD holders in PE are more likely to migrate abroad, while those specialising in the social sciences are not. The age of PhD completion also affects the decision on where to migrate, with those who completed a PhD before the age of 30 positively affecting both types of migration; in contrast, holding the PhD title in time negatively affects migration abroad. Regarding the doctoral pathway, having teaching experience (acquired during the PhD) negatively affects the decision to migrate, both within regions and abroad. Second, spending a visiting period at another university affects the decision to migrate to a different region (internal migration) or country (abroad migration). Surprisingly, teaching satisfaction regarding the course attended during the PhD is significant and positively correlated with interregional migration only, whereas it is not significant for abroad migration. This may indicate that teaching experience is an important requirement for continuing an academic career in Italy, but it is less so abroad. Satisfaction with collaboration with faculty members during the PhD negatively affects the decision to migrate to a different country, whereas no significant effect is found for interregional migration. In the case of the university's resources and equipment, they have a substantial and negative effect only on migration abroad. At the same time, no significant results have been found in the case of interregional migration. Moreover, economic resources measured through the FFO are not significant for either interregional or abroad migration. Notably, among individuals pursuing an academic career (columns 1–2[c–d]), the probability of domestic migration is negative; this indicates that most individuals who advance their academic careers remain at the same institution and/or within the same region where they earned their degree, while those who migrate internationally are primarily those opting to further their academic careers.

Macro level. When considering the regional variables, we found that only the labour market plays a role in influencing interregional migration, while the other regional variables do not influence the decision to migrate abroad. These results highlight how the migration decision of highly skilled individuals goes beyond economic reasons, encompassing both cultural and policy-related dimensions (Orsat and Ferrary 2023).

4.3. Robustness check

We extend the controls on the employment situation[13] by including a categorical variable with a non-working condition (5.9 percent), with a non-academic career (42.1 percent) as a reference (see Appendix 6). The coefficient for the former is negative and significant only for interregional migration, which implies that individuals who are not working are less likely to migrate internally than those who are working in non-academic careers. This result is intuitive, as people without jobs may be more mobile and willing to move for work opportunities. Moreover, we conducted additional regressions and excluded international students who completed their PhDs in Italy from the models, as we expected that they were more inclined to return to their home countries. Despite this exclusion, the results remained unchanged; this may be because they represent only approximately 4% of the total sample (see Appendix 7[a and b]). We also checked the performance measures of the universities using the year of graduation rather than the mean of the three years of study (see Appendix 8). Finally, we included a macro-level control by lagging the regional variables by 1 year; the significance remained unchanged (see Appendix 9).

5. Conclusion

The migration of highly skilled individuals has been highly debated in the extant literature, particularly for graduates, while PhD holders have been overlooked, until very recently. PhD holders represent the highest degree of tertiary education, and to enter the labour market (both within and beyond academia), they move across regions and countries. Once they enter the labour market, they transfer the knowledge acquired during their doctorate studies, fostering innovation and new ideas, thus supporting local and regional development. According to Alfano, Gaeta, and Pinto (2021, 12040), '*doctoral graduates are endowed with skilled and creative human capital that positively affects the economy*'. For these reasons, understanding the determinants of PhD holder migration becomes essential to limit the brain drain effect, particularly in the case of left-behind regions. By adopting a comprehensive perspective, this paper analysed the determinants of PhD holders' migration in Italy at three different levels: micro, meso, and macro.

Considering individual characteristics, our results align with the extant literature: the decision to migrate is negatively affected by gender and by having children and positively affected by previous personal migration experience, both for interregional and abroad migration. Considering the doctoral pathway and the university's characteristics, interesting results emerged. On the one hand, the perceived quality of the PhD course – measured in terms of satisfaction – differently affects the propensity to migrate: satisfaction regarding the collaboration with faculty members pushes PhD holders to remain

within the university where they obtained the degree, while teaching satisfaction positively affects the propensity to migrate to a different Italian region. Further, considering the field of specialisation, interesting results emerge when distinguishing between inter-regional and abroad migration: PhD holders in the physics and engineering disciplines are more likely to migrate abroad, which may be due, for example, to the international nature of scientific collaboration and experiments. Conversely, PhD holders in the social sciences migrate across the country.

At the regional level, our results confirm previous studies according to which future expectations regarding employment and local growth are relevant factors that affect migration (Columbu et al. 2021; Di Cintio and Grassi 2017; Ermini, Papi, and Scaturro 2019; Faggian and McCann 2006; Fratesi and Percoco 2014). By focusing on the migration of PhD holders, this paper contributes to the current literature on the relationship between migration and knowledge flows. This topic is of paramount relevance to regional economists and policymakers, as it is widely acknowledged that the migration of highly skilled individuals positively impacts the economic development of destination regions. PhD holders are more attracted by the richer regions in the north of Italy or abroad, where they contribute to further economic development, thus exacerbating the north–south divide and the negative effect of brain drain in the less developed Italian regions, which is in line with the results regarding graduates' mobility found by Marinelli (2013).

Important policy implications at the national level can be derived from these results. First, given the well-known problem of brain drain that particularly affects southern regions of Italy, our results reveal the importance of the meso level – that is, the relevance of the doctoral pathway in mitigating this effect. In fact, to retain the greatest human capital, universities should invest resources in improving their PhD programmes, thereby increasing doctoral satisfaction and designing specific PhD programmes aligned with the labour market perspective, particularly given that the academic job is not only a labour market outcome for doctorates. This, in turn, leads to the design of specific public policies and the allocation of dedicated resources from the national government to support universities in developing effective PhD programmes. Second, from a regional perspective, since southern PhD holders tend to move for work to other central and northern regions, it is essential to dedicate public policies to enhance the attractiveness of these regions to reduce both the north–south divide and labour-market mismatches in the south. Second, regarding the brain drain problem, it is necessary to also work at the PhD level, thus increasing students' overall satisfaction and creating fruitful collaboration with faculty members.

At the same time, although this study focuses on Italy, several of the mechanisms identified in our analysis may also be relevant in other European contexts. In particular, the role of doctoral pathways, PhD satisfaction with the doctoral program and the quality of the academic environment in affecting migration decisions has also been documented in other European countries (Lois et al. 2022; Mathies and Cantwell 2022).

This study is not without limitations. In fact, during the period analysed, the Italian higher education system was affected by the Gelmini Reform, which – among other policy measures – strongly reduced the budget, thereby reducing universities' hiring possibilities; this could have impacted the working and migration decisions of PhD holders. Second, since this study is based in the Italian context, future research could focus on conducting similar studies in other European countries to compare results and identify

policy implications for the Higher Education sector at the European level. Third, a future analysis of the different employment sectors in which PhD holders work, distinguished by industry, services, public, and private, would enable a deeper exploration of the distinct drivers and outcomes for those migrating for academic versus non-academic reasons in the actual labour market for PhD holders.

Notes

1. The survey questions used to identify the region where they work 'Where do you mainly carry out the work' or living 'Where do you reside'. In few instances, employed PhD holders may reside in a different region than where they work. In such instances, the latter is employed.
2. The definition of interregional migration adopted is based on administrative regional borders and the permanent relocation of residence, driven by labour market dynamics or quality of life. From a spatial perspective, utilizing administrative regions presents certain limitations, as some PhD holders may relocate between provinces within the same region (intra-regional migration). Nonetheless, conducting the analysis at a regional scale ensures comparability with existing literature of interregional migration (i.e., Aronica et al. 2023; Fratesi and Percoco 2014; Iammarino and Marinelli 2015; Marinelli 2013). These studies utilize interregional migration to describe the internal movement of individuals across regional boundaries within a single nation (for a comprehensive review of interregional migration of human capital, see Faggian, Rajbhandari, and Dotzel 2018).
3. The ISTAT survey did not have the date of marriage or having a child. According to Eurostat, the average age at first marriage and first birth in Italy is among the highest in Europe (35 years for marriage and 31.1 years old for women for first birth in 2017). In this regard, our premise was that marriage and childbirth occurred during or after completion of the PhD because 55% of our sample completed their degree after they were over 30 years of age.
4. The survey questions used to identify if they have migrated in the past was 'Before you enrolled at university to get your PhD, what region did you live'.
5. The dataset distinguishes 14 fields of study that are common only in Italy. In keeping with previous studies (i.e. Aronica et al. 2023; Parenti, Pinto, and Sarno 2022), we adopted the European classification and aggregated it into three groups. *(i) Science and Medicine (SM)*: biology; chemistry; medicine; agricultural and veterinary sciences; *(ii) Physics and Engineering (PE):* mathematics and informatics; physics; earth sciences; civil engineering and architecture; industrial and IT Engineering; *(iii) Social Science (SS)*: Antiquities, philology, literature and art history; history, philosophy, pedagogy; law; economics and statistics; political and social sciences.
6. The survey included six questions on PhD satisfaction, with a high correlation among them. To avoid multicollinearity, we included those that are not correlated.
7. We also ran a check with FFO only for the year in which the degree was granted – 2012 or 2014 (see Appendix 8).
8. We also ran a check with the regional variables lagged for one year (see Appendix 9).
9. To address the selection bias, the appealing approach is to insert an Inverse Mills Ratio IMR into the model of interest. According to Greene (2006), introducing the IMR is not the best procedure for performing multinomial probit. The best method to estimate the probit selection and multinomial probit outcome equations is by introducing selection into a nonlinear model and a method of maximum likelihood estimation by using the conditional (recursive) mixed-process model (-cmp- Stata command).
10. All the covariates appear significantly correlated with employment in the first stage (results are plotted below Tables 4 and 5).
11. For complementarity, we also run a simple Probit model (Appendix 3). The results are found to be robust.

12. The lowest AIC regression indicates a better-fitting model (Akaike 2015).
13. We replaced the dummy academic career with categorical variables on the employment condition: non-academic career (reference), academic career, and not working.

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