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When birds of a feather don't flock together: Different scientists and the roles they play in biotech R&D alliances☆

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ABSTRACT

A firm's ability to produce high-impact innovations depends upon the nature of its R&D alliances as well as its composition of scientific human capital. The firm's scientific human capital is made up of its scientists, who produce valuable research outputs and who engage with the broader scientific community, thus helping the firm to integrate new knowledge from universities and other firms. In this paper, we examine heterogeneity within the firm's scientific human capital, emphasizing the distinct role of 'bridging scientists' who engage in two related but dissimilar scientific activities: patenting and publishing. Using a panel dataset of 222 firms in biotechnology between 1990 and 2000, we show that bridging scientists have a positive and significant impact on patent performance relative to other scientists within the firm. Looking closer at bridging scientists, we draw a distinction between Pasteur bridging scientists and Edison bridging scientists, with the latter having less of an orientation towards fundamental research. We show that both types of bridging scientists complement the focal firm's R&D alliances with other firms. However, Pasteur bridging scientists are substitutive with university R&D alliances while Edison bridging scientists are complementary. Our findings suggest that the composition of a firm's scientific human capital and its R&D alliances interact in subtle ways to impact patent performance.

1. Introduction

In the biotechnology industry, R&D alliances contribute to a firm's success in establishing research pipelines and commercializing inventions (Barley et al., 1992; Kenney, 1986; Owen-Smith and Powell, 2004; Powell et al., 1996; Robinson and Stuart, 2007). Biotechnology firms increasingly play the role of intermediaries by translating scientific discoveries from universities and public research laboratories into commercially viable products (Edwards et al., 2003; Stuart et al., 2007). The firm's scientists and inventors play a key role in this process (Zucker et al., 1998; Cassiman and Veugelers, 2002; Almeida et al., 2011). In this paper, we show that the innovation impact on a focal firm depends upon the composition of the firm's scientific human capital and how that human capital interacts with the type of external R&D alliances partner involved (university partners versus other firms).

Existing studies on R&D alliances do not pay sufficient attention to the heterogeneity of scientific human capital in knowledge flows. The extant view is that firms employ scientists primarily to transform academic science into useful inventions, and they use R&D alliances as conduits to gain access to new scientific knowledge. Evidence suggests that success in science-intensive industries requires a firm to engage actively with external research organizations, with an emphasis on the firm's ability to hire star scientists (Zucker et al., 2002; Liebeskind et al., 1996), create a science-oriented research environment (Gambardella, 1995; Cockburn and Henderson, 1998), and engage with leading academic scientists (Baba et al., 2009). However, the earlier emphasis on star scientists masks considerable heterogeneity, even among leading scientists within the firm (Rothaermel and Hess, 2007). As discussed in Section 2 below, the definition of what constitutes a 'star' ranges broadly in earlier studies. As well, star scientists are heterogeneous to the extent that they participate in various scientific activities.

Of these activities, we focus on patenting and publishing, both of which are important functions but that are quite distinct in terms of

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the skills required and the degree of practicality involved. Patenting is oriented towards the generation of practical and appropriable applications of technology, while publications contribute towards the establishment of scientific priority and reputation, being closer to the norms of open academic science. Within industrial firms, the tension between patenting and publishing is particularly salient. Gittelman and Kogut (2003) show that high-impact innovations in the biotechnology industry do not come from a firm's capability to produce 'good science' alone but rather are enhanced through the firm's efforts to bridge the gap between science and innovation—namely, employing scientists who are capable of publishing scientific papers and creating patented inventions. These 'bridging scientists' play an important role in transforming scientific ideas into useful inventions. We build upon this research to suggest not all stars are the same, and that some bridging scientists have a significant impact on a firm's patent quality as compared to other scientists.

We then explore the interaction effects between scientific human capital and R&D alliances, introducing a distinction between Pasteur bridging scientists and Edison bridging scientists. The former have an above average publication record and above average patenting record, while the latter have an above average patenting record but below average publication record. Building upon Rothaermel and Hess (2007) we propose that Pasteur bridging scientists substitute for academic R&D partners, and therefore interact negatively with the R&D alliances between the firm and universities. In contrast, Edison bridging scientists complement the firm's R&D alliances with university partners and therefore exhibit a positive interaction term. Both Edison and Pasteur bridging scientists interact positively with R&D alliances when the partner organization is another firm, although for different reasons. Overall these hypotheses present a nuanced view of how the composition of a firm's scientific human capital intertwines with its R&D alliances in shaping the firm's patent performance, in a manner that is subtler than currently presented in the literature.

Our empirical setting is a sample of 222 biotechnology firms. We collected patent, publication and alliance data of these firms from 1990 to 2000, along with patent citation data up to 2004. We show that the higher the proportion of a firm's scientists that are bridging scientists, the higher the impact on patent citations. R&D alliances with firms and universities both have a positive effect on patent citations. We also show that a firm's scientific human capital moderates the relationship between R&D alliances and patent performance. The different types of bridging scientists and R&D alliance type are generally complementary, except for the interaction between Pasteur bridging scientists and university R&D alliances, which we found to be substitutive.

Our study contributes to a better understanding of the important role played by bridging scientists, showing them to be distinct relative to "highly publishing but non-patenting" scientists and "stars" in general. Each type of scientist plays a slightly different role, both in their knowledge transfer activities and how they interact with the firms' R&D alliances. We believe that as the lines between academic and industrial research increasingly continue to blur, a better understanding of how the firm's scientific human capital fits into the broader picture of scientific knowledge production and dissemination becomes increasingly important for academics and practitioners. For instance, our work suggests it is important for firms to manage the mix among its different types of scientists over time and raises the question of how firms might effectively manage the career transitions of individual scientists to balance economic returns with the need to collaborate with academic scientists and recruit scientific talent.

The remainder of this paper is organized as follows: The next section presents a literature review on R&D alliances and scientific human capital and develops hypotheses. Section 3 describes the research method and data, while Section 4 presents our analysis and results. Finally, Section 5 discusses the contributions and research implications and concludes with limitations.

2. Literature review and theory development

Successful innovation within a firm depends upon the production and integration of new knowledge. Understanding how scientific discoveries are translated into useful, commercially successful products requires a close examination of how a firm invests in scientific human capital, which is primarily composed of the scientists and inventors within the firm. In addition we need to examine how the firm shapes its relationships with universities and other firms, such as through R&D alliances.

A firm's scientific human capital engages with the external scientific community through the publication of scientific articles. This enhances its reputation (Audretsch and Aldridge, 2009) and facilitates cooperation, e.g., by maximizing incoming knowledge flows (Cassiman and Veugelers, 2002), which can influence the quality of patented inventions produced. The importance of scientific human capital and R&D alliances is consistent with earlier research by Ding and Choi (2011), Gittelman and Kogut (2003), Liebeskind et al. (1996), Murray (2004), Powell et al. (1996), Stuart et al. (2007), Zucker et al. (2002), and others.

A firm's scientists are not homogenous, and in the next section we suggest that different types of scientists play different roles in the knowledge production process, and moreover that they interact differently with the knowledge absorption process, in particular with the R&D alliances that a firm has established with universities and other firms in the industry.

2.1. Types of scientific human capital

In science-intensive industries, a critical component of human capital is the firm's scientific human capital. Skilled and talented knowledge workers are critical determinants of innovation (Merton, 1973; Nelson, 2003; Noyons et al., 1994). Scientists are heterogeneous in their preferences, skill sets and productivity (e.g., Laursen and Salter, 2006). People are motivated to join a scientific career for a variety of reasons, including the attraction of solving puzzles, building a scientific reputation, and the opportunity to do impactful work (Stephan, 2012). Earlier research explored two separate career trajectories among scientific knowledge workers. The first career track is that of industrial scientists and inventors (e.g., Allen and Katz, 1992; Goldberg and Shenhav, 1984). The second career trajectory is that of academic researchers who engage in scientific research (Keith and Babchuk, 1998). Sauermann and Stephan (2010) show that academic and industrial scientists differ along four key dimensions: basic versus applied research, freedom to pursue research questions, preference for particular tasks (e.g., a "taste for science"), and different disclosure mechanisms (e.g. patenting, publications and conferences).

Traditionally, an academic researcher worked at a university or independent research laboratory (Dasgupta and David, 1994). However, with the birth of science-intensive industries, such as biotechnology, and as a consequence of the Bayh–Dole act, an increasing number of scientists from academe began actively contributing to technological activities within firms. As well, firms began attracting scientists to join their organizations, offering incentives to publish their research findings and to collaborate with leading academic scientists (Helfat et al., 2006). The lines between academic and industrial science have blurred especially in the biomedical sciences (Murray, 2002; Vallas and Kleinman, 2008).