



Knowledge spillovers in the supply chain: Evidence from the high tech sectors



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ABSTRACT

In addition to internal R&D, external knowledge is widely considered as an essential lever for innovative performance. This paper analyzes knowledge spillovers in supply chain networks. Specifically, we investigate how supplier innovation is impacted by buyer innovation. Financial accounting data is combined with supply chain relationship data and patent data for U.S. firms in high tech industries. Our econometric analysis shows that buyer innovation has a positive and significant impact on supplier innovation. We find that the duration of the buyer–supplier relationship positively moderates this effect, but that the technological proximity between the two firms does not have a significant effect on spillovers.

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1. Introduction

Innovation has long been regarded as playing a key role in the competitive advantage and survival of firms (Audretsch, 1995; Cefis and Marsili, 2006; Schumpeter, 1942). To innovate, firms can invest in internal R&D or leverage external sources of knowledge. Such external knowledge can be exchanged via spillovers, collaborations, or direct market transactions such as technology licensing. Because of the complexity, uncertainty, and costs of the innovation process, firms are increasingly actively searching for external knowledge that is complementary to in-house R&D activities (Cohen et al., 2002; Chesbrough, 2003). With regard to particular sources, firms can benefit from the innovative activities of competing firms, academic institutions, and supply chain partners. Correspondingly, survey evidence suggests that downstream partners are an important information source for innovation (Cohen et al., 2002; Belderbos et al., 2004).

In response to the practical importance of external knowledge and downstream partners in firm innovation, various streams of the management and applied economics literature provide related insights. A comprehensive body of studies has quantified the

impact of inter-firm knowledge spillovers on firm innovation, traditionally focusing on unintentional knowledge transfers between rival firms (Jaffe, 1986; Bloom et al., 2013). Similarly, research on multinational firms and foreign direct investment has examined technology and productivity spillovers from foreign investors to local firms (Almeida and Kogut, 1997; Görg and Strobl, 2001; Javorcik, 2004). Also, a distinct body of studies has investigated the role of downstream users as a valuable source in firms' innovation processes (Von Hippel, 1976; Chatterji and Fabrizio, 2012). Finally, the operations management literature has explored how new product development can be improved by leveraging supplier innovation through integration and collaboration (Primo and Amundson, 2002; Azadegan and Dooley, 2010).

Despite the abovementioned research on knowledge spillovers, external sources of knowledge, and supply chain relationships, we propose that combining several perspectives in one study offers new and valuable insights. In particular, our study investigates (i) the impact of buyer innovation on supplier innovation with a focus on (ii) technological innovation as reflected by patents (iii) using a quantitative empirical design with information on direct linkages between suppliers and buyers. Besides documenting the prevalence and magnitude of knowledge spillovers, we also provide insights into drivers of heterogeneity across firms. One specific characteristic of a buyer–supplier relationship is the typically high frequency of interactions between the companies, which may increase spillovers over time. Thus, we consider

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relationship duration as a moderating determinant for the impact of buyer innovation on supplier innovation. Furthermore, the role of technological proximity as a moderating factor may differ in the supply chain context compared with that of competing firms.

Knowledge spillovers are often referred to as informal, unintentional and uncompensated transfers of knowledge. However, the innovation literature also routinely speaks of voluntary, intentional knowledge spillovers (De Jong and von Hippel, 2009) and strategic spillovers (Harhoff, 1996). In this paper we do not attempt to distinguish between intentional and unintentional knowledge spillovers and adopt a broader definition encompassing both. The empirical analysis relies on firm-level information for publicly traded American firms in high-technology sectors between 1990 and 2006. This information is combined with data on buyer–supplier linkages which is disclosed due to a financial accounting standard. Innovative output is proxied by patent data, which is extracted from the World Statistical Patent database (*Patsstat*). Our sample contains 706 supplier-year observations, with at least one observed buying firm per supplier.

By observing direct linkages between supply chain partners we document a positive effect of buyer innovation on supplier innovation. This result suggests that spillovers are also relevant in the context of supply–chain relationships and therefore complements findings about the positive impact of external knowledge on firms' inventive performance in studies on R&D spillovers and open innovation. However, the relationship is largely conditional on the duration of the buyer–supplier relationship since, interestingly, there is no evidence of spillovers in newly formed supply chain partnerships. This has novel and interesting implications for both research and practice. Moreover, we find no evidence that knowledge spillovers increase with technological proximity between the supplying and buying firms, which is unexpected since proximity is typically associated with positive benefits for learning (see Orlando, 2004).

The remainder of this paper is structured as follows: Section 2 provides a review of the most relevant literature. In Section 3, the hypotheses are developed. In Section 4, the research methodology and data are presented. The econometric results are presented and discussed in Section 5. Robustness tests and post hoc analysis are shown in Section 6. We conclude in Section 7.

2. Literature review

The impact of external knowledge on firm innovation in general, and knowledge flows between supply chain partners in particular, has received considerable attention from several streams of academic literature. The most relevant literature for our study originates from the research areas of R&D spillovers (including related studies on spillovers from firms' foreign direct investment), open and user innovation, and operations management.

It has been shown that knowledge spillovers lead to an increase in companies' R&D investments and higher innovation output and productivity (Jaffe et al., 1993; Cohen and Levinthal, 1989; Bloom et al., 2013). The impact of knowledge spillovers on firms' innovation productivity is amplified by technological (Orlando, 2004) and spatial proximity between a firm and its competitors (Jaffe et al., 1993; Lychagin et al., 2010; Mairesse and Mulka, 2008; Aldieri and Cincera, 2009). Using plant-level data, Ikeuchi et al. (2015) find that flows of technological knowledge originating from buyers increase the total factor productivity of suppliers.

Related to geographic proximity, studies on foreign direct investments, international business, and R&D offshoring explain firms' location choices in order to benefit from productivity and knowledge spillovers from proximate firms (e.g. Shaver and Flyer, 2000; Alcacer and Chung, 2007). The majority of the empirical

studies suggest, directly or indirectly, that the buyer–supplier relationship is an important channel through which productivity spillovers occur. Local productivity improvements are considered to be a sign of learning from foreign investors (Almeida and Kogut, 1997; Görg and Strobl, 2001; Havranek and Irsova, 2011; Javorcik, 2004; Meyer and Sinani, 2009) and trade (Antras and Helpman, 2004; Salioli and Zanfei, 2009; Sturgeon et al., 2008). Although these studies indirectly point to business transactions as important enablers for knowledge transfer, they cannot observe direct supply chain linkages between firms.

The importance of leveraging external knowledge sources is highlighted by studies on open innovation (Chesbrough, 2003; Laursen and Salter, 2006; Dahlander and Gann, 2010) and user innovation (Von Hippel, 1976; De Jong and von Hippel, 2009). Numerous case studies illustrate external knowledge as a crucial input for firms' inventive activities. Specifically with regard to users, the most prominent examples are open source software development and the medical instruments sector. User developers contribute actively to the creation of new software, and clinicians co-develop new surgery tools jointly with companies (e.g. Von Hippel et al., 1999; Von Hippel and Von Krogh, 2003; Jeppesen and Frederiksen, 2006). Because of the difficulties of obtaining large-scale data on firms' interactions with users, the majority of studies rely on qualitative information, with some notable exceptions.

Using data from the community innovation survey (CIS), Laursen and Salter (2006) show that firms that access a broader range of external knowledge sources (e.g. universities, competitors, and customers) and use them more deeply increase their innovation productivity. Belderbos et al. (2004) document that, among other partners, spillovers from customers (including both firm and end customers) may facilitate the creation of radical innovation. With a focus on user innovation, Chatterji and Fabrizio (2012) show that medical instrument firms can improve their patent productivity by interacting with clinicians.¹ While the user innovation literature acknowledges companies as a user group (intermediate users), the main focus is on the end users of the products and equipment providers, limiting the generalizability of the findings with regard to spillovers of technological knowledge in a supply chain context.

In the operations management literature, the supply chain is a common level of analysis. The effect of supplier involvement in new product development, with focus on project-related outcome dimensions such as project development times, project costs, product quality, and team effectiveness, has been investigated by conducting case studies and surveys (Primo and Amundson, 2002; Appleyard, 2003; Petersen et al., 2005; Azadegan and Dooley, 2010). The majority of studies suggest that supplier involvement and collaboration has a positive impact on new product development. However, this line of research has little emphasis on technological innovations and R&D.

3. Technological spillovers in supply chains

3.1. Buying firms as a source of valuable knowledge for innovation

Firms increasingly leverage external sources of knowledge because of the complexity and costs of the innovation process (Laursen and Salter, 2006). Compared with “traditional” horizontal R&D spillovers between rival firms, transactions between a buyer and a supplier can act as an additional channel for knowledge diffusion, whereby interactions at the individual level may

¹ Clinicians are an ambiguous user group, since the leading clinicians in university hospitals can also be regarded as university researchers.

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