



The determinants of firms' PhD recruitment to undertake R&D activities



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ABSTRACT

We have analysed the determinant factors which condition firms' employment of PhDs to undertake R&D activities. It has been traditionally thought that doctorate holders are employed only to generate and absorb scientific knowledge; nonetheless, our study has also revealed that there are additional reasons to employ PhD graduates. We have used an upstream–downstream approach of the innovation process, to establish which contingencies of this process increase the number of PhD holders in firms. We have focused on four contingencies: R&D cooperation, types of R&D activities, failures in the innovation process and key information sources to put into motion the innovation process. Results of this study have confirmed that PhD holders not only play upstream roles in the innovation process but in addition also downstream tasks undertaking knowledge exploitation activities.

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Introduction

Ongoing technological progress requires innovative firms to broaden their knowledge base with outside knowledge. The organizational processes whereby firms seek and accumulate new knowledge are complex and imply the development of a broad set of routines focused not only to acquire knowledge but also to incorporate it into the company's knowledge base (Gebauer, Worch, & Truffer, 2012; Zahra & George, 2002). One of the major channels used is the recruitment of PhDs, as they transfer up-to-date knowledge previously developed and accumulated in the public R&D system (Zellner, 2003), as well as embodied knowledge useful for developing and commercializing inventions (Agrawal, 2006).

Within the literature arguments in favour of firms' recruitment of PhD researchers abound. Some studies have stated that PhD holders constitute a primary source of scientific knowledge with commercial value (Zucker, Darby, & Armstrong, 1998a), they transfer key skills for the development of R&D activities (Almeida & Kogut, 1999) and can increase and improve firms' relationships with the public R&D systems (Cruz-Castro & Sanz-Menéndez, 2005). Studies in favour of a possible relation between the recruitment of PhD

researchers and the firm's innovation performance also exist, by means of simulating the innovation process inputs and outputs (Deeds, DeCarolis, & Coombs, 2000; Ettlie, 1985; Herrmann & Peine, 2011; Zucker et al., 1998a; Zucker, Darby, & Brewer, 1998b). In these studies, new product development is shown to be in function of employing PhD researchers, their knowledge backgrounds being presented as strong predictors of the firm's competitive strategy (Herrmann & Peine, 2011). Other studies have even gone further and established that the employment of PhD researchers is positively related to the number of new high-growth firms (Eckhardt & Shane, 2011), to product introduction rewards by new ventures (Rao, Chandy, & Prabhu, 2008) and to an increase of the firm's market value in the high-tech sectors (Darby, Liu, & Zucker, 2004).

Despite the importance given to PhD researchers working in firms, the literature which analyses their mobility has mainly focused at the individual level with regard to what motivates a researcher to seek work opportunities in the private sector (Crespi, Geuna, & Nesta, 2007; Fritsch & Krabel, 2012; Mangematin, 2000; Roach & Sauermann, 2010). While having identified numerous factors likely to influence the movement of doctors to firms, these studies have not explained why firms employ PhD researchers. To the best of our knowledge there exist no prior exhaustive research studies which have examined the factors or motivations of firms to recruit these human resources and, as a result, we do not possess a wide understanding of the labour market of PhDs outside of universities or research centres. At the firm level, studies are scarce and in general

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have used the structural characteristics of firms to describe the labour market of PhD holders (Auriol, 2010; Beltramo, Paul, & Perret, 2001; Cruz-Castro & Sanz-Menéndez, 2005). These studies have concluded that firm size, industry sector, previous R&D experience, location and collaboration with universities all significantly influenced PhD recruitment. Although they gave more specific profiles of firms hiring PhDs, it still remains unclear why they have done so.

The objective of this study has been to analyse the factors which determine the employment of PhDs by firms to undertake R&D activities. In this study, we present employment of PhDs as a function of opportunities that firms maintain in order to appropriate their knowledge and skills. Traditionally, it has been thought that PhDs are only employed to generate and absorb technological knowledge. Nevertheless, the literature reveals also that they can assume other roles downstream of the innovation process, all derived from their PhD training, their research skills and their in-depth knowledge of technology. In order to identify these roles, in this study we have used an upstream–downstream approach of the innovation process, with the objective to establish which activities of this process increase the number of new PhD holders in firms. We have focused on four types of up and down contingencies of the innovation process: types of R&D activities, R&D cooperation, failures in the innovation process and the importance of key information sources to put into motion the innovation process. The analysis of which activities of the innovation process are directly related to the recruitment of PhDs is important as it allows characterizing the labour market of doctorate holders, their importance with regard to the processes of knowledge transfer and their role played in the firms' innovation activities.

This article is structured as follows. First, the theoretical arguments and the hypotheses are presented. Next, details are given regarding the methodology used and the data variables are described. The findings of the empirical analysis are then discussed and, finally, conclusions are presented.

PhD researchers and firms' innovation activities

The importance of highly qualified human resources in relation to firms' innovation activities has been analysed by different authors who have recognized that knowledge is the most important competitive resource that a firm holds residing in its human capital (Lepak & Snell, 1999; Levinthal & March, 1993; March, 1991). This literature has focused on graduates with miscellaneous qualifications and has followed similar arguments with regard to the role of highly skilled employees in the development of the innovation process, studies having agreed that they generate ideas that set the innovation process into motion and monitor the external atmosphere to take advantage of the knowledge generated outside of the firm (Chen & Huang, 2009; Laursen, 2002; Shipton, West, Dawson, Birdi, & Patterson, 2006). In this context, the employment of PhD researchers has become an important object of analysis, as PhDs are trained to undertake research, have the highest educational level and are therefore considered to be the highest qualified manpower for the implementation and diffusion of knowledge and innovation (Auriol, 2010).

Despite the importance given to researchers in firms, a major shortcoming of investigations which analyse their mobility consists of an imbalance between the studies concerning the supply side (individual level) and the demand side (firm level). Literature on the topic has mainly focused on analysing the individual factors which predict the preferences for research careers carried out in the industry over academia, studies having shown that those researchers interested in a good salary and in downstream research are more likely to prefer careers in established firms (Roach & Sauer mann, 2010) while the quality of the research was not a de-

cisive criterion in seeking a permanent position (Mangematin, 2000). An additional finding involves the attraction felt by scientists towards the private sector as being related to the investigator's perception of the commercial potential of their research (Fritsch & Krabel, 2012). In this line, Zucker, Darby, and Armstrong (2002a) found that top academic scientists moved more readily from academia to the private sector if they had a high-level intellectual capital relevant to the commercialization of inventions. It has therefore been found that scientists with patenting and narrower technological experience value more highly working in firms than those without patents (Crespi et al., 2007; Fritsch & Krabel, 2012).

Studies have also shown that in certain disciplines such as biology, PhDs pay a compensating differential to stay in science, accepting lower wages to continue undertaking research (Stern, 2004) and that their alma mater plays a determining role at the moment of collaborating with the industry to reduce the labour market uncertainties (Lanciano-Morandat & Nohara, 2006). Other significant contextual determinants include the fact that PhDs hired by firms are unlikely to remain in the cities where they studied (Stephan, 2006), as is a well-established fact that some regions attract more PhDs than others, especially those with more R&D expenditure and research infrastructures (Sumell, Stephan, & Adams, 2009).

At a firm level, so far few studies have analysed the demand for PhDs by firms and those that exist have analysed experience in certain specific sectors, mainly in the high technology areas (Zucker et al., 1998a, 2002a; Zucker, Darby, & Torero, 2002b). Conclusions drawn highlight that high-tech firms with a high dependency on scientific knowledge and some absorptive capacity are more likely to hire PhDs (Auriol, 2010; Cruz-Castro & Sanz-Menéndez, 2005). On the other hand, Beltramo et al. (2001), by means of interviews carried out in firms localized in France, Spain and the United Kingdom, analysed aspects more concerned with firm strategy, arriving to the conclusion that the R&D organization and a firm's tendency to reach external R&D agreements had a positive influence on PhD recruitment. To the best of our knowledge, only Garcia-Quevedo, Mas-Verdu, and Polo-Otero (2012) and Herrera, Felisa Muñoz-Doyague, and Nieto (2010) have analysed the factors influencing the recruitment of scientists empirically. The former study analysed the mobility of researchers from public R&D centres to firms, without taking into account their qualification levels, finding that large firms in the high and medium technology sectors, with a high level of formalization of R&D activities had a greater tendency to recruit researchers. The latter study is perhaps the only research so far to have analysed the factors determining the recruitment of PhDs, concluding that the intensity of R&D activities, employing PhDs in the past and the university–firm relationships all had a positive and significant influence.

Although the above studies agree in general that firms with a clear orientation to undertake innovation activities are those that mainly recruit PhDs, none have analysed the firms' reasons for doing so in depth. As a result, it remains unclear which activities of the innovation process demand more PhD holders. During their doctoral studies and their scientific careers, PhDs develop a range of skills which could be useful to firms at different stages of the innovation process. In this study we have used an upstream–downstream approach to understand the role of PhD researchers taking part in this process. According to Hess and Rothaermel (2011) the traditional upstream–downstream approach that has been applied to understand the strategic alliances can further be useful to better understand the role played by the intellectual capital in firms, because this categorization reflects the knowledge which is needed to facilitate the innovation at different points along of the value chain. Because the literature analysing the role of scientists lacks any clear-cut conceptualization of the upstream and downstream activities (see Beltramo et al., 2001), in the present study the upstream research activities are linked to the generation

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