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Composition of inventor teams and technological progress – The role of collaboration between academia and industry

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ABSTRACT

It is generally claimed that universities provide the scientific basis for future technological progress. Still, empirical evidence of the impact of direct links between universities and firms remains weak and is often inconsistent. This paper aims at contributing to the literature by analyzing how direct academic involvement affects the output of inventive activities of research teams with different organizational backgrounds. By applying a unique dataset of German academic and corporate patents, we find that boundary-spanning knowledge production with academic inventors raises the innovative performance of SMEs and MNEs. Finally, in line with previous research, the results generally indicate a limiting effect of geographical proximity, while teams with academic involvement appear to be less affected.

1. Introduction

The literature on knowledge based economic development has made essential contributions in proving that basic science fosters technological progress (Adams, 1990; Jaffe, 1989). A new generation of studies on networks and open science additionally reveals an increasing importance of sourcing knowledge from external organizations in general and from universities in particular (Powell and Grodal, 2005; Cohen et al., 2002). However, further understanding the links between university and industry has significant implications for public policy and the rationales beyond funding basic research in universities as well as firms. In this context, knowledge creation and innovation are increasingly seen as a socially embedded process, which is highly dependent on inter-organizational and social networks. Particularly in collaborations between universities and industry, the often tacit nature of advanced scientific and technological knowledge makes relationship-based interactions highly relevant. R&D collaborations based on relationships are the preferred ways of exchange, enabling regular face-to-face contacts, reciprocal and bi-directional knowledge exchanges as well as the circulation of ideas between theory and practice (Perkmann and Walsh, 2007, 2009). In sum, border-crossing team work and inter-organizational collaboration activities can be seen as one of the most important mechanisms of knowledge flows from university to industry. This finds further support in the fact that potential tensions and cultural barriers between university and industry – due to different institutional norms governing public and private knowledge – can be overcome in trust-based interactions where corporate and academic researchers act as boundary spanners (Bruneel et al., 2010).

However, although there is a huge body of literature on the ties between universities and firms, few studies aimed at understanding the performance effect of direct industry-science links, especially on the invention or project level (Cassiman et al., 2008). Empirical evidence on the impact of academic involvement in corporate inventive performance remains weak (Ahrweiler et al., 2011). Quantitative studies, often based on single sectors, use indirect ways to measure the impact of academic research on industrial innovation, e.g. spillover studies using a knowledge production function (Jaffe et al., 1993). Others employ patent citations to non-patent literature (NPL) as a proxy for science linkages (Fleming and Sorenson, 2004; Harhoff et al., 2003; Narin et al., 1997) and provide interesting, but at least partly inconclusive results (Cassiman et al., 2008). NPL-citations, however, are a fragile measure for links to science. This is due to the fact that NPL-citations remain indirect, i.e., the real link and the true contribution of science cannot

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be observed, since searching and using codified scientific knowledge is fundamentally different from relationship-based links. It is particularly the person-to-person interaction that matters in the transfer of highly advanced technological knowledge. Empirical approaches, using direct links to measure the influence of academic involvement are, to our knowledge, largely missing. A number of studies, coming closest to our approach, use forward and backward citations to patents as indicators to analyze the quality or technological impact of inventions coming from universities (e.g., Czarnitzki et al., 2011, 2012; Mowery and Ziedonis, 2002; Sampat et al., 2003; Thursby et al., 2009; Traijtenberg et al., 1997). Czarnitzki et al. (2011), for example, show for German corporate patents that academic involvement results in a citation premium and provide the first study applying this approach to German universities. These remarkable studies added valuable empirical results and constitute the foundation we built upon. However, our approach departs in several aspects and aims to extend the knowledge on the performance effect of industry-science links on different fronts:

Firstly, we complement existing research by introducing the catalyzing effect on future technological progress as a new measure for the innovative performance of an inventor team. It builds on the frequently used technological impact (as measured by citations from subsequent patents), but enables us to further differentiate by accounting for the "basicness" of an invention, i.e., the amount of existing knowledge that an invention builds upon, indicated by references to earlier patents. Thus, we measure the technological contribution an invention provides along a particular technological path. At the same time, we acknowledge the degree to which it relies on existing codified technological knowledge. Therefore, we measure the catalyzing function of an invention by acknowledging the degree to which it creates new knowledge in relation to the amount of existing knowledge that it builds upon. In simple words, if an invention requires a small amount of knowledge in order to generate large impact on technological progress, we denote it as a catalyst. Section 3.1 presents a detailed discussion and provides an in depth argumentation of the indicator.

Secondly, employing a unique dataset, containing all German patents with academic involvement between 2000 and 2005, enables us to observe purely academic as well as patents from mixed teams with academic and corporate inventors, the latter representing direct science-industry links. To do so, we use a recently developed method that has several methodological advantages over previous approaches, particularly in the German context, as described in Dornbusch et al. (2013).[1] Complementing this with patents involving only inventors from SMEs or MNEs, we present (to our knowledge) the first study that applies a control group approach to compare collaborative (mixed inventor team) patents against patents invented by purely university or corporate teams and further distinguishes between large and small firm backgrounds. Thus, we use the inventor and ownership information on patents as a proxy for different compositions of inventor teams and their institutional-organizational backgrounds, i.e., if the research team is composed only of academic, corporate or a mixture of academic and corporate inventors (Bercovitz and Feldman, 2011; Von Proff and Dettmann, 2013). In doing so, the chosen approach enables us to contribute to an often neglected aspect, namely the direct organizational background inventor teams are embedded in (Cassimann et al., 2008).

In sum, this paper aims to answer the following question:

How does direct involvement of academic inventors influence the catalyzing effect that inventions exert on technological progress – in the light of heterogeneous organizational backgrounds?

The remainder of this paper is structured as follows. In the theoretical Section 2, we will lay out the theoretical framework and develop the hypotheses which are tested in the empirical section. Section 3 composes theoretical backup for the catalyzing effect, describes the data and the empirical strategy. Section 4 presents and discusses the results of our analyses. Section 5 concludes.

2. Inventors in universities, firms and in mixed teams: their role in technological progress

2.1. Inventor teams in firms and universities

Previous studies pointed to the importance of organizational backgrounds for innovative and inventive activities (Bercovitz and Feldman, 2011; Von Proff and Dettmann, 2013). The main line of argumentation is that the cultural background and the availability of resources significantly differ between heterogeneous organizational and institutional frameworks as given in universities, small as well as large firms. This in turn determines a research team's working environment as well as the type of research conducted. The most obvious differentiation here is between academic and industrial contexts. Though both, academic and industrial researchers, are interested in gathering new knowledge, the type and the ways to learn, operate and generate knowledge are fundamentally different (e.g., Traijtenberg et al., 1997; Jensen et al., 2007). Industrial researchers are interested in, and mainly conduct, applied research. Thus, we expect a rather incremental innovation behavior in corporate contexts. At the same time, academic environments focus on basic knowledge and academics are mainly interested in pushing frontiers of research and understanding particular fundamental phenomena (Stephan, 2012). Their research and innovation behavior is by definition less strongly connected to current technological markets and appropriability than that of corporations. Traijtenberg et al. (1997) further show, relying on the prior that inventions patented by universities are more basic, receive higher visibility from subsequent patents than corporate patents. In line with this, a study by Thursby et al. (2009) showed for a sample of US academic patents that a higher number of forward citations (indicating a higher technological impact) and a lower number of backward citations (indicating less incrementality; more basicness) predict that a university appears as the applicant. We therefore expect that university research is more basic and fundamental than industry research. If pieces of this research are patented, these are likely to be less incremental and rely less on existing technological knowledge. At the same time, the inventions are likely to be of higher relevance for future technological developments.

H1a. Inventions that emerge from inventor teams with university backgrounds are likely to be stronger catalysts for technological progress than purely corporate inventions.

Recent research highlighted that the availability of resources is a limiting factor for a firm's inventive performance. Its ability to access external knowledge and to exploit new technological opportunities strongly depends on its internal research and knowledge capacities (Fabrizio, 2009). However, R&D is conducted by individuals and within research teams that are engaged in inventive activities within an organization. We argue that the type of inventive activity conducted by these teams depends on the resources that their organization provides. From an individual's perspective this seems reasonable. Cognitive limitations make it impossible for researchers and engineers to know and to evaluate every technological opportunity in relation to other options. Thus, working in teams to combine internal as well as external knowledge and

[1] Among those, we do not rely on a professors' willingness to indicate his title and we include not only professors, but also other staff at universities. A more detailed discussion can be found in Dornbusch et al. (2013).