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# The influence of international research interaction on national innovation performance: A bibliometric approach

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ABSTRACT

International research interactions, specifically interpersonal collaboration, institutional collaboration and within multinational corporation (MNC) collaboration, have been increasing since the 2000s as a result of globalization and rising technological complexity. Yet the impact of international research interactions (IRIs) on national innovation performance is ambiguous. In this study patent-based bibliometric indicators are developed to investigate the influence of different types of IRI on innovation performance using bibliometric data covering eight knowledge intensive manufacturing sectors and 32 countries during the 2003–2008 period. This sector-based approach avoids some of the problems of using patents as innovation indicators, like varying patenting propensities across sectors by comparing the same sectors across countries. In the study a knowledge production function is estimated for each sector, with patents serving as an indicator of knowledge output. The overall results suggest an absence of positive influence of IRI on innovation performance, and sometimes even a negative influence pointing to 'reversed knowledge flows'. But the pattern is nuanced and differs per sector and type of collaboration. For example, interpersonal collaboration has a negative or no effect on innovation performance depending on the sector, and institutional collaboration has no effect on innovation performance. Within MNC collaboration has a positive influence on innovation performance in the chemicals and pharmaceuticals sectors, but a negative effect or no effect in other sectors. Computers are an exceptional sector in that the influence of IRI depends on the absolute size of the sector in the domestic economy. The paper concludes with the theoretical relevance of these findings and some policy implications are also discussed.



## 1. Introduction

International research interactions, specifically research collaboration and the global distribution of research activities, are increasing as a result of rising technological complexity and the ongoing process of economic globalization (Audretsch et al. 2014; Locke and Wellhausen 2014; OECD 2012). This leads to increased competition between firms and to a growing global division of labor in Research & Development (R&D), urging firms and other actors in knowledge creation and use (such as universities) to source knowledge internationally and to establish a presence in multiple locations around the world (Altbach et al. 2009; Awate et al. 2014; Castellani et al. 2013; OECD 2007). International research interactions are especially prevalent in knowledge intensive sectors (Asheim and Gertler 2005; Malecki 2014). These sectors have great strategic economic value because of the high barriers to entry created by complex institutional, technological and knowledge networks which cannot easily be replicated (Malerba 2002; Porter 1990). Knowledge intensive sectors continue to account for the largest share of economic growth in developed economies (Powell et al. 2013).

Despite the rapid growth of international research interactions, its influence on local innovation performance is ambiguous. On the one hand, the positive influence of international knowledge spillovers is supported by theory (Bathelt et al. 2004; Freeman et al. 2010; Gertler 2003) and several empirical studies (Grossman and Helpman 1991; Guan and Chen 2012; Guellec and Van Pottelsberghe de la Potterie 2001; Hottenrott and Lopes-Bento 2014; OECD 2009; Simmie 2003). On the other hand, international research interactions have been found to weaken local research activity and interaction under particular circumstances (Kwon et al. 2012; Leydesdorff and Sun 2009; Van Geenhuizen and Nijkamp 2012a, 2012b; Ye et al. 2013) and also weaken overall innovation performance in clusters (Chang et al. 2013; Propris and Driffield 2005).

In studying innovation, patents can be regarded as a "paper trail" (Jaffe et al. 1993), containing information about the inventors, assignees, technology and institutional and interpersonal links. This makes them a versatile and widely used data source for innovation studies (Lei et al. 2011; Shapiro 2015). While there are limitations and drawbacks to using patent data as an innovation indicator (Kleinknecht, Montfort, and Brouwer, 2002), patents do contain "clues" which can expand our understanding of the innovation process. Furthermore, patent output has been found to correlate fairly well with

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other innovation activity indicators (Acs et al. 2002). These authors also show that the number of inventors, as revealed by patent data, correlates closely to the number of researchers.

A critical issue in using patent data as an innovation indicator is the variation in patenting propensities between different sectors (Arundel and Kabla 1998; Malerba and Orsenigo 1996). This study tackles this problem by studying *sectors* and not aggregate patent statistics for whole *countries*, as was the case in other recent international innovation studies that use patent data (De Prato and Nepelski 2014; De Rassenfosse and van Pottelsberghe de la Potterie 2009). In addition to side-stepping an important methodological problem, the comparison of sectors also allows for the exploration of inter-sectoral differences in international research interactions (Iammarino and McCann 2006; Malerba 2002).

This study addresses the basic question: *To what extent does international research interaction influence national innovation performance according to patent-based indicators, and which differences in influence exist between sectors*?

This paper consists of five sections. First the relevant theory is reviewed and hypotheses are formulated (Section 2). This is followed by a description of the patent data set and the development of bibliometric indicators (Section 3). Analysis of the model estimation, results and validation (Section 4) comes before a brief discussion and the conclusion (Section 5).

## 2. International research interaction: theory and hypotheses

International research interaction can be understood from a variety of theoretical domains, including inter-organizational learning and various concepts of non-geographic proximity, including the competitive and technological pressures that are the drivers of increasing international research interaction.

International research interaction (IRI) exists in many forms, however this study considers two important ones: international research collaboration (both institutional and interpersonal) and the global network of research activities of knowledge intensive firms (especially MNCs) and other knowledge using and creating actors such as universities and public research institutions. While international research interaction does occur through other mechanisms, such as the trade in high technology goods and services, technology licensing, contract manufacturing and international labor mobility, international research collaboration appears to be rapidly growing in both developed and developing economies (Awate et al., 2014; Enkel et al., 2009; Locke and Wellhausen 2014). Furthermore, MNCs are among the largest investors in R&D and they conduct a significant share of their research outside of their home countries, making them the dominant actors in the global distribution of innovation activities (NCSES 2014).

The need to source knowledge globally can be understood from the perspective of rising technological complexity and global competition. Complexity makes it impossible for firms to create all necessary knowledge within their own region or country, let alone internally. Competition drives firms to seek out the best knowledge, wherever it may be (Archibugi and Iammarino 2002; Asheim and Gertler 2005; Bathelt et al. 2004; Chesbrough 2006; Doz et al. 2001).

International research collaboration and the global network of research activities within firms enable the access and use of new knowledge. While innovation is facilitated by proximity, this proximity is not necessarily geographical or spatial (Boschma 2005). In recent approaches of 'relational economies' non-spatial proximity is seen as an important factor in the innovation process (Asheim et al. 2007; Birch 2007; Ponds et al. 2007). It is related to the concept of cognitive distance, which is the extent to which different actors trust each other and share a common set of values, i.e. the extent to which they "speak the same language", which although facilitated by geographical proximity, is not automatic and can persist over long geographical distances (Fazio and Lavecchia 2013; Gertler 2003; Nooteboom 2013). These insights also build upon inter-organizational learning theory, which attaches importance to the development of interpersonal relationships, institutional support and creation of mutual trust as a prerequisite for successful research collaboration (Dodgson 1992).

Thus rather than claiming that innovation occurs in and through clusters, a more suitable generalization is that it is facilitated by networks which show varying degrees of spatial concentration (Ponds et al. 2010). An illustration of this tendency is the fact that collaboration in innovation in Europe and North America tends to occur either within regions or within a distinct network of cities and regions, instead of being geographically distributed or highly localized (Acs et al. 1994; Anselin et al. 1997; Fischer and Varga 2003; Jaffe 1989). In addition, knowledge exchanges also occur in long-distance collaborative networks of social and institutional relationships (Autant-Bernard et al. 2007; Breschi et al. 2003; Huber 2012; Knoben 2009; Ponds et al. 2010; Wilhelmsson 2009).

Research collaboration is generally assumed to be beneficial for all participants involved (Dosi et al. 1988; Gertler 1995), provided that there is a balance of power between the participants; unequal relationships reduce the likelihood that the weaker party will benefit from research collaboration (Lazonick and Mazzucato 2013). In fact, power inequalities between partners within research networks tend to reduce research collaboration overall (Liu 2014).

MNCs and other globally distributed organizations have a unique advantage in that they provide an organizational structure and standard culture that reduces the aforementioned cognitive distance and thus facilitates the transfer of tacit knowledge over large distances within the organization (Awate et al. 2014; Castellani et al. 2013). MNCs are also among the largest investors in innovation worldwide, for example in the United States 72.2% of all business R&D expenditure came from US MNCs (Archibugi and Iammarino 2002; NCSES 2014). At the same time, increased participation by MNCs in local innovation systems (regional or national), be it through research collaboration or commercially driven, can weaken research interactions among local actors by reorienting them towards external collaborations (Kwon et al. 2012; Van Geenhuizen and Nijkamp 2012a, 2012b; Ye et al. 2013), thus potentially reducing innovation performance.

It should be noted that smaller clusters tend to be more outwardly focussed than larger clusters because they lack internal knowledge resources (Huallacháin and Lee 2014; Tödtling and Trippl 2005). However there are also indications that absorptive capacity, i.e. the degree to which local knowledge resources are available, is a necessary factor for firms in a region to benefit from international knowledge interactions (Fu 2008; Liefner et al. 2012). Thus, while innovation systems can potentially benefit significantly from IRI (Bathelt et al. 2004), the interaction does not appear to "automatically" improve innovation performance.

The factors that influence innovation performance are summarized in a simplified model in Fig. 1. Accordingly, innovation performance is

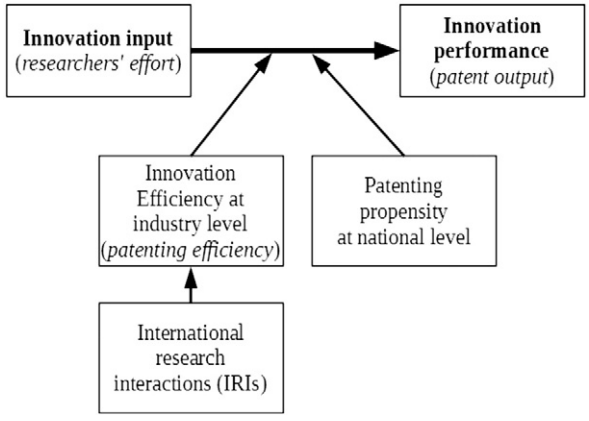


**Fig. 1.** Simple model of innovation performance.