



When publications lead to products: The open science conundrum in new product development[☆]



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ABSTRACT

This paper examines interdependencies between firms' activities in the realms of open science and commercial product development. We present a theoretical framework that outlines when a firm's involvement in academic communities enhances its innovative performance in terms of new products in development. We argue that the disclosure of more, valuable R&D work in quality scholarly publications and collaborations with academic partners positively affect firm innovation. We further hypothesize a differential effect of adopting open science strategies on the innovation type, being more pronounced for radical innovations than for incremental innovations. We empirically analyze a unique panel dataset containing information on the product innovation performance and R&D activities of 160 UK therapeutic biotechnology firms over the period 1998–2009. Our results from count data models on the number of new products in development provide empirical support for our hypotheses.

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1. Introduction

A growing number of firms in knowledge-intensive sectors participate in open science, a system of cumulative knowledge production that facilitates the disclosure of scientific discoveries through publications in academic journals (Dasgupta and David, 1994; Ding, 2011; Gittelman and Kogut, 2003; Mukherjee and Stern, 2009). In fact, prominent firms have developed into core hubs for scientific knowledge exchange in several fields. Whereas in 1975 none of the 25 most-cited articles in Science were (co-) authored by researchers affiliated with firms, in 2009 there were 6.¹ Comparative research on the extent to which products and processes build on academic science across different sectors highlights that this development has been particularly potent in the life sciences sector (Mansfield, 1995, 1998). A single biotechnology firm, Genentech published 5038 articles in scientific journals over the period 1976–2008, of which 249 in Science or Nature.²

Despite success stories of firms like Genentech, significant variation remains in the extent to which individual firms embrace open science strategies, with some firms adopting more open R&D

models and others opting to adhere to more traditional, closed R&D models. Scholarship suggests that the imprint left by founders plays an important role in shaping corporate R&D strategies in general and firms' willingness to adopt open science practices in particular (Ding, 2011; Jong, 2006; Murray, 2004; Powell and Sandholtz, 2012). Although the importance of organizational imprinting for firms' varying strategies in interacting with academic communities is well understood, the dynamics governing the interdependencies between firms' activities across the realms of open science and commercial product development remain less clearly defined.

Existing studies highlight a range of benefits for firms that participate in open science, including the opportunity to learn from academic collaborators (Almeida et al., 2011; Cockburn and Henderson, 1998; Liebeskind et al., 1996; Zucker et al., 2002), to enhance firms' absorptive capabilities (Cohen and Levinthal, 1990; Fabrizio, 2009; Fleming and Sorenson, 2004), to attract and retain high-quality scientists (Stern, 2004), and to signal the possession of strong scientific competences to external parties (Luo et al., 2009; Polidoro and Theeke, 2012). However, other studies highlight potential drawbacks for firms' involvement in open systems of knowledge exchange because of the conflicts that exist between the institutional logics governing the realms of science and technology. For example, Gittelman and Kogut (2003) point out that the production of high-profile scientific papers actually harms the production of high-value patents.

Our research aims to explore boundary conditions that govern the benefits of firms' involvement in academic communities. Specifically, we examine the impact of publishing better scholarly research and collaborating with university scientists on firm

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¹ Source: Web of Science, Science Citation Index Expanded, accessed 8 June 2012.

² Source: Web of Science, Science Citation Index Expanded, accessed 8 June 2012.

innovative performance. Building on insights from the sociology of organizations and knowledge literature we propose conditions under which the stratification logics of science and technology are mutually reinforcing: We argue that the academic value of firms' publishing activities and the ties firms develop with academic laboratories positively affect firms' ability to leverage resources embedded in external open scientific systems of knowledge exchange in internal R&D programs. However, we contend that this positive effect varies with the type of innovation and is more pronounced for radical than for incremental innovations.

To test our hypotheses we create a panel dataset containing detailed information on the publishing and R&D activities of 160 UK therapeutic biotechnology firms over the period 1998–2009. This dataset allows us to analyze how variations in firms' interactions with academic communities have an impact on firm R&D productivity, after controlling for R&D input related variables. The biotechnology sector has proven a fruitful context, in which to examine the effect of adopting open science strategies on firm innovation for several reasons. First, there is no sector, in which commercial and academic research networks are so closely intertwined as these are in biotechnology (Mansfield, 1995, 1998). Second, the commercialisation environment and appropriability regime in biotechnology are among the most supportive to open exchanges of ideas across organizational boundaries in general and the science–industry boundary in particular (e.g. Gans and Stern, 2003; Teece, 1986). Third, for the specific purposes of this study, the choice of the setting of therapeutic biotechnology enables a systematic classification and operationalization of the degree of novelty of product innovations.

Our results from estimating negative binomial models on the number of new therapeutic projects entering clinical trials provide support for our main hypotheses. Specifically, our findings reveal that firms that disclose more, valuable R&D work in quality scholarly publications exhibit higher levels of innovative output in terms of the new therapeutic projects these firms move into the development pipeline. Adding to previous work on the value of connectedness to university scientists, we find that while controlling for firms' publishing activity, pursuing research collaborations with scientists at academic institutions further enhances firms' innovative performance. In addition, we find that the beneficial effect of making more substantive contributions to open science is a limited effect; while increasing a firm's propensity to develop radically innovative products, it does not increase a firm's propensity to develop incrementally innovative products.

Our research advances the literature on firms' interactions within open systems of knowledge exchange in two principal ways. First, it contributes to on-going debates about the interrelationships that govern firms' activities across the spheres of science and technology. While some suggest that corporate science that is more highly valued in academic circles is associated with superior innovative performance (e.g. Almeida et al., 2011; Zucker et al., 2002), others argue that a stronger performance by a firm in one sphere is associated with a weaker performance in the other sphere (Gittelman and Kogut, 2003). We highlight that open science strategies have an overall positive effect on new products in development. Notably, this effect holds if the academic esteem of firms' scholarly contributions is taken into account, which some suggest to be a drag on the production of commercially valuable knowledge (Gittelman and Kogut, 2003). Consequently, we extend previous studies on positive effects of publishing and collaborating with university scientists on the importance of firm patents (Cockburn and Henderson, 1998), the timing and importance of firm inventions (Fabrizio, 2009), and the number of patent families (Almeida et al., 2011).

Second, our study makes a contribution by defining boundary conditions for the efficacy of efforts to enhance innovative

performance through open science strategies and advances scholarship on the challenges firms face in capturing value in open innovation networks. Prior work for example highlights how firms face behavioral constraints in managing too many academic collaborations (Lavie and Drori, 2012; McFadyen and Cannella, 2004). Our study illuminates the contingent value of open science strategies for the type of innovation outcome (e.g. radical or incremental innovations) that firms focus on in R&D. By considering the type of innovation, this work extends past research on the link between the importance of inventions and the usage of scientific and distant knowledge (Fabrizio, 2009; Fleming and Sorenson, 2004; Rosenkopf and Nerkar, 2001).

The remainder of this paper is organized as follows. First, we present the conceptual motivation behind the study. We subsequently construct our theoretical framework and develop testable hypotheses. Next, we describe the study design and the data used to perform the empirical analyses. We subsequently present and discuss the results of our analyses. Finally, building on a discussion of the generalizability of our findings, we outline future research directions.

2. Theory and hypotheses

Creative processes underlying product innovation in many industries increasingly extend beyond the commercial realm. The central role academic communities now play in fuelling product innovation in sectors such as the biotechnology, nanotechnology, and clean technology sectors exemplifies this trend (Cockburn and Henderson, 1998; Fleming and Sorenson, 2004; Laursen and Salter, 2004; Liebeskind et al., 1996). To tap into creative processes in scientific communities firms rely on so-called absorptive capabilities that allow firms to assimilate and exploit external knowledge. The development of such capabilities is a principal rationale for investments in in-house R&D (Cohen and Levinthal, 1990; Fabrizio, 2009; Rosenberg, 1990).

Managers face a number of trade-offs in the organization of in-house R&D. The extent to which firms adopt organizational models associated with open science, and disclose and share R&D findings, is among the most important of these trade-offs. There used to be clear differences between organizational models governing academic and commercial research, in particular with regards to the willingness of researchers to disclose and share work in open forums such as scientific journals (e.g. Dasgupta and David, 1994). High levels of secrecy used to be the norm for corporate R&D organizations, which were seen as necessitated by the for-profit orientation of these organizations. However, assertions underlying traditional, closed corporate R&D models have become increasingly contested with the rise of successful new firms adopting open science strategies over recent decades (Ding, 2011; Fabrizio, 2009; Powell and Sandholtz, 2012). Such strategies entail the incorporation of academic practices in corporate R&D such as encouraging priority-based publishing of research findings, sharing of proprietary knowledge with community members, and showing deference to academic status hierarchies (Dasgupta and David, 1994; Gittelman and Kogut, 2003; Kaplan and Murray, 2010; Merton, 1968; Stephan, 1996).

The extent to which firms incorporate more open approaches in interactions with academic communities has been linked to the organizational imprint founders left on the R&D organizations of these firms. Firms with a higher level of involvement of senior academic scientists during the formative development phase generally embrace more academic, open approaches in the organization of R&D. Firms with a more corporate imprint, at which managers and researchers with an industry background play a more dominant role during the formative development phase tend to stick to more

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