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The employment destination of PhD-holders in Italy: non-academic funded projects as drivers of successful segmentation¹

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Abstract

In all developed countries in recent years, the non-academic labour market destination of PhD-holders (segmentation) has emerged as an issue. Universities and other research-intensive institutions can no longer absorb the major share of PhD-holders. Their employment has become a matter of segmentation both in horizontal (economic sector) and in vertical (income) dimensions. The paper tests what factors segment labour market outcomes in both dimensions – economic sector and income. Findings suggest that whilst scientific mobility and type of funding during PhD period do not play a notable role, some types of experiences such as post-doc, instead, predict exit from academic employment and also a higher income overall. The most significant experiences that contribute to segmentation are in fact projects funded by private companies or international organizations in postdoctoral periods. Policy-making implications are relevant for both PhD-holders, universities and external organizations. For instance, non-academic employers may maximise their collaborations with universities with beneficial outcomes for PhD-holders themselves as well

Keywords: doctoral holders, employability, industry-university relations, post-doctoral funding, self-employment, natural experiment, Italy

JEL Codes: I23; I25; I26; J21; J24; J31; J62; O32; C36

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Introduction

A wide body of literature has pointed out that the labour market of PhD-holders, especially the non-academic one (Mangematin 2000; Enders 2002, Caparros-Ruiz 2019; Cruz-Castro, & Sanz-Menéndez 2005; Jackson & Michelson 2015; Neumann & Tan 2011, Pedersen 2016; van der Weijden et al. 2016), has become critical. PhD-holders have been detected as a target of people under *segmentation* – meaning that PhD-holders will have to get non-academic positions in any economic sector due to shortage of positions in academia and in other public research institutes, especially tenured or secure positions. Nevertheless, the body of knowledge about what may facilitate segmentation is poor in relation to this increasing phenomenon. What does fully unleash the potential of PhD-holders when they can't or don't wish to continue a career in academia? This problem is increased by the evidence that the arguable attractiveness of such highly qualified education does not necessarily occur spontaneously by non-academic employers (Casey 2009). Hence, to understand the drivers for such not yet fully developed segmentation is important.

The topic is intriguing because arguably PhD-holders may prefer to work as researchers although opportunities for permanent positions are poorer in comparison to some decades ago (van der Weijden et al. 2016; Haley et al. 2018). In analysing a context like PhD-holders from Italian universities, the paper explores one of the most difficult OECD country in which to pursue an academic career, exacerbating the pressing issue of getting alternative employment.

The paper investigates which steps in a PhD-holder's career facilitate a transition towards non-academic and non-public research institute careers (this representing the first hypothesis) and which steps make one's career a successful one – meaning resulting in having higher income, the second hypothesis. Push-factors in contemporary academic labour market are the background theory that generates these two hypotheses regarding sector destination and differentials in wages. By means of using a dedicated survey about PhD-holders employment destination after several years of PhD attainment, the paper contributes to this debate finding that PhD-holders are more likely to get positions outside academia when they worked in projects funded by non-academic organisations. Non-academic post-doctoral projects are also prediction of establishing oneself as self-employed, giving further insight and wider perspective to the topic of academic spin-offs. This relationship between PhD-holders and non-academic organisations via post-doctoral projects that took place in universities is also a successful gateway for higher incomes. In order to deepen knowledge, we conceptually assume that multiple events across a career trajectory may constitute patterns of labour market destinations. To take into account this well-known dynamic in life cycles, the paper provides extensive endogeneity analyses using key past events about doctoral and postdoctoral experiences as instrumental variables.

The paper is organised in the following way. The literature review outlines the main debates in the field of PhD career trajectories. The Data section describes the dataset and its variables used for the analysis. Hypotheses and results section provide the two hypotheses: 1) what does predict a non-academic employment; 2) what does predict a higher salary. A subsection provides evidence of tests of endogeneity in order to check whether main events sorted chronologically determine following career steps. The Discussion section supplies more in depth implications with literature. Conclusions attempt recommendations to policy makers at European level also out of the specific Italian higher education context.

Literature review

The topic of employment of doctoral holders is relatively recent in Europe or other developed countries. When facing this topic and looking primarily on destination employment, some clusters of relatively homogenous bodies of research emerge. These clusters identify following subsections: involvement in projects and the relevance in a timeline; the spin-offs option; the appreciation of the PhD title; the post-doc condition per se; discriminations by gender; factors facilitating job matching; the realisation of one's chances to be academics forever. This section also provides some details of the Italian context in the larger European sphere, which is propaedeutic for the interpretation of these results in a broader European perspective.

Involvement in post-doctoral projects.

Projects are the main mode of work at doctoral and post-doctoral levels. Projects may differ by their nature: some are publicly funded for unfettered research; some others aim at facing a socio-economic problem within one or more disciplines. The latter typology is arguably the most compelling for non-academic employment development. Non-academic organizations, for instance, may expect from PhD-holders that they bring collaborations with universities along with research, development activities and functions (e.g. R&D capacities), plus other skills (Manathunga et al. 2009). Nevertheless, an ex-post study among non-academic employers found that only around a fifth of them detects specific reasons for having hired such a highly qualified personnel (Haapakorpi 2015). Following this evidence, it is reasonable to investigate patterns of over-education and/or over-skilling (Gaeta et al. 2017). Involvement in different post-doctoral projects arguably may predict different eventual career steps. For instance, Garcia-Quevedo et al. (2012) analysed PhD-holders destinations in depth, describing the opportunity to have non-academic employment – not necessarily private companies – by previous events. In addition, the perspective of different types of projects carried out as a researcher is relevant though unexpectedly unexplored in this topic. A project funded by a company for a scholarship of a PhD student or for a post-doc is a joint investment in a specific person holding the post. A PhD student and a post-doc researcher, though costing in some cases almost the same according to Italian legal framework, might display considerable differences in terms of ability to produce results. This is a cogent point from the employers' perspective, if one follows a human capital assumption. Nevertheless, this issue appears underdeveloped in literature.

Spin-offs.

Spin-offs are one interesting alternative to traditional academic jobs, preserving R&D intensity and exploiting PhD-holders' expertise (Horta et al. 2016; Meoli et al. 2018). The main difference between these studies and the findings from this analysis is that self-employment as a category includes a larger set of workers in comparison to spin-offs. Self-employment is also not necessarily happening in campuses, in specific labs, or under specific policies, possibly aimed at tackling paucity of opportunities (Rizzo 2015).

Appreciation of PhD title.

The title of PhD per se may change by country. Also the structure of the labour market in a country as a whole is important. The Austrian labour market for PhD-holders is very different from the Italian one, for instance: in Austria recent cohorts of PhD-holders are more likely to work in companies and much less likely to do work in education sector other than higher education one (Schwabe 2011). In Italy education and training other than higher education remains a sort of second-best option with lower wages, but also showing less gumption, such as strategic use of social networks (Baruffaldi et al. 2017). Some other specific features by

country are worth mentioning. Literature highlights the importance of connecting doctoral programs to destination employment in Anglo-Saxon countries (Rominger 2018), or more broadly in OECD ones (Gokhberg et al. 2016). This aspect is less developed in Italy. Last, in Italy the Anglophone expression PhD is mostly unknown outside academia, and the Italian “Dr.” identifies Master graduates also, generating confusion in acknowledging the possible surplus of competence by PhD-holders.

The post-doc condition.

A large corpus of research deals with post-doctoral experiences. Some previous studies highlight the increasing number of fixed-term post-doc positions within research-intensive universities, finding that post-doc period(s), if not too long in duration, are somehow beneficial regardless (or with uncertain relation with) prestige of hosting institutions (Su 2013). However, other evidence reveals that postdoc positions are potentially endless (Powell 2015). Other authors argue that the post-doctoral condition itself is pernicious inasmuch uncertainty per se is detrimental (Signoret et al. 2019). In a not very stratified higher education system like the Italian one, it is likely that post-docs positions constitute a sort of “survival tournament” where some PhD-holders get a tenure as soon as they can, while others may drop towards other non-academic or non-public scientific positions. This may happen in an unpredictable mode and with unclear patterns (Wöhler 2014). To this regard, it is relevant to understand the role of these post-doctoral positions to determine the extent to which different post-docs and non-tenured experiences predict any exit from academic positions. On top of this point, postdoctoral duration is arguably subject to the rule of diminishing returns (Su 2013; Webber & González Canché 2015). At the same time, the higher the scientific productivity, the higher the probabilities to continue to progress in universities or public research institutes, according to new career progression patterns based on scientific production (Marini 2017). All in all, it is unclear the extent to which post-doctoral positions are predominantly positive or negative experiences.

PhD-holders and gender.

PhD-holders are not immune to gender discrimination. Gender pay gap among PhD-holders has been found (Platow 2012; Schwabe 2011; Webber & González Canché 2015), although people in higher percentiles in earnings do not suffer this disequilibrium (Canal-Domínguez & Wall 2014). This latter evidence leaves room for speculations about possible family burdens as a concurring factor of the gender pay gap.

Factors facilitating job matching.

The public debate and the discourse about the role of PhD-holders outside academia in Italy is not systemically covered by any support organization, like for instance Vitae in the UK. There is also poor attention towards what a PhD student ought to develop in order to increase his/her probabilities to get valuable positions in other sectors (Hancock & Walsh 2016), resulting in a situation whereby labour market transition is arguably a determinant of personal inclinations or occurring opportunities. Notoriously, in Italy one’s social capital play a relevant role. Social capital, unfortunately, is seldom measured in this topic, and it probably revealed interesting patterns about PhD-holders’ eventual employment trajectories. This study to this regard provides some proxies of social capital to disentangle why a fresh PhD-holder might happen to stay in academia or to opt for another industry. These proxies derive from different types of contacts a PhD-holder may experience during and after PhD attainment.

Realising one's chances.

It is reasonable to argue that for PhD-holders any non-academic position is still today perceived as a sort of exit from an academic career. This may happen once a person has pursued research for research's sake and after having accomplished this interest. More likely, to continue to carry on *one's* research sooner or later may clash with the issue of what to do for a living. In this scenario, PhD-holders realise at different stages that only few people will have the opportunity to do research forever, and, more importantly, PhD-holders realise at different stages whether they are among those few achieving a career in academia. We also cannot assume that any PhD-holder is able to realise his/her actual chances promptly and with no biases. They also may realise only after a given period of time the extent to which they really want to stay in academia, or under which conditions they wish to continue to be academics (Sauer mann & Roach 2012). Only occasionally, research casts light on preferences for salary and career as such, at disfavour of research for research sake (Roach & Sauer mann 2010). This problem is exacerbated by the fact that a PhD-holder do not accrue particular advantages in the labour market outside academia in comparison to a Master graduate, at least for the private sector (Pedersen 2016). The conundrum of having spent years in doing research and finding oneself in a precarious and/or dead-end career trajectory lasts.

As a result, the literature is still not fully developed in analysing the employment opportunities for PhD-holders in the mid/long-term, leaving space for essential research to understand, for instance, which skills ought to be developed during PhD studentship for the sake of future employability, or to understand which events at the aftermath of doctoral attainment are more likely to help PhD-holders finding a good job in non-academic sectors.

Data

The analysis is based on a secondary dataset – a dedicated survey about PhD-holders' employment destination from any discipline released from Italian statistical office (Istat, *Indagine sui dottori*³). The data refer to PhD-holders who obtained their qualification in 2008 and 2010 in any Italian institution. This study cannot analyse career paths across a long time span and with events in a timeline like Webber & González Canché have done (2018). Nevertheless, the data afford to identify some events such doctoral studentship, post-doctoral positions (either on-going or accomplished) and current employment, along with scientific productivity, participation in projects, and mobility. Descriptive statistics of the dataset are presented in Table 1.

Dependent variables.

Economic sector of employment is the first dependent variable. To minimize this variable into a few coherent categories, we disentangle two possible different sectors other than the academic-scientific one: other education, and all the rest. This distinction is relevant because education can be considered in Italy a second-best-alternative for PhD-holders who might not have found a stable employment in academia after a certain number of years. Some PhD-holders thus may opt to teach, using their knowledge and qualification for this career. In comparison to academic employment, these jobs are on average lower in wages. All the other sectors instead include anything, and they are more likely employment destinations with

³ For full reference please go to <https://www.istat.it/it/archivio/56512>. This paper analyses the most recent available data at that time of acquisition in early 2018.

more diversified demanded skills. In principle, PhD-holders should spread in many different sectors regardless of the R&D intensity of a sector. PhD-holders in other sectors, in fact, – either public, private or “third sector” (i.e. quasi-governmental, quangos, associations, etc.) – may arguably use their skills and knowledge from any discipline in more innovative ways, filling R&D positions in any sector. For this reason, any employment in academia is compared against these two possible destination sectors separately, using the same set of independent variables in hypothesis 1 (horizontal segmentation, see below). The analyses exclude PhD-holders who already were in employment when they started the PhD in order to avoid the effect of possible improvement of qualification on the evidence that these PhD-holders usually do not change sector, nor even employer, when the PhD is obtained (figures available upon request).

The second dependent variable used for hypothesis 2 (vertical segmentation, see below) is salary [WPPP; average 64.46€ net per day] (See Table 1). Considering the net monthly income declared and the respective weekly worked hours, it is possible to compute this variable. In particular, this variable has been generated taking into account the net income of different possible taxation regimes, and after having compared the income at purchasing power parity (PPP) of the country of residence, applying coefficients available from OECD figures for the year 2014. Yet, this variable also considers further possible income from any other work, which is relevant for several PhD-holders active in flexible working conditions. This portion of the income is considered proportionally to the time spent on average in order to have a fair overall average of wage per unit of time. Some supplementary benefits are included, such as *tredecimesima* and *quattordicesima* – typical monetary benefits for employees in Italy. Since the variable is about salary over working time, we overlook whether part-timers are not full-timers on a personal preference or not (around two thirds of respondents declared they would have preferred not to be part-timers). We reckon this caveat a minor limitation. The test for the second hypothesis regresses the natural logarithm of this variable.

Independent variables.

Independent variables might be grouped in some groups such as biographical information, doctoral experience, employment after PhD attainment (either post-doctoral or other), and current employment. Some of these variables are discussed to facilitate the results interpretation. Funding of PhD stipend [d1_10] explains if the PhD was covered by any stipend, and, if yes, which type of source the stipend was based on. This variable is interesting to understand if at this studentship stage contacts with non-academic source of funding may predict a future career in non-academic positions (Horta et al.2018). The dataset also offers the opportunity to check employment trajectories by periods spent abroad, both during the PhD [mob_during; pursued by 46%] and afterwards as PhD-holders [mob_post; pursued by 27.5% of the sample]. This distinction affords comparisons with previous researches (Di Cintio & Grassi 2016; Caparros-Ruiz 2019; Marini 2018) and it is relevant for understanding if and when mobility does happen. A binary variable [d1_15] provides information whether the doctorate was finished on time (12.3% of respondents “yes”) or if more time was needed – a variable coherent with literature (Horta et al. 2019). Employment at end of PhD [d2_52; 58.3% already had a position at the moment of viva] is relevant to understand whether PhD-holders had any frictional unemployment and to discount any respective effect.

A set of variables illustrate what PhD-holders have achieved or have done after PhD attainment. Different types of scientific outputs are grouped together [nprod], keeping patents outside from this computation. Scientific projects PhD-holders might have participated in are provided by type of funding organization [d2_47 series; universities and public research institute being the most frequent sources of post-doctoral scholarships, followed by

companies]. In testing the two hypotheses (Table 2 and Table 3), these latter two sets of variables have been normalized by number of years elapsed after PhD attainment – the dataset incorporates two close-range cohorts, those who got the PhD in 2008 and those who got it in 2010. The variable about participation in projects, like that of source of funding of PhD stipend, is relevant to understand whether some types of organizations are more likely to serve as a gateway to let a PhD-holder get a job in sectors other than the academic or educational ones. These variables referring to participation in projects are categorical: no projects, national projects, international projects. They are kept as continuous on the assumption that international projects are more important, more prestigious, and may convey more social capital than the national ones.

Completion of post-doc [expostdoc; 20.5% of sample] is a binary variable about any possible completed experience as a post-doc. This variable includes the typical Italian post-doc position (*assegno di ricerca*), such as other atypical contracts usually occurring to fund relatively short fixed-term contracts in academia. All these contractual forms are not necessarily propaedeutic to achieve any permanent position as assistant professor, or even the more recently established in the early 2000s fixed-term assistant professorship (*ricercatori a tempo determinato tipo A and B*).

Possible channels through which PhD-holders got the current job are also available [d2_36 series]. The base in Table1 is set to “formal competition” because this is the way academic positions are obtained in Italy, whereas for other sectors (especially the non-public one) any other option more likely applies. Table2 and Table3 foster a simplified version of channels to get jobs.

Variable “PhD title in getting job” [d2.39; 43% essential; 37% desirable and 20% not useful] and variable “PhD actually useful in job” [d2.40; 46.5% yes] further describe the relationship between PhD and current occupation considering the moment of interview. These variables can be relevant in understanding the capacity by employers to realise the actual value of PhD-holders. A combination of these two variables may individuate a possible bias in not including PhD title at least as a desirable criterion when selecting staff.

Table 1 around here

Hypotheses and results

The dataset as introduced is suitable to test two hypotheses.

Hp1. Specific doctoral and post-doctoral experiences determine the extent to which PhD-holders remain in an academic career, with no specific role of teaching experience or research performances.

Hp1a. These predictors are different between PhD-holders who exit academic career toward other education employment and those who work in other economic sectors.

Hp2. PhD-holders have significantly different wages per unit of time according to specific doctoral and post-doctoral experiences, with no specific role of teaching experience or research performances.

The first hypothesis about sector of employment is tested with two separate multilevel mixed-effects logistic regressions – layers defined by all main 14 disciplinary categories used in Italian higher education system. This hypothesis helps individuate key factors in facilitating horizontal segmentation, assuming that it is useful to understand what does facilitate PhD-

holders finding alternative careers to academia – either fall-back in non-academic education (Table 2, Model1), or non-education at all (Table 2, Model2).

The second hypothesis predicts income expressed as net income per unit of time. At parity of sector of employment and of academic discipline, it is relevant to understand what may predict a more successful use of one's PhD title. This second test can be referred as vertical segmentation, on the ground that typical and traditional academic careers use to have uniformed pay scales.

This hypothesis accounts for two layers of multilevel analysis: the three destination sectors used for hypothesis 1; disciplines as per Hp1. This choice is justified by the evidence that labour market of PhD-holders by salary varies considerably by type of sector also within a single discipline (McFall et al. 2015).

For all regressions, tests were launched accounting for heteroscedasticity in residual distribution (robust standard errors). Also possible multicollinearity is tested, resulting in having no problems (VIF scores for each variable below 2.35, average 1.41).

Hp1. How does leave academia?

The results shown in Table 2 are split between what does predict a move from academic employment into other education on one hand (Model1), and, alternatively, what predicts a move from academic employment into any other economic sector (Model2). This distinction is justified by the average salaries, but also by the assumption that pursuing other non-education sectors as an employment destination implies more gumption in comparison to seeking employment in the 'other education' sector – an argument in line with Baruffaldi et al. (2017). It is in fact expected that at least to some extent "to teach in schools if one couldn't make what he/she studied a real academic career" is a "lazy" option. The results give substantially different explanations in comparing these two sector destinations. Observing Model1, PhD-holders are more likely to get a job in the 'other education' sector if their performances as undergraduates were successful [d1_7]. Nevertheless, there are no other predictors of this outcome related to biography or descriptions of doctoral experience. In terms of scientific productivity, there are no statistically significant coefficients. Participation in projects funded by universities [d2_47 series] is instead a strong predictor for not abandoning academic positions, possibly also the precarious ones. As expected, PhD-holders whose destination sector is "other education" are substantially less likely to have moved abroad [d2_24]. Overall, the profile of the PhD-holder who dropped from academia into other education seems to be that of an excellent student who did not find the way to participate after PhD-attainment to academic life and moved into a non-research position, possibly also because of preferring to stay nearby one's residency.

Model2 gives different results. People who went to work outside the academic career or other educational sectors are more likely to be older (possibly because people try to persist in academic positions), males, and with more educated mothers. They are also more likely to have spent more time to complete the doctorate [d1_15], but they were already working at the moment of completion [d2_52].

Table 2 around here

Even more so than is the case in Model1, these PhD-holders are less likely to have continued an academic career if they joined any project funded by universities. They are also more likely to have worked in academia under a project funded by private organizations [d2_47e and d2_27f]. There is also a very strong prevalence in becoming self-employed [10.d2_36]. In comparison to Model1, those who move on non-education sector are less likely to pursue research, but this is sensibly less prominent as a predictor. Overall, the typical PhD-holder

described in Model2 is a person who is more likely to have worked with private stakeholders when still in his/her years spent in university. Moreover, they are more likely to become self-employed. They also did not always have to give up research entirely [d2_24].

Hp2. Why some PhD-holders earn more?

Table 3 shows the results of the second hypothesis about better jobs in terms of salary. Multilevel regression is apt in accounting for the assumption that wages are a function also of sector, and not only of discipline of doctoral study. Notably, the types of projects held after PhD attainment are relevant in predicting income more than other factors such as publications: projects funded by universities predict lower income; projects funded by private firms or international organizations predict higher income. Post-doctoral mobility is also associated with a higher salary [mob_post]. Direct call from employers, and – above all – self-employment as channels to access PhD-holders' current jobs are the strongest predictors for having higher income. This fact is relevant as self-employment can be either very munificent or precarious, especially in the Italian context. This finding is useful if non-linear effect between entrepreneurship of skilled workers and respective *push* effect enacted to avoid unemployment is taken into account (Horta et al. 2016). This finding compels to investigate in future studies whether self-employment is incentivised by policies or it is a purely autonomous endeavour.

Table 3 around here

Possible endogeneity factors in career timeline

Some post estimation tests aim at checking what might have engendered such a high coefficient for self-employment condition. We consider three main events in time, according to recent literature (Horta et al. 2018): funding of PhD studentship (stage0); funding at post-doctoral period (stage1); current employment (self-employment mode; stage2). Annex reports these tests by hypotheses, endogenous variable, and instrumental variables. Types of projects funded and held with private and international organization (stage1) determine self-employment (tests #6, 11, and 12), causing a PhD-holder to be more likely to become a successful self-employed PhD-holder, especially when PhD-holders do not work in other education sectors. These tests demonstrate a link between working as a PhD-holders in partnership with companies and other organizations, and a consequential increasing likelihood in establishing one's own business, which is coherent with literature (Folta et al. 2010). Funding of PhD (no scholarship during PhD studentship – stage0) is determinant of exiting academic career into other sectors (test #8), but not other education – reinforcing the idea that horizontal segmentation is a bifurcation between other education from one side, and other sectors on the other side.

Discussion

Several aspects upon results deserve discussion against empirical literature. The most interesting finding pertains to funding players and the types of collaborations universities may have with companies or other organizations. PhD-holders are definitely more likely to get a job in other sectors than (broadly speaking) academic ones when PhD-holders are involved in projects funded by enterprises or international organizations at post-doctoral stage. Notably, this is not true when these types of potential future employers fund doctoral stipends, which is coherent with findings about funding PhD studentships (Horta et al. 2018). This is relevant also in relation to the highest coefficient found – that of becoming self-employed predicting higher salaries (vertical segmentation – hypothesis 2). This mode of employment is found to have endogeneity with specific players funding projects at post-

doctoral stage, such as companies or other international organizations – suggesting a specific Italian labour market pattern. Not necessarily other European labour markets are similar in relation to self-employment and how and why one person chooses to establish one's own business or professional activity. Arguably, the relationship with non-academic organizations could favour the absorption of PhD-holders by means of recruiting them in a second instance, if another context with different labour market pattern were taken as a case. The paper thus offers novel evidence to support arguments in the literature about the importance of partnerships with other sectors (non-higher education and non-public research institute) for increasing PhD-holders' chances to develop one's career. For some funding players, in fact, collaborations in the form of funding projects is a kind of investment. In this light, this study confirms Garcia-Quevedo's (2012) findings in terms of likelihood of hiring PhD-holders, but it adds that the best matching occurs at the end of post-doctoral relationships. A fair interpretation is that projects with post-doc holders probably allow PhD-holders and non-academic employers to make sounder reciprocal acquaintance. Arguably, they also let a given PhD-holder understand how to convert his/her scientific knowledge into a viable business, which does not necessarily exclude research *in toto*. In this light, our analysis resonates the idea that self-employment is more likely to be a smooth transition from wages into entrepreneurship (Folta et al. 2010), rather than a sharp decision.

PhD-holders find themselves increasingly within specific, fixed-term, projects (Nielsen & Cappelen 2014; Cantwell & Taylor 2015; Signoret et al. 2019; Hokanson & Goldberg 2018; Teelken & van der Weijden 2018) anyway. Ultimately, these results glimpse viable solutions to this well-known phenomenon, suggesting that projects with a link to external world are valuable opportunities to develop a better next step for one's career.

In terms of sector of employment (horizontal segmentation), the paper finds that men are more likely to get a job in other sectors, which is in line with other findings on the interplay between gender, tenure and getting jobs (Rudd et al. 2007). Coherently with other studies (Webber & González Canché 2018; Evers & Sieverding 2015), there are no discernible differences in gender when it comes to define employment destination of PhD-holders.

The vertical segmentation (differences in salary) is as well relevant. Whilst post-doc periods don't appear to have a pay-off (Recotillet 2007), women are more likely to suffer the family burden, although there is no gender pay gap at the highest levels of income. This study also finds no relevance of parents' education in predicting higher income of PhD-holders, as was the case in findings from a study in Spain (Caparros-Ruiz 2019) and Chile (Chiappa & Perez Mejias 2019).

Mobility does play a particular role. The findings corroborate the results by Caparros-Ruiz (2019) and Bonnard et al. (2017) in interpreting scientific mobility as a behaviour apt to increase scientific opportunities. It is possible that academic positions nowadays have to be so specific that the probabilities to find them elsewhere from one's university of PhD attainment are high. This pattern tends to spread academic job opportunities across an international ray. Mobility, in other terms, could mean a search for better conditions (Caparros-Ruiz 2019; Di Cintio & Grassi 2016), and it does not necessarily generate beneficial effects in terms of wage. This study also finds that mobility does not predict sector of employment, which tends to reinforce the aforementioned interpretation. The overall interpretation regarding mobility is similar to that of recent debate about Italian PhD-holders and the respective brain drain (Passaretta et al. 2019; Cattaneo et al. 2019). However, mobility after PhD attainment positively predicts higher salaries at parity of cost of life in country destination, which does not happen with mobility during PhD. This difference could be read analogously with findings about funding players.

Conclusion

Nowadays any practice favouring an exit from academic labour market for PhD-holders is not just an option. It is an increasing necessity. The destiny of PhD-holders is that of getting jobs like any other graduate, otherwise biases about the poor contribution of PhD-holders to the whole economy (Santos et al.2016) might continue to recur. To this respect, the paper contributes not only in confirming that PhD-holders can be useful for society and for PhD-holders themselves, but it gives novel insights about: *a*) how getting a job in the non-academic labour market is more likely to happen; and *b*) when PhD-holders more likely yield the most from their highly skilled profiles. From this analysis, segmentation of PhD-holders' employment destinations can be predicted both at studentship and especially post-doctoral stages due to specific non-academic projects funders. Attempting a more general understanding of the topic, PhD-holders are more likely to benefit from situations where awareness about science-in-the-making (e.g. research funded by private organizations or other organizations) and respective *impact* can stimulate other career pathways, as a seminal study already highlighted (Mangematin 2000). For the particular Italian context, this happens via entrepreneurial behaviour, but for a more tentative generalized conclusion at European level one may think about incorporating novel engaging practices to favour both supply and demand sides of labour market. These engaging practices are likely to realise reciprocal benefits. Many funding schemes at national and European regional level might refer in the future to possible conversions of research activities into innovations as part of evaluation criteria. Such evaluations may favour the matching between PhD-holders and projects stakeholders. Self-employment is a valuable option, although this is only one possible modes of conversion of PhD-holders' highly specific knowledge and expertise into viable non-academic employability.

The practice of considering non-academic funders as drivers of segmentation could bring about reciprocal benefits to all: universities that might propel more projects; employers who might discover unexpected human resources from “young talents”; PhD-holders themselves who increasingly will have to demonstrate what a PhD in their portfolio may bring for the “real world”.

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Table 1 – Descriptive statistics grouped by stage of PhD-holders' career

s	Variable	Label	Obs.	Average	SD	Min	Max	
Ys	Sector	Higher Education and PRIs	4,881	48.78				
	Sector	Other Education	913	9.12				
	Sector	Other	4,213	42.10				
	WPPP	Net Salary per unit of time (€)	7,622	64.46	113.830	6.07	3000	
biographical	age2	age^2	10,007	115.60	69.894	49	1225	
	d5_10	education mother (five modes)	10,007	3.095	1.374	1	6	
	d5_5	education father (five modes)	10,007	3.225	1.403	1	6	
	d1_7	graduation mark	10,007	2.595	0.718	1	3	
	d0_1	Sex (1 woman)	10,007	0.519	0.500	0	1	
	senior	Overall seniority in any employment (years)	10,007	4.519	1.722	1.4	7.8	
	d5_4	child/children (1 yes)	10,007	0.676	0.468	0	1	
during PhD	d1_10	funding of PhD: MIUR national funding						
	d1_10b	funding of PhD: other public	10,007	0.068	0.252	0	1	
	d1_10c	funding of PhD: private organization	10,007	0.057	0.231	0	1	
	d1_10d	funding of PhD: international organization	10,007	0.015	0.120	0	1	
	d1_10e	funding of PhD: Nil – no stipend	10,007	0.184	0.387	0	1	
	Mob_dur	mobility during PhD	10,007	0.460	0.498	0	1	
	d1_15	duration of PhD (1: more than 4 years)	10,007	0.123	0.329	0	1	
	d1_14	teaching during PhD	10,007	1.765	0.820	1	3	
	d2_52	employment at end of PhD (1 yes)	9,301	0.583	0.493	0	1	
	post PhD	Ln_prod	Scientific production (ln)	10,007	2.229	1.180	0	4.97
d2_46h		Scientific production: patents	10,007	0.114	0.657	0	10	
d2_47a		Funding players in postdoc: university	10,007	2.028	0.820	1	3	
d2_47b		--- public research institutes	10,007	1.578	0.797	1	3	
d2_47c		----private research organizations	10,007	1.314	0.647	1	3	
d2_47d		----research consortia	10,007	1.296	0.637	1	3	
d2_47e		----companies	10,007	1.373	0.673	1	3	
d2_47f		----international organizations	10,007	1.240	0.635	1	3	
expostdoc		finished a post-doc	10,007	0.205	0.404	0	1	
d2_57a		R&D intensity of first job	10,007	0.466	0.499	0	1	
d2_64a		R&D intensity of job in 2011 (1 yes)	10,007	0.540	0.499	0	1	
Mob_post		mobility after PhD	10,007	0.275	0.447	0	1	
current employment		d2_36	channel in getting current job (base is "competition"):					
		d2_36b	personal acquaintance of employer	10,007	0.070	0.255	0	1
	d2_36c	endorsement from kins	10,007	0.049	0.215	0	1	
	d2_36d	endorsement from university or job agencies	10,007	0.030	0.172	0	1	
	d2_36e	after stage or internship	10,007	0.021	0.143	0	1	
	d2_36f	direct call from employer	10,007	0.045	0.207	0	1	
	d2_36g	job alerts	10,007	0.041	0.198	0	1	
	d2_36h	sending CV to employers	10,007	0.125	0.331	0	1	
	d2_36i	public job center	10,007	0.001	0.033	0	1	
	d2_36j	self-employment	10,007	0.046	0.211	0	1	
	d2_36k	private job matching agencies	10,007	0.011	0.104	0	1	
	d2_36l	other	10,007	0.053	0.225	0	1	
	d2_39	PhD essential criteria for current job	10,007	1.773	0.760	1	3	
	d2_40	PhD essential for current job (1 yes)	10,007	0.440	0.450	0	1	
	d2_44	Currently doing R&D job (inverted scale)	10,007	1.777	0.812	1	3	
	d2_24	Having moved abroad (1 yes)	10,007	0.161	0.367	0	1	

Table 2 Prediction of sector of employment. Model 1: Other educational sector against Higher education and Public Scientific Institutes. Model 2: not-academic and not other education against Higher education and public scientific institutes. Both models are multilevel regressions by disciplinary field of PhD attainment.

		M1	<i>p</i>	M2	<i>p</i>
age2	age^2	-0.0002		-0.0002	
ln_senior	Seniority in employment (ln of years)	-0.0775		0.4406	***
d5_10	education mother (five modes)	-0.0885		0.0383	
d5_5	education father (five modes)	0.0567		-0.0527	
d1_7	graduation mark	0.2171	*	0.0572	
d0_1	Sex (1 man; 2 woman)	0.1969		-0.1555	*
d5_4	child/children	-0.1507		0.0320	
2.d1_10	funding of PhD: other public				
3.d1_10	funding of PhD: private organization	-0.2774		0.0423	
4.d1_10	funding of PhD: international organization	-0.1028		0.0992	
5.d1_10	funding of PhD: Nil – no stipend	0.1550		0.6136	*
Mob_dur	mobility during PhD	-0.0731		-0.1053	
d1_14	Teaching during PhD	-0.0383		0.1894	
d1_15	Duration of PhD	0.0529		-0.0379	
d2_52	employment at end of PhD	0.2120		-0.2727	**
ln_prod	Scientific production (ln)	0.1038		-0.1501	***
d2_46h	Scientific production: patents	-0.3820	***	-0.5544	***
d2_47a	Funding players in postdoc: university	-0.6170	**	0.1400	***
d2_47b	--- public research institutes	-0.4689	***	-0.4976	***
d2_47c	----private research organizations	0.0153		-0.0931	
d2_47d	----research consortia	0.1773		0.4324	***
d2_47e	----companies	-0.2154		0.0212	
d2_47f	----international organizations	0.0505		0.1094	
expostdoc	finished a post-doc	-0.2168		0.1369	
d2_57a	R&D intensity of first job	-0.0251		-0.0847	
d2_64a	R&D intensity of job in 2011	-0.0610		0.1634	
Mob_post	Mobility after PhD	-0.1882		-0.0674	
Self-empl.	Self-employment	-0.0812		0.1442	
d2_39	PhD essential criteria for current job	1.6111		2.9027	***
d2_40	PhD essential for current job	1.2859	***	1.3213	***
d2_44	Currently doing R&D job	1.5993	***	1.1577	***
d2_24	Having moved abroad	1.8418	***	0.6222	***
_cons		-0.5638		0.5209	*
var(_cons[d0_10])		0.1862 (0.1019)		0.1526 (0.0444)	
var(_cons[d0_10>d0_5])		0.2638 (0.1184)		0.0057 (0.0159)	
<i>N</i>		5169		8272	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3. Prediction of income per unit of working time. Multilevel regressions by sector of employment (as per Hp1) and disciplinary field of PhD attainment with test of endogeneity.

		ln_WPPP	<i>p</i>	
Insenior	Seniority in employment (ln of years)	0.014		
age2	age^2	0.000	**	
d5_10	education mother (five modes)	0.003		
d5_5	education father (five modes)	0.004		
d1_7	graduation mark	0.012		
d0_1	Sex (1 man; 2 woman)	-0.014		
d5_4	child/children	-0.079	***	
1.d1_10	funding of PhD: MIUR national funding (base)			
2.d1_10	funding of PhD: other public	-0.052		
3.d1_10	funding of PhD: private organization	-0.009		
4.d1_10	funding of PhD: international organization	0.002		
5.d1_10	funding of PhD: Nil – no stipend	0.006		
Mob_dur	mobility during PhD	-0.013		
d1_14	Teaching during PhD	0.008		
d1_15	duration of PhD (1: within 4 years)	0.013		
d2_52	employment at end of PhD	0.001		
Ln_prod	Scientific production	-0.014	**	
d2_46h	Scientific production: patents	0.025	**	
d2_47a	Funding players in postdoc: university	-0.038	***	
d2_47b	--- public research institutes	0.009		
d2_47c	----private research organizations	-0.002		
d2_47d	----research consortia	-0.017		
d2_47e	----companies	0.032	**	
d2_47f	----international organizations	0.016		
expostdoc	finished a post-doc	-0.029		
d2_57a	R&D intensity of first job	0.028		
d2_64a	R&D intensity of job in 2011	0.000		
Mob_post	Mobility after PhD	0.076	***	
Self-empl.	Self-employment	1.229	***	
d2_39	PhD essential criteria for current job	-0.040	**	
d2_40	PhD essential for current job	0.015		
d2_44	Currently doing R&D job	-0.019		
_cons		3.968	***	
var(_cons[d0_10])		1.13e-10	(8.54e-10)	
var(_cons[d0_10>d0_5])		0.0121	(0.007)	
<i>N</i>		7035		
	Number of group	Min N per group	Average N per group	Max N per group
d0_10 (Discipline)	14	184	502.5	1,034
Sector	42	13	167.5	515
(as per Table1)				

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Annex. Tests of endogeneity checking chronological determinants in career steps

Hp	#test	Dep variable	Endogenous variable	Instrumental variables	Output
Hp1	1	Academic vs. other Education	selfemployment	fund_PhD (stipend/no-stipend)	
Hp1	2	Academic vs. other Education	selfemployment	d1_10	
Hp1	3	Academic vs. other Education	d2_47e/f	fund_PhD (stipend/no-stipend)	
Hp1	4	Academic vs. other Education	d2_47e/f	d1_10	
Hp1	5	Academic vs. Other Sectors	selfemployment	fund_PhD (stipend/no-stipend)	
Hp1	6	Academic vs. Other Sectors	selfemployment	d1_10	***
Hp1	7	Academic vs. Other Sectors	d2_47e/f	fund_PhD (stipend/no-stipend)	
Hp1	8	Academic vs. Other Sectors	d2_47e/f	d1_10	***
Hp2	9	Wage per unit of time (ln)	selfemployment	fund_PhD (stipend/no-stipend)	
Hp2	10	Wage per unit of time (ln)	selfemployment	d1_10	
Hp2	11	Wage per unit of time (ln)	selfemployment	d2_47e/f	***
Hp2	12	Wage per unit of time (ln)	selfemployment	d2_47a-f	***
Hp2	13	Wage per unit of time (ln)	d2_47e/f	fund_PhD (stipend/no-stipend)	
Hp2	14	Wage per unit of time (ln)	d2_47e/f	d1_10	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

1.