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Bridging science and technology through academic–industry partnerships

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ABSTRACT

Partnerships that foster the translation of scientific advances emerging from academic research organizations into commercialized products at private firms are a policy tool that has attracted increased interest. This paper examines empirical data from the Danish National Advanced Technology Foundation, an agency that funds partnerships between universities and private companies. We assess the effect on participating firms' innovative performance, comparing patent count, publication count and proportion of cross-institutional publications between funded and unfunded firms. Specifically, we measure the impact on each of these variables based on three dimensions – small and medium-sized enterprises (SME), younger firms, and size of the collaboration firms participated in – to establish boundary conditions. Our results suggest that receiving funding affects firms' innovative behavior differently depending on the type of firm, where (1) peer-reviewed publications increased significantly more for SMEs and larger projects, (2) granted patents increased significantly up to 4 years after funding for young firms and those in larger projects, and (3) proportion of cross-institutional publications increased significantly more 3 years after funding for all three sample specifications.

1. Introduction

How ideas are produced and the means by which they are diffused is an area of great interest to researchers. This is driven by the belief that technological innovations, which are grounded in basic research, spur wealth creation and stimulate economic growth. Research universities, with their primary missions of educating and creating knowledge, are an important source for such ideas. The Bayh–Dole act of 1980 in the US and similar legislation in European countries enabled universities to patent technologies resulting from government funded research, and as a consequence universities have undertaken a third role of fostering knowledge and technology transfer to spur economic growth (Etzkowitz et al., 2000). As a result, universities have employed many instruments to push newly generated knowledge into industry (Feldman et al., 2002; Mowery et al., 2004; Thursby and Thursby, 2002), while firms have used various ways to draw upon the research and pull new technology from academia (Henderson and Cockburn, 1996; Liebeskind et al., 1996). Despite these efforts knowledge still tends to be trapped in the ivory tower (Bikard, 2014). In light of these results, many countries have increasingly turned toward academic–industry partnership programs that combine these mechanisms to facilitate and foster the bridging between academic science and commercialization of technology.[1] Though there are many such programs globally, there is little research that assesses the impact of academic–industry partnership funding on participating firms' innovative performance compared to non-participants.

We examine academic–industry partnerships sponsored by the Danish National Advanced Technology Foundation[2] (DNATF), a funding agency of the Danish government. DNATF awards grants for projects that partner at least one academic institution and one

[1] In the US, National Science Foundation Shared Resources Centers often require partnership with private firms to accelerate product development, while the National Institute of Health Academic–Industry Partnership Program seeks cross-boundary opportunities that link biomedical research with commercial opportunities. In Germany, the Fraunhofer–Gessellschaft is a partially state-supported application-oriented research organization with direct utility to private and public enterprises. The Technology Strategy Board in the UK runs programs such as its Knowledge Transfer Partnership that support businesses wanting to improve their competitiveness by accessing the expertise available within universities.

[2] Højteknologifonden in Danish, DNATF was merged into the InnovationsFonden in May 2014.

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firm in a co-funding structure where academic partners provide one sixth of the budgeted amount, industry partners one third, and the agency providing the remaining half. As few existing works explore how academic–industry funding affects subsequent firm innovative performance, our analysis is mainly exploratory. We contrast a sample of funded firms with those that applied for DNATF funding but did not ultimately receive a grant, comparing on an annual basis up to 5 years after funding. Since all proposal applications were ranked, we mitigate selection bias by including qualitatively similar participant and non-participant firms. We first assess how such partnerships affect collaborations with academic research institutions in helping firms partake in innovative activities translated from basic research by studying the quantity and the collaborative nature of peer-reviewed publications. We then explore how these partnerships affect commercialization by studying the quantity of granted patents. Finally, we investigate three dimensions – the size and age of the participating firms, and the size of the collaborations – in order to establish the boundary conditions of such a funding scheme.

Although our results do not show consistent significant effects of academic–industry funding on the full sample of heterogeneous participating firms, we find significant effects along the three dimensions. For the samples of qualitatively similar small and medium-sized enterprises (SMEs) and firms in large projects, peer-reviewed publications increased significantly among funded compared to unfunded firms. For the young firm and large project qualitatively similar samples, granted patents increased significantly for funded firms compared to unfunded firms up to 4 years after funding. Moreover, for all three sample specifications, the proportion of cross-institutional publications increased significantly for funded firms compared to unfunded firms, when looking at a point 3 years after the start of funding. Taken together, our findings suggest that receiving the grant affects firms' innovative behavior differently depending on characteristics of the firm.

This work departs from prior works in a number of novel ways. It showcases a hybrid model that incorporates both academic engagement (Perkmann et al., 2013) and university entrepreneurship (Rothaermel et al., 2007) – academic–industry partnerships – and lends empirical evidence to the effect of governmental grants that foster these bridging partnerships on the resulting scientific and technological knowledge that is created. It takes a distinctive perspective from most works that study university technology transfer. Instead of focusing on academic scientists who cross institutional boundaries (Ding and Choi, 2011; Stuart and Ding, 2006), this work centers on the firm as the level of analysis and investigates the impact of academic–industry projects on firm innovative performance. Finally, given the nine-year window that we employ in our analysis (4 years before and 5 years after funding), we possess a rare longitudinal dataset that shows the dynamic and longer-term effects of the funding on firm innovative performance.

The structure of this work is as follows. We begin by presenting the theoretical framework from the literature. We then describe the setting from which we compiled our data, detail the estimation methodology employed to run our analyses, and interpret our results. Finally, in the discussion we elaborate on our quantitative results with interviews of project managers working in funded firms and explore potential factors that explain our findings. We also discuss the contributions this work brings to extant literatures and consider the implications for policymakers and managers.

2. Academic engagement, university entrepreneurship and government funding

Merton (1957) first pointed out the distinctive incentive systems between the institutions of science and technology. Science is primarily embodied in research universities where scientists are free to choose the direction of research, outputs are mainly encoded in the form of peer-reviewed publications, and the reward system is based on priority. Technology, in contrast, encodes ideas in protected modes, using patents, trademarks or copyrights to facilitate commercialization and appropriation of economic rewards (Dasgupta and David, 1994). The two institutions also differ in the nature of goals accepted as legitimate, as well as norms of behavior, especially with regard to the disclosure of knowledge. Science is concerned with additions to the stock of open knowledge, whereas technology is concerned with additions to the stream of rents that may be derived from possession of private knowledge. Though theoretically the two institutions are distinct, starting with the Bayh–Dole act of 1980 (Mowery et al., 2001) and analogous policies in Europe, the boundary between science and technology have become blurred as universities started to transfer technology by patenting their research and increasing their involvement with industry.

The literature that examines the relationship between science and technology has illustrated their interplay using two models. The first perspective depicts a linear model with science exogenous to technology, in which knowledge initiated from science spills over into technology thereby creating positive externalities for innovation and commercialization (Freeman, 1992; Mansfield, 1995). The second perspective suggests that there is a more complex bidirectional relationship rather than a pure linear model, where progress in science may be due in part to feedback from technology (Murray, 2002; Nelson, 1995). In other words, science is not viewed as a self-contained exogenous process but rather endogenous to technical progress and commercialization. However, as knowledge tends to be sticky (von Hippel, 1994), there are many challenges that prevent it from being diffused easily across institutional boundaries.

Practically, both institutions have used various means to enhance the transfer of knowledge and technology that they create as they co-evolve together. From the perspective of science-based firms, a number of mechanisms of how science influences technological progress and ultimately financial performance through knowledge spillovers have been identified. These include publishing in peer-reviewed journals (Henderson and Cockburn, 1994), coauthoring with academic scientists (Cockburn and Henderson, 1998; Liebeskind et al., 1996), movement of human capital through hiring of academic talent (Dasgupta and David, 1994), and geographically collocating close to academic organizations (Zucker et al., 1998). From the perspective of research universities, academic researchers engage in knowledge-related collaborations with firms (Perkmann et al., 2013) in the form of collaborations, contract research, or consulting, and as well as the founding of science-intensive firms (Murray, 2004; Stuart and Ding, 2006; Stuart et al., 2007). Universities actively foster commercialization (Rothaermel et al., 2007) through technology transfer offices that patent and license inventions from academic laboratories (Bercovitz and Feldman, 2006; Debackere and Veugelers, 2005), science parks to create clusters of expertise and incubators to nurture university spin-outs (Phan et al., 2005), and equity investment in start-ups (Feldman et al., 2002). Conceptually, academic engagement pursued for broader objectives, such as to assess resources and obtain learning opportunities (Lee, 2000), is seen as separate from and precedes university technology transfer (Perkmann et al., 2013), with the main goal of reaping financial reward from universities technologies.

The setting of this paper is a hybrid model of academic engagement and university entrepreneurship. The academic–industry partnerships under study entail collaborations between university scientists and industry researchers with the goal of developing technologies important to industry. These partnerships differ from the traditional model of separately generating basic scientific