It Takes Time, but It Pays: International Postdoctoral Mobility and Career Effect in Italian Academia

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Abstract

We investigate the effect of international postdoctoral mobility on academic careers. International postdoctoral appointments can help researchers' career achievements by expanding their scientific and technical human capital or make their return and career in the home country's academic system more difficult by disconnecting them from their national academic network. We use duration models to investigate the impact of such appointments on time-to-entry and time-to-promotion (from assistant to associate or full professor positions). Using a panel dataset of 18 thousand Italian academics in all disciplines over 30 years, we find that international postdoctoral appointments, while weakly related to a slower entry into the academic system, positively affect career outcomes and reduce the waiting time for tenure. We provide evidence that early-stage international mobility is beneficial for academics' careers in the long term. We use institution-based bibliometric indicators to measure different dimensions of social capital/network that affect researchers' careers, namely localism, home country linkages, and persistence in the scientific network, finding significant effects.

JEL Classification: I21, I23, J61, J45, M51.

Keywords: Academic career, International mobility, Social capital.

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1 Introduction

When scientists are mobile across national borders or cooperate, knowledge is disseminated, and new combinations of knowledge are created. From an individual perspective, international mobility of scientists – especially in the early phase of their career – is increasingly seen as a strategy to enhance academic success (Netz et al., 2020). Whether international mobility influences scientists' careers is a question that has been explored by several studies in the last decade (Cañibano et al., 2020; Kotsemir et al., 2022; Liu & Hu, 2022; Tartari et al., 2020). However, the empirical evidence is still fragmented, and results are not univocal (Netz et al., 2020).

While increasing attention has been given to the impact of scientific mobility on productivity (Franzoni et al., 2014; Geuna, 2015), the lack of appropriate data has limited the study of this phenomenon's impact on academic careers. Traditional migration data are often employed to have a picture of scientists' migration flows (Cañibano & Woolley, 2015). Still, they are not suitable for fully capturing this phenomenon's complexity and circulatory nature (Jöns, 2007). In fact, unlike other types of migrants, researchers are motivated by the intrinsic nature of the scientific profession to engage with new ideas and non-redundant knowledge and to expand their scientific networks (Baruffaldi & Landoni, 2012). As a result, they frequently seek new career opportunities abroad. (Ackers, 2005; Liu & Hu, 2022).

Given the need for more suitable data, only a handful of studies have been carried out in a few European countries, with mixed results. For example, Cruz-Castro and Sanz-Menéndez (2010) and Sanz-Menéndez et al. (2013) focus on Spain and find a negative effect of extended stays abroad on occupational outcomes. On the other hand, studies focusing on Germany (Lutter & Schröder, 2016; Zhao et al., 2022), Russia (Kotsemir et al., 2022), or Japan (Lawson & Shibayama, 2015) find a significant positive impact of experience abroad on the attainment of a tenured position in the respective academic systems.

However, the main limitation of these previous studies is that they usually rely on cross-sectional survey data, covering a limited span of time and scientific areas. This paper overcomes this limitation. We built a unique dataset of doctorate holders in all disciplines who obtained their degrees in Italian universities from the first created

PhD cycle (1986) until 2006. We identified doctorates who pursued an academic career in Italy by matching them with academics in the official archives of the Italian Ministry of University and Research and followed in their career until 2015. From this matched dataset, we identified those researchers who undertook a postdoctoral (hereafter PD) appointment before entering the Italian academic system. We used affiliation information reported in scientific publication data from Scopus to classify mobility in the PD period. About 20% of postdoctoral researchers were classified as internationally mobile. We were also able to associate the supervisor with a subsample of PhDs (82% of the empirical sample) to control the internationalization of the supervisor's career, to the best of our knowledge a characteristic never studied before in the literature.

In this paper, we study how international PD appointments and social capital correlate to job outcomes at different career stages: time-to-entry as assistant professor and time-to-promotion to associate or, in a small number of cases, to full professor. International PD mobility may help or harm in speeding up career progression and ensuring career stability. International mobility is a phenomenon that gained increasing importance in shaping public policies (Stephan, 2015). The evidence regarding the ability of international mobile academics to provide benefits to their own countries in terms of spill-overs (Ackers, 2005; Saxenian, 2005) fosters policy initiatives aimed at encouraging national scholars to go abroad and migrant academics to return (Hunter et al., 2009).

The paper aims to answer the following questions: are internationally mobile postdocs faster/slower than national postdocs in entering (and being promoted in) the academic system? Does social capital correlate with the returnee's career timing and path?

The setting of our paper is relevant as Italy is among the top countries in terms of academic research performance, for example, ranking third for percentage of scientific publications in the world's top 10% most cited papers, just after the US and the UK in 2016 (Abbott, 2018). Comparative data from Scopus on the research performance of G7 countries for the period 1996-2020 (that overlaps with our period of observation),

highlights a continuous growth path[2]. Italy produced about 3.4% to 4.0% of world publications in the twenty-five years considered, overtaking France in more recent years. It had a better and growing performance in terms of citations, moving from a fork of 3.5-4.5 in the first ten years to 4.5-5.6 in the 2006-2015 period to arrive at 6.7% of world citations in 2020, again overtaking France. When the Field Weighted Citation Impact is taken into account, the performance is even better; by 2010, Italy had similar values to France and Germany, and by 2015, it had overtaken both countries, having similar values to the UK; in 2020, Italy was second only to the US. Finally, a similar growth pattern is shown when we look at highly cited papers (top 1%). By 2015, Italy had values similar to those of France, and by the end of the period, it was above both France and Germany. Interesting is also the productivity data, though it should be taken with some caution, for the period 2006-2014 Italy is either the country with the highest productivity or very near to the UK and Canada level, well above France, Germany and the US.[3]

The governance of the Italian academic system is comparable to other continental European state systems, such as the French and the Spanish, all of which have undergone a series of reforms in the last 30 or so years to introduce more competition and evaluation. Finally, the Italian scientific system has always been internationally well connected, and traditionally, Italian researchers have spent periods abroad, though the system is not too inward open, with only a tiny percentage of foreign nationals working in the Italian university system (Carriero et al., 2023; Franzoni et al., 2012).

We use survival models to estimate time-to-entry and time-to-promotion and confirm our results with a matched sample approach. We provide evidence that international PD appointments while being related to a slower entry into the academic system (international PD researchers returning to Italy take up to 17% longer to attain an assistant professor position compared to their non-internationally mobile peers), have a

[2] See the 2022 report "International comparison of the UK research base" by the UK's Department for Business, Energy & Industrial Strategy (https://www.gov.uk/government/publications/international-comparison-of-the-uk-research-base-2022, last visit: July 2024).
[3] See the 2016 report "International comparison of the UK research base" by UK's Department for Business, Energy & Industrial Strategy (https://www.gov.uk/government/publications/performance-of-the-uk-research-base-international-comparison-2016, last visit: July 2024).

positive correlation with career outcomes with a reduction of the waiting time for tenure of 1.2 years, which corresponds to a significant decrease of 10-15% relative to their peers without international PD experience. We also show that career entry and progression weakly correlate with three dimensions of social capital/network: localism, home country linkages, and persistence in the composition of the co-author network. These results are robust to controlling for the international experience of the PhD supervisor in the matching procedure. Moreover, once this characteristic is controlled for, the positive moderating effect of local connections becomes more evident for promotion.

2 International mobility, social capital, and academic careers

International mobility has often been investigated in economics of science regarding its role in skill investment and its impact on scientific productivity, notably through the enhancement of scientific and technical human capital (Bozeman et al., 2001). However, comparatively less attention has been directed towards its influence on academic career trajectories (for a recent literature review, refer to Netz et al., 2020). Nonetheless, given the significance of scientific productivity in career progression, it is worth examining international mobility's role in career advancement and occupational outcomes (Fernández-Zubieta et al., 2015).

Of course, the timing of international mobility within one's career will likely affect subsequent career outcomes differently. Additionally, the nature of mobility – such as short-term visits versus extended research stays – can produce distinct impacts. International mobility, particularly in the early stages of one's career, holds significant importance as it helps young scientists enhance their skills and shape their research trajectory. This enables them to work more efficiently, increasing their scientific productivity and influence (Cruz-Castro & Sanz-Menéndez, 2010; Geuna, 2015). Moreover, it serves as a signal of researchers' dedication to the academic profession (Carriero et al., 2023), or as an indicator of their capabilities and the depth of their social connections, with this effect being amplified in particular when they move towards more prestigious institutions or countries.

Most studies examining the international mobility of scientists focus on its impact on international networks (e.g., Baruffaldi et al., 2020; Scellato et al., 2015) and scientific productivity (e.g., Cruz-Castro & Sanz-Menéndez, 2010; Jonkers & Cruz-Castro, 2013). However, the literature exploring the effects of scientists' mobility on career outcomes is also rich. In particular, some studies have investigated the time to tenure or promotion for internationally mobile scientists and have found mixed results.

Jonkers (2011) examines the time to promotion of Argentinian scientists who had extended stays abroad and finds no significant effect after controlling for productivity. Sanz-Menéndez et al. (2013) explore the time to tenure for Spanish scientists who underwent a postdoctoral period abroad and discover a significant and negative impact on the time to achieving associate professorship positions. Conversely, Lawson and Shibayama (2015) investigate extended stays abroad among Japanese scientists and observe a significant positive effect on the time to promotion. Similarly, Lutter & Schröder (2016) analyze international stays of German PhDs and find a significantly positive impact on attaining tenured positions, attributed mainly to increased publication output.

In this study, we consider the main social capital and network factors examined by the literature on the international mobility of scientists, and we apply them to the context of academic careers.

Firstly, we examine the role of localism in influencing the time it takes for international mobile scientists to enter academia. Institutional inbreeding refers to hiring PhD graduates from the same institutions where they were trained (Horta, 2013). This practice often relies on the strong connections to the local scientific network developed during the PhD, which can expedite the return of international mobile scientists to their home countries. In particular, for exceptional PhD candidates, supervisors may send them abroad to gain experience to rehire them upon their return. Consequently, international mobile scientists who secure their first positions at their *alma mater*, the institution where they earned their PhD, experience a shorter time-to-entry compared to their counterparts. However, some literature suggests that inbred scientists may exhibit lower productivity (Horta et al., 2010), possess smaller international networks

(Scellato et al., 2015), and undergo slower career development (Inanc & Tuncer, 2011). Therefore, we expect that inbred scientists may face longer time-to-promotion.

Secondly, research has shown that international mobility positively impacts research productivity when mobile scientists maintain linkages to their home country (Baruffaldi & Landoni, 2012). This is also significant in the context of time-to-entry, as international mobility may coincide with career instability. In fact, detachment from the domestic scientific network may expose international mobile scientists to career risks, as it could be more challenging for them to reintegrate into their home country (Gill, 2005). Therefore, maintaining connections to their home country while abroad will assist international mobile scientists in returning more quickly, thereby reducing their time-to-entry compared to other international mobile peers.

Finally, we consider the persistence of collaboration networks established during periods abroad. Literature indicates that international mobility enables researchers to connect with potentially more prolific and reputed scientists, thereby expanding their scientific network and allowing them to access international peers otherwise unavailable to them without mobility (Jonkers & Cruz-Castro, 2013). These new "weak ties", as Granovetter (1973) refers to them, are particularly advantageous for scientists as they provide access to non-redundant information, thus enhancing creativity and productivity.

Additionally, studies show that while scientists typically maintain ties with co-authors and collaborators abroad (Kato & Ando, 2017), resulting in a positive impact on productivity, maintaining these ties becomes increasingly challenging over time, and the positive effects tend to diminish unless scientists continue to engage in international mobility (Wang et al., 2019). Therefore, international mobile scientists who can maintain collaboration ties with co-authors they worked with while abroad upon their return to their home country will experience a positive effect on their time-to-promotion.

3 Institutional framework: The Italian academic career system

The academic labour market in Italy is similar to that of other European countries such as France and Spain. Employees at Italian universities are civil servants, which means that the key aspects of employment (wages, contract terms, and responsibilities such as teaching loads) are governed by national laws rather than local agreements or negotiations.

The Italian academic system comprises 92 universities, 31 private and 61 public institutions, and seven specialized higher education institutions. These specialized institutions primarily offer master's and PhD programs and are more research-focused than most other universities. Among the public universities, four are technical universities, while eleven of the private institutions offer distance learning. The system is organized into 370 scientific sectors, which are grouped into fourteen research areas. Every professor at Italian universities is associated with a single scientific sector, and recruitment commissions within each of these sectors manage the selection of candidates at national and local levels.

The Italian academic system has three main positions: assistant professor, associate professor and full professor. Since 2012 the assistant professor position has been transformed with a mix of temporary 5 years entry contract and tenure track contract with a starting 5-years temporary position. Salaries in public universities vary only by type of position and seniority. Hence, Universities cannot link wages to research productivity or other performance indicators, though professors can be paid for teaching more than the hours of frontal teaching required by their contract. As a consequence, the primary motivation for academic researchers to produce scientific work is the prospect of career advancement.

In 1990, 42,209 professors were active in Italian universities. In the period we consider in this paper, 45,795 academics entered in the Italian system and 33,219 exited, reaching the maximum in 2008 to then decrease to 54,785. Figure 1 summarizes the number and the share of Italian professors by academic position in this time period.

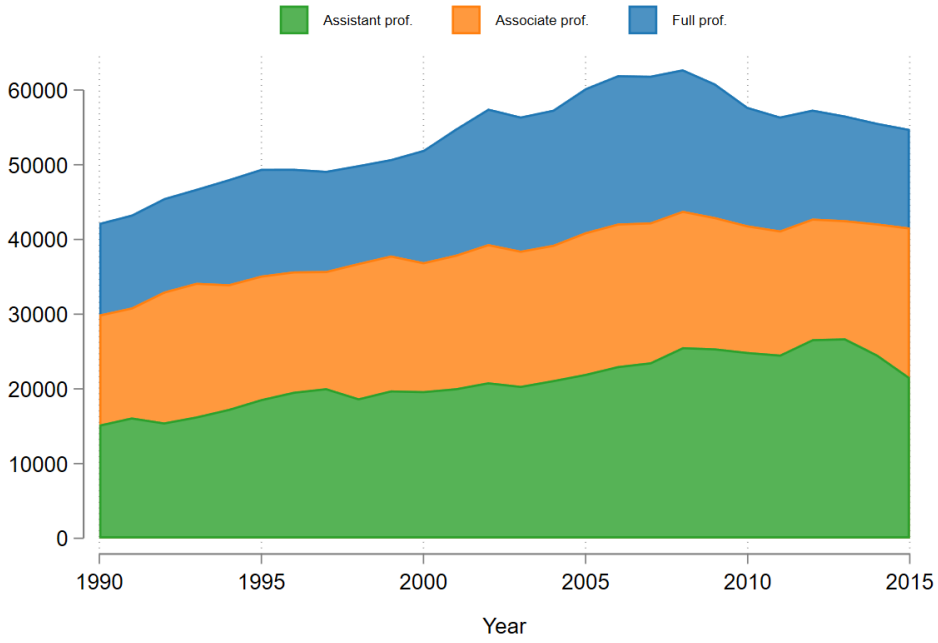

Figure 1 – Share of Italian professors by academic position 1990-2015

From the early 1980s until the late 1990s, the hiring of assistants, associate professors, and full professors was managed through standardized national competitions, with recruitment centralized by national committees. These competitions were held every 3 to 4 years. Beginning in 1999, the recruitment process shifted to a local level, allowing individual universities to conduct their own selection procedures. The most recent reform, in 2010, established a two-tier process involving a national habilitation followed by local competitions for professor positions. Figure 2 shows the number of new assistant professors and newly promoted associate and full professors in Italian academia. As in other national university systems the entry and promotions are quite cyclical.

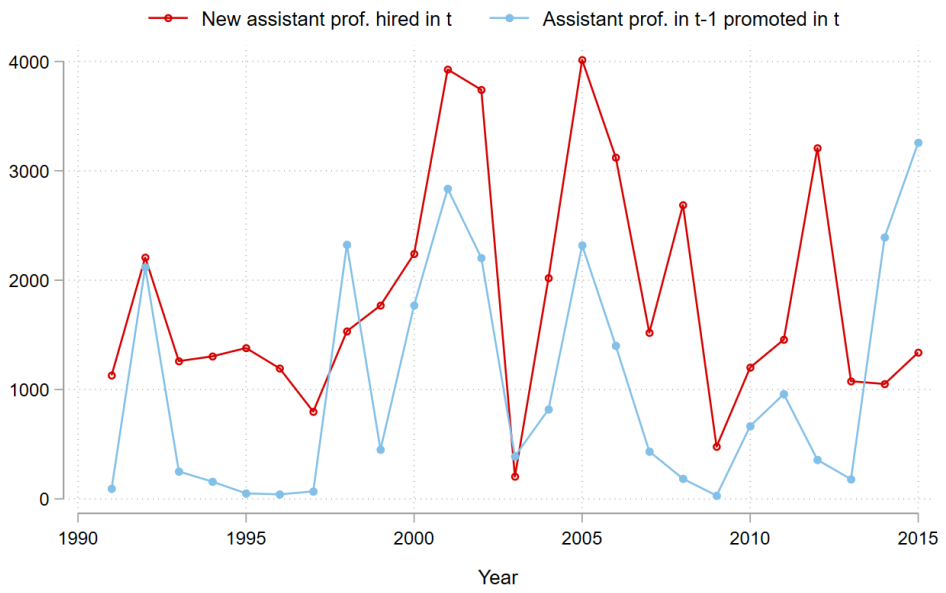

Figure 2 – Yearly entrances and promotions in Italian academia, 1991-2015

4 Data sources

We have collected information from three primary sources: the National Library of Florence (BNCF), the Italian Ministry of University and Research (MUR), and Elsevier's Scopus database. From BNCF, we retrieved all doctoral dissertations discussed in Italian universities from I cycle (1986) to 2006 (ca. 76 thousand doctoral theses). The BNCF's online public access catalog furnished details, including theses' author, title, supervisor, granting institution, scientific field, and year. From the MUR, we obtained administrative records of all academics working in Italian universities from 1990 to 2015. These records encompass academic positions, disciplinary domains, university affiliations, and individual data, such as birth year and gender. Using these two sources of information, we identified PhD holders from Italian universities who pursued an academic career in Italy.

We identified academics holding Italian doctoral degrees by employing record linkage between academics listed in the MIUR dataset and individuals with doctorate degrees from Italian universities, as recorded in the BNCF dataset. This matching process was grounded in four key fields: name, gender, scientific domain, and year of obtaining the PhD. As a result, we successfully identified the population of researchers with doctoral

degrees from Italian universities who have engaged in academic work within Italy for at least one year. Additional insights into the retrieval process from BNCF, the methodologies used for record linkage and data cleansing, and the outcomes of these procedures can be found in Coda Zabetta and Geuna (2020).

Our analysis narrows down to a subset of these researchers, specifically the 18,039 individuals who achieved doctorate degrees and entered Italian academia as assistant professors within ten years following their PhD completion. Furthermore, all of these individuals were part of the Italian academic workforce in the year 2015 (i.e., they did not migrate nor retire before the end of our observational period).

For these researchers, we extracted from Scopus all scientific articles published in international journals from their initial publication to 2015. As a result, we find that a significant portion of them – comprising 15,385 individuals, approximately 85% – published at least one paper in Scopus-indexed journals throughout their entire career until 2015. In total, we collected 285 thousand scientific articles.

To identify authors, our initial step involved utilizing the Scopus API for conducting author searches, using the first name, last name, and the institution where the academic earned their PhD from our dataset. This process aimed to retrieve relevant author information from Scopus's database. Subsequently, we employed the gathered information to establish a connection between each academic in our sample and a corresponding Scopus Author Identifier (AU-ID). This identifier is unique to each author within the Scopus database.[4]. Please refer to online appendix A for comprehensive technical details concerning the procedures employed, including handling errors, author identification, field matching, and more.

[4] Prior research (Kawashima & Tomizawa, 2015) assessed the accuracy of Scopus Author IDs within the bibliographic database. This involved cross-matching bibliographic records between Scopus and an open database encompassing the largest public fund for academic researchers. The study subsequently computed the recall and precision of Scopus Author IDs for researchers. The outcomes revealed that recall and precision were approximately 98% and 99%, respectively.

4.1 Identification of scientists' early career mobility

We proxy early career mobility using the affiliations reported in the scientific publications from Scopus. This methodology enables us to detect researchers who, following their PhD and before their initial appointment within Italian academia, engaged in a research period, usually in a post-doctoral (PD) position. However, we disregard short research visits that do not typically lead to published work. This technique permits us to monitor mobility to the extent that researchers produce at least one paper and specify their affiliation on the publication, allowing for traceability.

Several studies provide qualified validation for utilizing this data for investigating mobility (Conchi and Michels, 2014; Zhao et al., 2022). Laudel (2003) and Aman (2018) compared scientist mobility derived from bibliometric data and alternative data sources such as CVs and researcher surveys. Moed and Halevi (2014) assess the precision of the bibliometric method in identifying scientists' mobility patterns in 17 countries, comparing official statistics and scientists' mobility as inferred from Scopus's publication records. The findings of these studies collectively indicate that the error rates of the bibliometric approach are estimated to be substantially below 10%.

Utilizing affiliation information extracted from Scopus, we selected the institutional affiliations for each author as mentioned in their scientific publications. This procedure enabled us to identify researchers' mobility in scenarios where i) the researcher has published and ii) the publication includes the affiliation details. When an author reported multiple affiliations[5], we selected the first one, which we regarded as a representation of their primary affiliation (OECD, 2017). To ensure the accuracy and disambiguation of affiliation data from publication records, we employed the Research Organization Registry (ROR) database.

For our empirical analysis, we intend to compare international mobile scientists with their counterparts who did not leave Italy during the PD period. Since our methodology relies on the publication records of scientists to identify international mobility, some scientists who did not publish during this period may have undertaken PD research abroad without publishing. We refine our sample selection criteria to mitigate

[5] Only 9.4% of the author-publication pairs reported more than one affiliation.

this issue and ensure a more accurate comparison between international mobile scientists and their non-mobile peers. Specifically, we limit our sample to researchers actively engaged in research during their postdoctoral period, meaning they published at least one scientific article between completing their PhD and obtaining their first position as assistant professors in Italian academia. Thus, the final sample comprises a total of 9,912 scientists[6].

Table 1 and Figure 3 provide preliminary insights into the characteristics of international mobile academics. Notably, as we transition from the first to the second cohort, there is a rise in the absolute count of mobile individuals. However, the intriguing observation lies in the decline of the proportion of internationally mobile PhDs, from 24% to 18%. Women researchers exhibit lower mobility rates compared to their male counterparts, with percentages of 16.6% and 21.7%, respectively.

From a geographical point of view, PD mobility encompasses a broad spectrum of 50 different countries. The United States stands out as the top destination, attracting 45% of mobile PD scholars, followed by EU countries, notably the United Kingdom, France, and Germany. Collectively, all EU countries account for 46% of mobility. The remaining 9% is directed towards various other countries.

Table 1 – Number of PhD, international mobiles and share by gender and cohort

	All	M	W	Cohort 86-96	Cohort 97-06
Nb. PhDs	9,912	5,852	4,060	2,578	7,334
Nb. PD abroad	1944	1268	676	615	1329
Share PD abroad	19.6%	21.7%	16.6%	23.9%	18.1%

Notes: we only consider researchers that published at least one article in Scopus indexed journal between the PhD and the first appointment as assistant professor.

[6] They represent 55% of the total sample. Within the Natural Sciences (including mathematics, physics, chemistry, biology, and earth sciences), they constitute 89%; in Medicine and Veterinary (together with agricultural) fields, they account for 77%; in Architecture and Engineering, they make up 64%; in the realm of Social Sciences, they represent 28%, and in Humanities and Law, they constitute 14%.

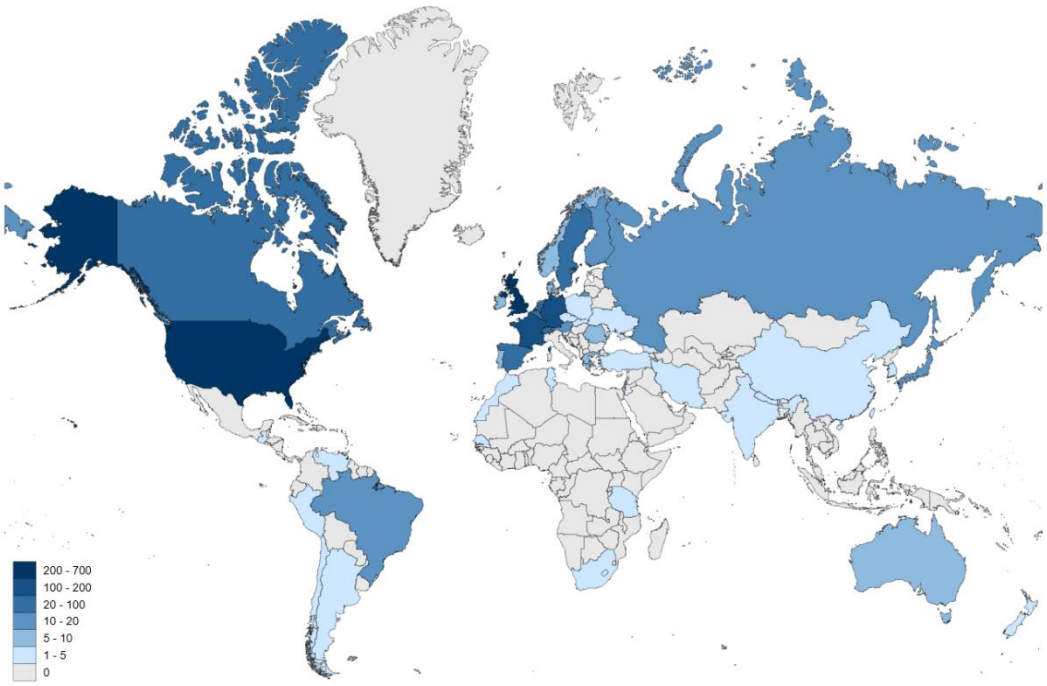

Figure 3 – Geographical international mobility of Italian international postdocs

5 Econometric methodology

We estimate a duration model as a function of international post-doctoral appointments considering two moments in researchers' career: from PhD to entry as assistant professor and from entry to the promotion to associate or full professor.[7] In this setting, each academic is at risk of entering Italian academia since the year of PhD, and being promoted since the year of first appointment as assistant professor.

We employ a Cox-proportional hazard model[8] using as dependent variable the years from PhD to entry (for the time-to-entry analysis) and from first appointment until promotion to associate or full professor position (for the time-to-promotion analysis). This model is the following:

$$h(t) = h_0(t) \times \exp\left(\alpha PD\_Abroad_i + \beta SOC\_CAP_i + \gamma \boldsymbol{X}_i + \boldsymbol{\delta}_{y,a,u}\right) \quad (1)$$

[7] Out of the 9,912 researchers in our empirical sample, only 28 experienced a promotion from assistant to full professor. Removing these observations from the analysis does not change the results.
[8] We run robustness checks for several alternative parametric survival models, finding consistent results concerning our baseline estimations. They are available upon request.

where h_0 is the baseline hazard, PD_Abroad_i is a dummy variable which takes value one if the researcher spent a PD period abroad. To better explore the main effect, we include in different specifications a set of variables that aim to capture the social capital/network effect (SOC_CAP_i). In each model, we include $\boldsymbol{X}_i$, a vector of individual characteristics. Among these, precocity (i.e., the presence of pre-PhD publications) researchers' gender, age at PhD and first appointment (only for the time-to-promotion analysis), and their squared terms, are included. Performance measures (yearly number of publications and citations) are included to control for the impact of merit on the time to entry/promotion. Finally, $\boldsymbol{\delta}_{y,a,u}$ represents indicators of PhD year, scientific area, and university, which are also included as controls.

To mitigate the endogeneity concerns, we employ Coarsened Exact Matching (CEM), as introduced by Iacus et al. (2012). We thus match each internationally mobile academic with peers actively engaged in research during their postdoctoral period but who have not undertaken a postdoctoral appointment abroad. The matching process relies on pre-mobility observable characteristics, such as gender, birth year, year of PhD completion, university attended, number of publications, yearly citations[9], and scientific field. This approach treats a postdoctoral appointment abroad, typically pursued by junior academics, as a form of treatment with long-lasting effects on academics' career trajectories.

We thus divide our sample into two groups: the treated group, consisting of internationally mobile academics, and the untreated control group, comprised of their matched counterparts. Subsequently, we apply a Cox proportional hazard model to this matched sample to analyze the data.

We also perform a more restrictive CEM procedure by including, when available, the variable *Intl_SV* as a matching variable. This variable is an indicator that takes the value of one if the researcher's PhD advisor has international experience. We proxy advisor's international expertise by her having published with a foreign affiliation before the advisee's PhD granting year. We expect that a PhD student with an advisor

[9] Scopus provides the total number of citations an article received at the time of data download. Therefore, we computed the average yearly citation rate by dividing the number of citations at retrieval by the years elapsed between the article's publication and the data retrieval.

who has international experience is more likely to spend a PD period abroad. Including this variable imposes a stricter condition on the matching procedure, further reducing the matched sample size but allowing us to ensure that our treated and control groups are as similar as possible, reducing endogeneity concerns as much as we can. For additional details regarding the CEM procedure, please refer to online appendix B, which provides a more comprehensive explanation.

Time-to-entry and time-to-promotion also depend on the social capital and the connections that the researcher can create with peers and the academic community. We tested this effect by making use of three proxies for researchers' social capital/network.

First, we include a variable identifying whether the focal academic got her first position in her PhD granting institution (*Localism*). We interact this variable with international PD appointments to assess whether entry in academia is speeded up by a tight social network in one's *alma mater*. In the time-to-promotion analysis, we explore whether these ties have long-lasting effects on promotion.

We then identify the strength of the connection between a researcher in a PD appointment and her home country. We make use of two dummy variables: *PD_Abroad (Home Linkages>TH)* and *PD_Abroad (Home Linkages≤TH)*. These two variables are based upon information on researchers' co-authors' affiliation, as derived from the Scopus publications records[10]. The two variables are calculated as follows. We retrieve all the publications during the PD period for each internationally mobile researcher in our sample. We then identify all the unique co-authors' affiliations and compute the share of Italian and foreign co-authors' affiliations in the post-doctoral period. Finally, we create the two dummies which take value one, respectively: if the share of Italian affiliations among co-authors is higher (or lower) than a certain threshold (TH) computed by the scientific area. In the empirical analysis, we will show how the results change by setting different thresholds.

Finally, only for the time-to-promotion analysis will we investigate whether maintaining scientific collaborations with PD co-authors leads to quicker promotion. To explore this, we distinguish two groups: firstly, the co-authors with whom the focal researcher

[10] Each Scopus entry provides separate fields for authors' names and their corresponding affiliations, ensuring a one-to-one match between each name and its associated institution.

collaborated during the PD period, referred to as "PD co-authors"; and secondly, the co-authors with whom the focal researcher collaborates after entry and before promotion (or the end of the observational period), denoted as "post-entry coauthors." Subsequently, we construct two dummy variables. *PD_Abroad (Netw. Persistence>TH)* is assigned a value of one if the researcher's proportion of "PD co-authors" among "post-entry coauthors" exceeds a TH, calculated by the scientific area. Conversely, the complementary variable, *PD_Abroad (Netw. Persistence≤TH)*, is assigned a value of one if this proportion is below the TH. Also, in this case, we will show how the results change by setting different thresholds in the empirical analysis.

Since scientific performance is pivotal in career advancement, our analysis incorporates controls for scientific productivity and quality. To quantify this, we calculate the annual number of publications and the average number of citations, adjusted for the number of co-authors of each scientific article. We obtain these data by extracting all scientific articles authored by individuals in our sample from Scopus and the total number of citations each article has received. We compute the number of publications and the average number of citations per year for two distinct periods within our analysis: the first period spans from the time of the PhD to the first academic appointment, while the second period extends from entry into academia to the year of promotion (or the last year of observation for individuals who were not promoted in our observational period). In our regression models, we employ the natural logarithms of these two measures, denoted as *Ln_Pubs* and *Ln_Cits*, respectively. Additionally, we introduce a binary variable, *Precocity*, which takes a value of 1 for researchers who published at least one scientific article during their PhD.

We include indicator variables in all our regression analyses to account for potential disciplinary variations in job availability and promotion opportunities. These indicators capture differences associated with each PhD year, scientific area, and university of affiliation. This approach allows us to control for the specific characteristics and dynamics within these categories. It helps ensure that our analysis accurately reflects the influence of these factors on our outcomes of interest.

Table 2 – Definition of the main variables

Variable	Description
Main dependent variables	
PD_Abroad	1: PD period abroad
PD_Abroad_USA	1: PD period in the US
PD_Abroad_EUR	1: PD period in an EU country
PD_Abroad_OTH	1: PD period outside US and EU
Social Capital moderators	
Localism	1: first appointment obtained at the PhD granting university
PD_Abroad (Home Linkages>TH)	1: share of co-authors' Italian affiliations
PD_Abroad (Home Linkages≤TH)	higher/lower than the threshold (TH)
PD_Abroad (Netw. Persistence>TH)	1: share of co-authors from the PD is
PD_Abroad (Netw. Persistence≤TH)	higher/lower than the threshold (TH)
Controls	
Precocity	1: published a scientific article during the PhD
Ln_Pubs	Natural logarithm of the average number of publications by year
Ln_Cits	Natural logarithm of average number of citations by year
Woman	Researcher is woman
Age_PhD	Researcher's age at PhD

Table 3 – Summary statistics of main variables

	Mean	Std Dev	Min	Max
Time-to-Entry	3.84	2.57	1	10
Promoted	0.50	0.50	0	1
Time-to-Promotion	7.97	3.66	1	24
PD_Abroad	0.20	0.40	0	1
PD_Abroad_USA	0.09	0.28	0	1
PD_Abroad_EUR	0.09	0.29	0	1
PD_Abroad_OTH	0.02	0.13	0	1
Localism	0.61	0.49	0	1
N_Pubs_Entry	0.71	0.75	0	12.70
N_Pubs_Prom	0.58	0.52	0	7.54
N_Cits_Entry	1.30	2.62	0	98.98
N_Cits_Prom	1.29	1.77	0	38.98
Precocity	0.65	0.48	0	1
Woman	0.41	0.49	0	1
Age_PhD	30.78	2.53	25	39
Observations	9912			

Table 2 provides a description of the variables utilized in the empirical analysis, while Table 3 outlines the descriptive statistics of the primary characteristics within the sample. Specifically, 20% of individuals pursued a PD position abroad, with 9% in the United States and the European Union and the remaining 2% elsewhere. Additionally, 61% of the PhD recipients secured their initial Assistant Professor position at the same university where they earned their PhD. Women researchers constitute 41% of the sample, and the average age at obtaining a PhD was 31 years.

6 Results and discussion

6.1 Time-to-entry

Table 4 presents the findings from the Cox model estimations, analyzing the time until the first appointment as an assistant professor. The analysis explores the impact of spending a PD period abroad and the influence of social capital variables. Table 5 reports the results for the restricted sample of academics obtained using CEM.

Column 1 shows that the estimated hazard ratio for *PD_Abroad* is 0.771, indicating that internationally mobile postdocs experience a 23% lower hazard of entry into Italian academia. To give an idea of the magnitude of the effect, easier to interpret than the hazard ratio, we estimate the average treatment effect – i.e., the difference in the time to first appointment if everyone spent a PD period abroad instead of if no one did. The estimated average time-to-entry for all non-internationally mobile postdocs is 3.7 years. With a PD appointment abroad, the average time-to-entry is estimated to be 0.64 years more, which corresponds to a significant increase of 17% relative to the previous case (14% for the CEM-restricted sample).

In column 2 the variable of interest *PD_Abroad* is split in three according to the geographic area in which the mobility occurred (US, Europe or the rest of the world). Irrespective of the destination, doing a PD abroad delays entry as an assistant professor compared to those that did it in Italy, especially in the case of postdocs mobile outside the USA and Europe. In the estimation for the CEM sample (Table 5), the magnitude of the coefficient and its significance are similar.

Table 4 – Risk of first appointment in t, baseline results

	(1)	(2)	(3)
PD_Abroad	0.771***		0.774***
	(0.021)		(0.033)
PD_Abroad_USA		0.809***	
		(0.030)	
PD_Abroad_EUR		0.767***	
		(0.028)	
PD_Abroad_OTH		0.636***	
		(0.050)	
Localism	1.047**	1.047**	1.049*
	(0.023)	(0.023)	(0.026)
PD_Abroad × Localism			0.769***
			(0.026)
Ln_Pubs_Entry	3.417***	3.433***	3.417***
	(0.162)	(0.162)	(0.162)
Ln_Cits_Entry	0.785***	0.783***	0.785***
	(0.024)	(0.024)	(0.024)
Precocity	1.162***	1.161***	1.162***
	(0.030)	(0.030)	(0.030)
Woman	0.972	0.973	0.972
	(0.021)	(0.021)	(0.021)
Age_PhD	1.198**	1.192**	1.198**
	(0.092)	(0.091)	(0.092)
Age_PhD^2	0.998**	0.998*	0.998**
	(0.001)	(0.001)	(0.001)
PhD Year, Area & Uni FE	Yes	Yes	Yes
Observations	9912	9912	9912
Log-likelihood	-82222.9	-82218.7	-82222.9
Chi-squared	1615.2	1623.7	1615.2

Notes: The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

In column 3, we interact *PD_Abroad* with the first proxy for social capital: the dummy variable *Localism*. We can see that the coefficient for *Localism*, which represents the hazard ratio of postdocs in Italy who get the first appointment in the PhD granting institution – where they are expected to have already strong acquaintances developed during the doctorate years – have a higher hazard of getting the position faster with respect to their internationally mobile peers. However, the inbreeding variable is only significant at the 10% level, and the coefficient is not significant in the CEM-matched

sample (see column 3 in Table 5). Both the coefficients of *PD_Abroad* and the interaction of the latter with *Localism* are below one, and, in the CEM sample (Table 5), the coefficient of the interaction is lower than the former (0.710 versus 0.816, respectively), and their difference is significant. Hence, inbreeding (i.e., getting the first position as assistant professor in one's *alma mater*) delays entry into Italian academia for internationally mobile PD researchers.

Table 5 – Risk of first appointment in t, baseline results (CEM sample)

	(1)	(2)	(3)
PD_Abroad	0.745***		0.816*
	(0.049)		(0.088)
PD_Abroad_USA		0.723***	
		(0.062)	
PD_Abroad_EUR		0.797***	
		(0.064)	
PD_Abroad_OTH		0.586***	
		(0.098)	
Localism	1.012	1.009	1.086
	(0.070)	(0.070)	(0.105)
PD_Abroad X Localism			0.710***
			(0.057)
Ln_Pubs_Entry	3.254***	3.289***	3.245***
	(0.420)	(0.425)	(0.419)
Ln_Cits_Entry	0.914*	0.919*	0.915*
	(0.047)	(0.047)	(0.047)
Precocity	1.210**	1.210**	1.209**
	(0.094)	(0.095)	(0.094)
Woman	0.969	0.958	0.967
	(0.080)	(0.079)	(0.080)
Age_PhD	1.518	1.388	1.477
	(0.656)	(0.607)	(0.638)
Age_PhD^2	0.993	0.995	0.994
	(0.007)	(0.007)	(0.007)
PhD Year, Area & Uni FE	Yes	Yes	Yes
Observations	1114	1114	1114
Log-likelihood	-6771.8	-6770.0	-6771.2
Chi-squared	250.0	253.6	251.1

Notes: The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

In Table 6, we split the *PD_Abroad* variable into two complementary variables based on the network developed by the researcher during their PD period. Specifically, we focus on the share of the researcher's co-authors' Italian affiliations. In the three columns of Table 6, we set different thresholds (abbreviated as TH) for this percentage to observe how the *PD_Abroad* variable reacts to different cases, ranging from less extreme to more extreme. We begin in column 1 with a TH corresponding to the first quartile (Q1), which means that the variable *PD_Abroad (Home Linkages)>TH* takes the value 1 for those researchers who published with the share of co-authors' Italian affiliations during their PD abroad being higher than the first quartile of the distribution in their scientific field. In contrast, *PD_Abroad (Home Linkages)≤TH* is the complementary variable when, in this case, the share is less than or equal to the first quartile. In columns 2 and 3, we increase the TH to the second and third quartile (Q2 and Q3 respectively). Additionally, we report in each column the result of the Wald test to determine if the difference between the two coefficients of *PD_Abroad (Home Linkages)* above vs. below the TH is statistically significant. In the results table below we only report the coefficients of these two variables, but all models include the same control variables as the main analysis reported in Table 4 and Table 5, including the dummy *Localism*. The results, which are reported only for the CEM sample (but are similar in the full sample), indicate that collaborating primarily with co-authors from the home country reduces the time to entry for internationally mobile researchers when the percentage of Italian co-authors' affiliations is above the third quartile (column 3). The hazard ratio in this case is 1.419 and significantly different from the complementary hazard of 0.672.

The estimation results uncover two different approaches to managing the scientific workforce in Italy. On one hand, young doctorate holders may reluctantly accept postdoctoral appointments abroad, as these positions could potentially delay their progression to an assistant professor role. On the other hand, if the researcher continues working mainly with Italian academia during the foreign PD, she has a higher probability of getting an assistant professor position sooner.

Table 6 – Risk of entry in t, additional results (CEM sample)

	(1)	(2)	(3)
	TH: Q1	TH: Q2	TH: Q3
PD_Abroad (Home Linkages>TH)	0.721***	0.814**	1.419**
	(0.050)	(0.079)	(0.247)
PD_Abroad_Ita (Home Linkages≤TH)	0.917	0.721***	0.672***
	(0.119)	(0.052)	(0.046)
PhD Year, Area & Uni FEs	Yes	Yes	Yes
Observations	1114	1114	1114
Log-likelihood	-6770.2	-6771.1	-6523.2
Chi-squared	253.3	251.4	365.5
Prob.	0.066	0.227	0.000

Notes: All models include the same control variables as Table 4, column 1. The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

We find weak evidence of a positive effect on time-to-entry for those researchers who do not move internationally and who seek their first academic position in their *alma mater*. However, the effect is not significant in the CEM sample estimation.[11] On the other hand, we find a statistically significant difference in the effect for researchers who spent a PD period abroad and then returned to their *alma mater*, with respect to those who got hired by a different university. The first group experiences a longer time-to-entry than the second. While localism has a negative impact on the career velocity of international mobile researchers, maintaining a strong connection with the home country yields benefits in terms of entry speed for internationally mobile postdocs. PD researchers abroad who primarily collaborate with co-authors from Italian institutions attain assistant professor positions sooner than their counterparts.

As in previous literature, control variables provide evidence for a positive productivity effect in terms of publications, especially for publications before the end of the

[11] In an unreported result, available upon request, we utilized the complete sample of 18,039 researchers and conducted CEM with "being research active during the PD" as the treatment variable instead of *PD_Abroad*, as in the main analysis. This process resulted in a CEM sample of 3,483 researchers. Subsequently, we employed the same regression model as presented in column 3 of Table 5. Our observations indicate a notably stronger and statistically significant effect of inbreeding. Specifically, the results demonstrate that the hazard ratio of *Localism* is 1.216 with a p-value < 0.01. This implies that researchers who did not publish during the PD and secured their first assistant professor position at their PhD granting university exhibit a higher hazard rate of entry. For the inbred, the average time-to-entry is estimated to be 0.37 years less, corresponding to a significant decrease of 11% relative to non-inbred. The result holds also for the full sample of 18,039 researchers. This underscores the influential role of inbreeding on the entry of researchers that have not been publishing before the appointment (non-research active).

PhD (*Precocity*). Contrary to evidence in other countries (see, for example, Lawson & Shibayama, 2015), citations by year are negatively correlated to the probability of entry. Age has an "inverted-U" shape tendency, and we do not find any significant difference in the time needed to get to the assistant professor position for women researchers.

6.2 Time-to-promotion

To provide a first impression of the survival process for the time-to-promotion analysis, Figure 4 depicts the Kaplan-Meier survival estimate (left) and the hazard curve (right) for the observations split by our main variable of interest, namely the dummy *PD_Abroad*, which takes value 1 for researchers who spent a PD period abroad. We can observe that this latter group exhibits a steeper survival curve (left panel), which means that the survival probability (i.e., the probability of not being promoted) decreases faster with respect to researchers without international experience and a higher hazard of being tenured at all times, with a peak at 13 years after their first appointment (right panel).

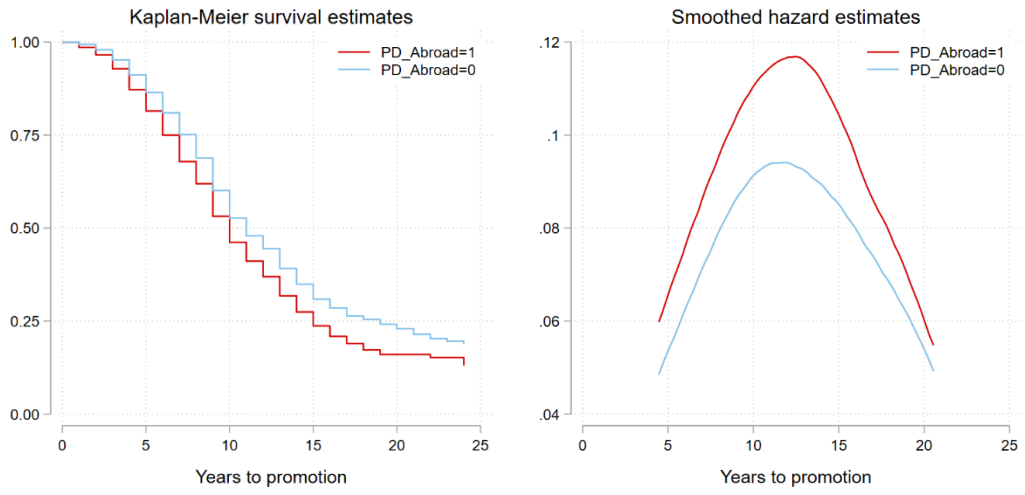

Figure 4 – Kaplan-Meier survival estimate (left) and hazard curve (right)

Table 7 – Risk of being promoted in t, baseline results

	(1)	(2)	(3)	(4)
PD_Abroad	1.211***		1.236***	
	(0.045)		(0.071)	
PD_Abroad_USA		1.276***		1.371***
		(0.063)		(0.109)
PD_Abroad_EUR		1.151***		1.114
		(0.059)		(0.086)
PD_Abroad_OTH		1.186		1.407*
		(0.133)		(0.262)
Localism	0.926**	0.925**	0.933*	0.936*
	(0.033)	(0.033)	(0.037)	(0.037)
PD_Abroad × Localism			1.195***	
			(0.056)	
PD_Abroad_USA × Localism				1.227***
				(0.075)
PD_Abroad_EUR × Localism				1.183**
				(0.079)
PD_Abroad_OTH × Localism				1.088
				(0.153)
Ln_Pubs_Prom	4.069***	4.083***	4.069***	4.112***
	(0.335)	(0.337)	(0.335)	(0.340)
Ln_Cits_Prom	1.201***	1.195***	1.201***	1.192***
	(0.054)	(0.054)	(0.054)	(0.054)
Precocity	1.093**	1.091**	1.093**	1.090**
	(0.040)	(0.040)	(0.040)	(0.040)
Woman	0.825***	0.826***	0.825***	0.826***
	(0.027)	(0.027)	(0.027)	(0.027)
Age_PhD	0.941	0.939	0.942	0.942
	(0.111)	(0.111)	(0.111)	(0.111)
Age_PhD^2	1.001	1.001	1.001	1.001
	(0.002)	(0.002)	(0.002)	(0.002)
PhD Year, Area & Uni FE	Yes	Yes	Yes	Yes
Observations	9912	9912	9912	9912
Log-likelihood	-40369.7	-40368.4	-40369.6	-40367.0
Chi-squared	2528.5	2531.0	2528.7	2534.0

Notes: The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

Table 7 shows the results of the Cox model estimations for being promoted from assistant professor to associate or full professor positions (the latter case is rarer), investigating the effect of having spent a PD period in a foreign institution. The baseline Cox results shown in column 1 reveal that international PD appointments have a significant positive impact. This suggests that academics with research experience abroad

tend to advance in their careers more quickly compared to peers who lack such experience. The estimated average time-to-promotion for all non-internationally mobile postdocs is 12.3 years. With a PD appointment abroad, the average time-to-promotion is estimated to be 1.2 years less, corresponding to a significant decrease of 10% relative to the previous case (15% for the CEM sample).

In column 2, we split international PD positions into appointments to the USA, Europe, and the rest of the world. We find that PD appointments in the USA increase the likelihood of being promoted more than elsewhere. This follows our expectations, given the global prestige of American institutions.

In column 3, we analyze the relationship between localism (obtaining the first academic position at one's PhD institution) and international PD appointments. We expect inbred academics to benefit more from PD appointments due to their institutional connections. Still, we find a negative main effect on time-to-promotion for inbred academics without international experience. While the interaction effect between international PD mobility and inbreeding is positive, it is not significantly different for non-inbred international mobile academics. Hence, localism does not significantly impact researchers' career paths with international PD experience.

Interestingly, looking at the results for the CEM sample presented in Table 8, it becomes apparent that only researchers who are mobile to the USA significantly reduce their time to promotion (column 2). Additionally, in column 3, the coefficient of the interaction *PD_Abroad × Localism* is significant at the 5% level, while the coefficient for *PD_Abroad* alone is only significant at the 10% level. Thus, it would appear that internationally mobile researchers experience faster promotion only in their *alma mater*[12]. To delve deeper into this finding, we conduct further analysis in column 4, where we interact *PD_Abroad_USA*, *PD_Abroad_EUR,* and *PD_Abroad_OTH* with *Localism*. The results reveal that the coefficient for *PD_Abroad_USA* and its interaction with *Localism* are positive and significant, although not significantly different from each other. Consequently, we conclude that it is the destination of international mobility

[12] The scenario of an international mobile researcher obtaining their initial appointment at their *alma mater* and subsequently changing universities for a promotion is indeed quite rare, accounting for less than 5% of promoted researchers.

for researchers, rather than their inbred status, what truly influences the time to promotion. Notably, with its high-quality research institutions, the US emerges as the most rewarding destination for international mobile researchers.

Table 8 – Risk of being promoted in t, baseline results (CEM sample)

	(1)	(2)	(3)	(4)
PD_Abroad	1.279***		1.348*	
	(0.117)		(0.212)	
PD_Abroad_USA		1.486***		1.461*
		(0.172)		(0.309)
PD_Abroad_EUR		1.111		1.216
		(0.132)		(0.238)
PD_Abroad_OTH		1.210		1.750
		(0.296)		(0.714)
Localism	0.896	0.891	0.933	0.941
	(0.130)	(0.129)	(0.163)	(0.165)
PD_Abroad × Localism			1.247**	
			(0.138)	
PD_Abroad_USA × Localism				1.482***
				(0.200)
PD_Abroad_EUR × Localism				1.055
				(0.155)
PD_Abroad_OTH × Localism				1.013
				(0.311)
Ln_Pubs_Prom	4.954***	5.070***	4.958***	5.118***
	(1.292)	(1.320)	(1.294)	(1.334)
Ln_Cits_Prom	1.109	1.086	1.108	1.081
	(0.150)	(0.147)	(0.150)	(0.146)
Precocity	1.035	1.005	1.037	1.020
	(0.113)	(0.111)	(0.113)	(0.113)
Woman	0.666***	0.675***	0.665***	0.676***
	(0.089)	(0.091)	(0.089)	(0.091)
Age_PhD	0.389	0.404	0.387	0.394
	(0.258)	(0.268)	(0.256)	(0.261)
Age_PhD^2	1.015	1.014	1.015	1.015
	(0.011)	(0.011)	(0.011)	(0.011)
PhD Year, Area & Uni FE	Yes	Yes	Yes	Yes
Observations	1114	1114	1114	1114
Log-likelihood	-3685.1	-3682.8	-3685.0	-3682.1
Chi-squared	495.7	500.1	495.8	501.6

Notes: The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

Looking at the control variables, *Age_PhD* has a negative impact on the scientists' velocity to tenure, but it is not significant. *Woman* has an important negative impact: in all the specifications considered, women scientists have about 33% lower hazard rate of being promoted. Scientific productivity, measured by number of publications, have a positive impact on being promoted, while citations are only significant in the full sample but not in the CEM estimation, indicating self-selection into mobility of higher quality researchers.

Finally, we divided *PD_Abroad* into two variables in Table 9 based on the proportion of co-authors who are acquaintances from the PD period. We tested our hypothesis on the persistence of collaboration with these acquaintances and its importance. As already discussed when commenting Table 6, we set the three quartiles of this proportion, measured by scientific field, as the threshold (TH). The results reported in columns 1 to 3 refer to the CEM sample, and we performed the Wald test on the difference of the two coefficients. The findings indicate that maintaining an active scientific collaboration with acquaintances from the PD period increases the promotion velocity of researchers who spent time in a PD period abroad (see columns 2 and 3). The difference between the two coefficients is significant based on the Wald test in the most "extreme" case (column 3).

Table 9 – Risk of being promoted in t, additional results (CEM sample)

	(1)	(2)	(3)
	TH: Q1	TH: Q2	TH: Q3
PD_Abroad (Netw. persistence>TH)	1.266**	1.355***	2.174***
	(0.132)	(0.149)	(0.304)
PD_Abroad (Netw. Persistence≤TH)	1.305*	1.193	1.081
	(0.179)	(0.141)	(0.108)
PhD Year, Area & Uni FE	Yes	Yes	Yes
Observations	1114	1114	1114
Log-likelihood	-3685.0	-3684.6	-3674.1
Chi-squared	495.7	496.5	517.5
Prob.	0.840	0.349	0.000

Notes: All models include the same control variables as Table 7, column 1. The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

6.3 Additional results: control for advisor's international experience

Our BNCF data contain information on the advisor of the PhD candidates, although this information is not available for all observations in the empirical sample. We retrieved the advisor's information for 8,168 observations (82% of our sample). For these observations, we collected the names and surnames of the advisors and searched for them in Scopus using the Scopus API. We successfully found the advisors in Scopus for 7,804 observations (almost 80% of our empirical sample). Table 10 shows summary statistics for the baseline sample and the subgroup for which we have supervisors' information. Besides small differences, the sub-sample with advisors' information is very similar to the full empirical sample across all variables.

Table 10 – Summary statistics of main variables, by sample

	Empirical sample		Sample with advisors' info	
	Mean	SD	Mean	SD
Time-to-Entry	3.84	2.57	3.83	2.54
Promoted	0.50	0.50	0.46	0.50
Time-to-Prom	7.97	3.66	7.88	3.57
PD_Abroad	0.20	0.40	0.19	0.39
PD_Abroad_USA	0.09	0.28	0.09	0.28
PD_Abroad_EUR	0.09	0.29	0.09	0.28
PD_Abroad_OTH	0.02	0.13	0.02	0.13
Localism	0.61	0.49	0.63	0.48
Log_Pubs_Entry	0.48	0.33	0.48	0.33
Log_Pubs_Prom	0.41	0.27	0.42	0.26
Log_Cits_Entry	1.42	1.01	1.50	1.01
Log_Cits_Prom	1.60	0.95	1.68	0.95
Precocity	0.65	0.48	0.66	0.48
Female	0.41	0.49	0.42	0.49
Age_PhD	30.78	2.53	30.76	2.56
Observations	9912		7804	

For the advisors found in Scopus, we downloaded their publications referring to the period before each advisee's PhD defence and checked whether they published any papers while affiliated with a non-Italian institution. This was used to proxy the international experience of the supervisors. We identified 2,844 such cases where the

supervisors had international work experience (36.4% of the PhDs with advisor's information, 33.4% of the unique advisors).

We then created a dummy variable, *Intl_SV*, which takes the value of 1 if the supervisor has international experience. We reran our CEM procedure, adding this variable to the relevant characteristics discussed in online appendix B. This new matching is more restrictive than the one performed in the baseline analysis and resulted in 708 matched observations, with 354 having completed a postdoctoral period abroad (treated) and the same number of controls. We refer to this sample as "alternative" CEM sample.

Using this new restricted sample, we reran the baseline regressions of our empirical analysis. We found results consistent with those discussed above for time-to-entry analysis. In contrast, for time-to-promotion, we find stronger statistical evidence that faster promotion is obtained mainly for researchers who stayed in the US and got promoted to associate or full professor in their university of PhD graduation. These results for entry and promotion are reported in Table 11 and Table 12, respectively. Specifically, we see that for the time-to-entry analysis we do not see significant differences with the results reported in Table 5 of section 6.1. For the time-to-promotion analysis, we see that in Table 12, column 1, *PD_Abroad* is significant only at the 11% level (the p-value is 0.107) and, in columns 3 and 4, PD_Abroad and *PD_Abroad_USA* are significant and positive only when interacted with *Localism*. The latter plays a much more important role for internationally mobile researchers once we control for advisors' internationalization.

Table 11 – Risk of entry in t, baseline results (alternative CEM sample)

	(1)	(2)	(3)
PD_Abroad	0.707***		0.694***
	(0.059)		(0.095)
PD_Abroad_USA		0.709***	
		(0.076)	
PD_Abroad_EUR		0.729***	
		(0.075)	
PD_Abroad_OTH		0.586**	
		(0.131)	
Localism	0.984	0.978	0.969
	(0.090)	(0.089)	(0.122)
PD_Abroad X Localism			0.715***
			(0.074)
Log_Pubs_Entry	3.458***	3.492***	3.462***
	(0.568)	(0.577)	(0.569)
Log_Cits_Entry	0.929	0.928	0.928
	(0.060)	(0.061)	(0.060)
Precocity	1.002	0.990	1.002
	(0.104)	(0.104)	(0.104)
Female	0.989	0.990	0.988
	(0.106)	(0.106)	(0.106)
Age_PhD	1.283	1.224	1.286
	(0.662)	(0.636)	(0.664)
Age_PhD^2	0.997	0.998	0.997
	(0.008)	(0.008)	(0.008)
PhD Year, Area & Uni FE	Yes	Yes	Yes
Observations	708	708	708
Log-likelihood	-3977.3	-3976.8	-3977.3
Chi-squared	175.7	176.6	175.7

Notes: The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

Table 12 – Risk of being promoted in t, baseline results (alternative CEM sample)

	(1)	(2)	(3)	(4)
PD_Abroad	1.227		0.983	
	(0.156)		(0.219)	
PD_Abroad_USA		1.570***		1.403
		(0.242)		(0.406)
PD_Abroad_EUR		0.899		0.663
		(0.156)		(0.194)
PD_Abroad_OTH		1.216		2.559
		(0.415)		(1.877)
Localism	0.681	0.669	0.579*	0.612*
	(0.174)	(0.169)	(0.166)	(0.177)
PD_Abroad X Localism			1.344**	
			(0.198)	
PD_Abroad_USA X Localism				1.649***
				(0.287)
PD_Abroad_EUR X Localism				1.070
				(0.226)
PD_Abroad_OTH X Localism				1.045
				(0.415)
Log_Pubs_Prom	6.927***	7.150***	6.817***	7.259***
	(2.628)	(2.698)	(2.587)	(2.746)
Log_Cits_Prom	1.184	1.164	1.204	1.161
	(0.236)	(0.232)	(0.239)	(0.230)
Precocity	1.283	1.236	1.293	1.235
	(0.201)	(0.198)	(0.203)	(0.199)
Female	0.859	0.898	0.847	0.897
	(0.156)	(0.164)	(0.154)	(0.163)
Age_PhD	2.635	3.314	2.591	3.209
	(2.419)	(3.044)	(2.382)	(2.980)
Age_PhD^2	0.984	0.980	0.984	0.980
	(0.015)	(0.014)	(0.015)	(0.015)
PhD Year, Area & Uni FE	Yes	Yes	Yes	Yes
Observations	708	708	708	708
Log-likelihood	-2006.4	-2002.3	-2005.7	-2000.6
Chi-squared	381.5	389.7	382.9	393.1

Notes: The coefficients reported in the table are hazard ratios. SE in parenthesis; * p<0.1 ** p<0.5 *** p<0.01.

7 Conclusions

In this paper, we have explored the impact of international postdoctoral appointments and social capital on career outcomes in Italy, focusing on the duration until first academic appointment and subsequent promotion. We have assembled data on affiliations, productivity and careers of researchers active in Italian academia between 1986 and 2015. We focused on international PD research appointments, which, on the one hand, may help to expand existing scientific and technical human capital while on the other may cut the social capital of the researcher making return in the academic system of the home country more difficult. We employed Coarsened Exact Matching to pair each academic who engaged in international mobility with a peer who did not, ensuring the match was based on observable characteristics prior to the move. Our baseline results show that internationally mobile postdocs experience a 17% longer time-to-entry (0.64 years more) in Italian academia and a 10-15% lower time-to-promotion (1.2 years less) with respect to their peers. Overall, mobility to the US is the most rewarding form of international mobility.

Besides examining international mobility, we have also looked into both personal and social factors that influence time to entry and promotion to professorial roles. Regarding personal factors (like productivity, gender, and early-career achievements), our findings align with the existing literature, which is primarily based on studies from the US. We observe that scientific productivity, particularly early publication output during PhD years, significantly reduces time-to-entry, while it has a positive but not significant effect on time-to-promotion. Conversely, we find that women researchers tend to experience longer durations for promotion with respect to their male counterparts, while we find a negative but not significant effect on time-to-entry.

Regarding social determinants, we identified three distinct aspects of social capital (localism, home-country linkages and persistence in the collaboration network) and developed individual and bibliometric indicators to capture the unique nuances of each.

We did not find evidence of localism at the entry level, except for those PhD that entered the academic system without having published, for whom inbreeding is signifi-

cant and important. Localism is indeed important in our full sample for the less research active. We also find an indirect effect of localism associated to international mobility. Specifically, researchers who are internationally mobile and secure their initial position at their PhD-granting institution tend to encounter a longer time-to-entry. Conversely, at the promotion stage, they experience a shorter time-to-promotion, particularly if they have moved to the US. Once we control for the career of the supervisor, the shorter time-to-promotion effect is more important but holds only for those who went to the US and returned to the *alma mater*.

We found evidence that PD positions abroad slow down entry into the Italian academic system. In this career phase, however, maintaining scientific collaboration with the home country makes the entry quicker than peers working primarily with foreign authors during their international PD appointments. Also, we found that nurturing the collaboration ties created during the PD period abroad accelerates academic promotion. In particular, the ability of maintaining the scientific networks obtained by moving across different universities or laboratories, is a relevant form of social capital and valuable in the long term.

Table 13 – Summary table of main findings

		Career stage	
		Entry	Promotion
Main effect	International Mobility	(–)	(+) Especially for the US
Social Capital moderating effect	Localism	(–)	(+) Especially for the US
	Home country linkages	(+) For high levels of home connections	/
	Persistence in the composition of the co-authors network	/	(+) For high levels of persistence

Table 13 summarizes the main findings of the paper concerning three dimensions of social capital: localism, home-country linkages, and persistence in the collaboration network. While previous literature (Baruffaldi & Landoni, 2012) has already noted the importance of home-country linkages for return mobility, our study highlights the significance of maintaining persistent collaborations with acquaintances established during the postdoctoral (PD) period. The analysis reveals that a PD appointment abroad delays re-entry into the academic system. However, mainly when undertaken at prestigious institutions like those in the US, not only does it enrich the researcher's experience but also cultivates social capital that, if nurtured throughout one's career, proves valuable during promotion stages.

Our study comes with a number of limitations. First, our strategy does not account for mobility that did not result in a publication, such as visiting periods or research stays. To address this, one would likely need to collect *the curricula vitae* of scientists or use information in repositories of scientists' biographies. Second, we only consider returning mobility to academia; ideally, we would also analyze the careers of international mobile scientists who did not return to their home countries. Lastly, similar to other studies of this type (Cruz-Castro & Sanz-Menéndez, 2010; Lawson & Shibayama, 2015; Lutter & Schröder, 2016; Sanz-Menéndez et al., 2013), our empirical strategy cannot completely rule out the endogeneity of international mobility.

Despite these limitations, our findings offer valuable insights into the impact of international post-doctoral mobility on career advancement. The results indicate that specific international research positions early in a career can mitigate some of the negative aspects of job mobility, such as career uncertainty and instability, and are more likely to result in quicker promotions. This topic is of considerable interest to policymakers who aim to enhance the internationalization of their country's scientific community.[13] Our study supports the argument for governments to create stronger incentives for organizations to recognize and reward different forms of mobility. By shedding light on the career incentives and challenges faced by individual scientists, as we

[13] A recent example is the 2024 Annual Report from the German Commission of Experts on Research and Innovation, presented to German Chancellor: https://www.bundesregierung.de/breg-en/service/efi-report-presentation-2262670 (last visit: July 2024).

attempetd to do, future research may better evaluate recent reforms in Italy aimed at attracting “returning brains” (Bassetto & Ippedico, 2023).

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Online Appendices

A. Retrieving publications data

To retrieve publication information for the 18,039 researchers in our sample, we followed a specific procedure. We utilized the Scopus API to conduct a query using the researchers' full names along with their last affiliation, sourced from MIUR data. This operation yielded 34,419 results, corresponding to 15,968 unique combinations of researcher names and affiliations.

Each result includes a Scopus Author ID (AU-ID), meaning the same researcher may be associated with multiple AU-IDs. Additionally, for each result, Scopus provides a list of scientific fields (or "subject areas"[14]) along with the corresponding number of articles published in journals within each field. Using this information, we filtered out observations that were likely incorrect. This involved verifying whether the scientific field of the researcher and the subject area of the corresponding author profile aligned.

To attribute comparable disciplinary categories for authors and individuals, we aggregate disciplines defined by MIUR and Scopus subject areas into the following categories: Agriculture; Chemistry; Biology; Physics; Mathematics and Computer Science; Architecture and Engineering; Medicine and Veterinary; Economics and Management; Humanities and Law, Sociology and Political Science.

After this step, we identified 10,582 AU-IDs that were linked to a unique researcher profile, and we retained them. The remaining researchers were linked to two or more AU-IDs. For these cases, we selected a single AU-ID, prioritizing the one with the highest number of registered publications. We obtained 15,385 researcher–AU-ID pairs at the end of this process.

[14] Scopus subject areas are: Agricultural and Biological Sciences-AGRI; Arts and Humanities-ARTS; Biochemistry, Genetics and Molecular Biology-BIOC; Business, Management and Accounting-BUSI; Chemical Engineering-CENG; Chemistry-CHEM; Computer Science-COMP; Decision Sciences-DECI; Earth and Planetary Sciences-EART; Economics, Econometrics and Finance-ECON; Energy-ENER; Engineering-ENGI; Environmental Science-ENVI; Immunology and Microbiology-IMMU; Materials Science-MATE; Mathematics-MATH; Medicine-MEDI; Neuroscience-NEUR; Nursing-NURS; Pharmacology, Toxicology and Pharmaceutics-PHAR; Physics and Astronomy-PHYS; Psychology-PSYC; Social Sciences-SOCI; Veterinary-VETE; Dentistry-DENT; Health Professions-HEAL and Multidisciplinary-MULT.

B. Coarsened Exact Matching

We employ Coarsened Exact Matching (CEM) to identify suitable matches for each academic. Matching is based on observable characteristics assessed before the international postdoctoral mobility, ensuring:

- Similar levels of number of publications and citations before PhD;
- Similar birth year and PhD year distributions;
- Same gender, university of PhD, and scientific field.

The desired outcome of this process is a balanced sample of treated and control subjects. In this instance, we identified 577 treated academics, each paired with one coarsened exact match from the pool of all possible pairs (see Table B1). The matching process yielded two groups that exhibit no statistical differences across any of the matching criteria. Descriptive statistics of pre-treatment variables for academics who participated in research visits and those who did not are presented in Table B2. The test of means demonstrates a significant difference in time to entry and promotion.

Iacus et al. (2012) propose a measure of imbalance (*L1*) as the semi-sum of the absolute differences between relative frequencies of treated and control groups within each identified stratum. In our case, the overall *L1* for the population is 0.98, indicating a highly unbalanced distribution of treated and control subjects. This implies that many cells in the multidimensional matrix have either zero controls or zero treated cases. Comparing the *L1* of the matched population with the original population provides evidence of improved balance resulting from CEM. After CEM, *L1* is reduced to 0.87, indicating a higher degree of balance between treated and control groups.

In addition to this baseline CEM, we also run a more stringent CEM by including, in addition to the variables detailed, *Intl_SV* — a dummy variable that takes the value one if the advisor of the focal researcher has international experience, as proxied by the fact that they have published with a foreign affiliation before their advisee's PhD defense. Running the CEM with this additional variable further reduces the matched sample to 708 observations (354 treated and 354 controls). Nonetheless, the matching obtained is more accurate, reducing the differences between the treated and control

groups, which remain statistically non-significant for all the matching variables (see Table B.3).

Table B1 – Treated and control units by CEM group.

	Treated	Controls
All	1944	7968
Matched	577	577
Un-matched	1367	7391

Table B2 – Descriptives and t-test of matched units by treated and controls

	Controls		Treated		Diff.	
	Mean	SD	Mean	SD	b	t
Time-to-Entry	3.55	2.36	4.05	2.46	-0.51***	(-3.51)
Promoted	0.53	0.50	0.60	0.49	-0.07*	(-2.48)
Time-to-Prom	8.89	4.21	7.87	4.00	1.02***	(4.16)
Nb. Pubs during PhD	2.08	2.70	2.37	2.60	-0.29	(-1.81)
Nb. of yearly Cits during PhD	3.17	6.98	3.90	7.46	-0.72	(-1.67)
Woman	0.32	0.47	0.32	0.47	0.00	(0.00)
Year of birth	1969.69	4.84	1969.75	4.93	-0.06	(-0.20)
Year of PhD	1999.70	4.35	1999.66	4.34	0.04	(0.16)
Field: Natural Sciences	0.46	0.50	0.46	0.50	0.00	(0.00)
Field: Med. & Veterinary	0.10	0.30	0.10	0.30	0.00	(0.00)
Field: Arch. & Engineering	0.36	0.48	0.36	0.48	0.00	(0.00)
Field: Humanities & Law	0.03	0.18	0.03	0.18	0.00	(0.00)
Field: Social Sciences	0.04	0.20	0.04	0.20	0.00	(0.00)
Observations	557		557		1114	

Table B3 – Descriptives and t-test of matched units by treated and controls

	Controls		Treated		Diff.	
	Mean	SD	Mean	SD	b	t
Time-to-Entry	3.40	2.23	3.95	2.40	-0.55**	(-3.13)
Promoted	0.51	0.50	0.55	0.50	-0.05	(-1.20)
Time-to-Prom	8.79	3.86	7.83	3.86	0.96**	(3.30)
Nb. Pubs during PhD	2.63	5.05	3.32	4.59	-0.69	(-1.90)
Nb. of yearly Cits during PhD	4.00	13.82	5.17	13.39	-1.18	(-1.15)
Woman	0.35	0.48	0.35	0.48	0.00	(0.00)
Intl_SV	0.40	0.49	0.40	0.49	0.00	(0.00)
Year of birth	1970.21	4.39	1970.17	4.46	0.03	(0.10)
Year of PhD	2000.27	3.89	2000.24	3.85	0.03	(0.11)
Field: Natural Sciences	0.44	0.50	0.44	0.50	0.00	(0.00)
Field: Med. & Veterinary	0.09	0.29	0.09	0.29	0.00	(0.00)
Field: Arch. & Engineering	0.39	0.49	0.39	0.49	0.00	(0.00)
Field: Humanities & Law	0.05	0.21	0.05	0.21	0.00	(0.00)
Field: Social Sciences	0.03	0.18	0.03	0.18	0.00	(0.00)
Observations	354		354		708	