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Different competences, different modes in the globalization of innovation?

A comparative study of the Pune and Beijing regions

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Keywords: globalization, innovation, regions, competences, China, India

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Furthermore, little attention has been paid to the interplay of the micro characteristics of firms, the region in which they are embedded and different forms of globalization of innovation.

Our paper is based on three distinct modes of globalization of innovation: global exploitation of innovation, global sourcing of technology and global research collaboration, thus adapting Archibugi and Michie's taxonomy to a developing country context. We then use this taxonomy to explore empirically the linkages of firm-level competences, the nature of the international activities and the region in which the firms are located: Pune in India and Beijing in China.

We use primary data on the two regions to show that the Pune region is specialized in the three types of globalization of innovation, and in particular in the exploitation of innovation more than Beijing. A deeper analysis of the micro characteristics of the firms shows that the three modes of globalization of innovation are associated to different competences. Firms with technological and organizational competences show a higher propensity to develop international linkages, while firms with a high level of educated human resources seems to focus more on the domestic market.

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1. Introduction

The globalization of innovation activities is not a new phenomenon. Firms have long exploited economies of scale by internationally commercializing new goods and services. The extensive literature on international business has contributed largely to our understanding of the corporate determinants of the internationalization of firms, pointing out the role of size, ownership, strategy and the qualifications of the CEO, among other factors explaining the internationalization of economic activities (Dunning, 2001).

However, it was only in the last decade that scholars in this line of literature started to pay attention to the internationalization of knowledge-intensive activities (Blanc and Sierra, 1999; Cantwell and Piscitello, 2002, 2005, 2007; Dunning and Lundan, 2009; Zanfei, 2000). These authors argue that the internationalization of knowledge-intensive activities is of a different nature from the internationalization of pure production activities. Among other things, it reflects a different strategy (from asset exploitation to asset seeking) which might require a different set of competences and networks (Castellani and Zanfei, 2006).

While the international business literature has concentrated on the internal characteristics of firms, explaining their propensity to access international markets, innovation scholars have been concerned with the role of regions, industries or nations supporting the accumulation of competences that enable local firms to start upgrading and accessing international markets (Chaminade and Vang, 2008; Giuliani et al., 2005; Schmitz, 2007). As we will argue in this paper, these two perspectives are complementary.

The region (and the national innovation system) in which the firm is embedded might support the firm in the acquisition of the specific competences that are needed to access international markets. In innovation studies, the region has long been considered a key level in which innovation is shaped (Asheim and Gertler, 2005; Cooke, 1992). Geographical proximity facilitates the access to qualified human capital and other specialized resources and the production, identification, appropriation and flow of tacit knowledge (Allen, 2000; Amin, 2000, Amin and Cohendet, 2004 cf Asheim and Gertler, 2005), which is paramount for innovation. In this paper, we explore the role of the region as well as the role of firm-specific competences explaining the globalization of innovation in two regions: Pune in India and Beijing in China.

Pune and Beijing are particularly interesting because of their very recent rise both as recipients of innovation activities (e.g. location of R&D activities by multinational firms in India and China) (UNCTAD, 2005) and as transmitters of knowledge to other parts of the world (e.g. location of R&D activities by Indian or Chinese multinationals abroad). It has been argued that one of the possible explanations of this global shift in the location of innovation activities from and towards Pune or Bangalore in India and Shanghai or Beijing in China is the increasing accumulation of technological capabilities in these regions over the last decades (Arora and Gambardella, 2004, Asheim and Vang, 2006; Chaminade and Vang, 2008; Yeung, 2006, 2007; Saxenian, 2001). But how much of the globalization of innovation of firms in Pune and Beijing can be explained by the accumulation of competences at regional level and how much at corporate level remains to be explored.

Furthermore, this literature tends to implicitly refer to the “globalization of innovation” as a unique phenomenon rather than considering that it embraces a multiplicity of processes, from the global exploitation of innovation activities (asset exploiting) to the global sourcing of knowledge for innovation activities (asset seeking), each of them requiring different competences. Which competences are required for which form of globalization is still a question to be researched.

This paper attempts to contribute to this research gap by exploring the linkages between firm-level competences, the region in which the firm is located and different forms of globalization of innovation in which the firms are engaged. To do so we use econometric analysis based on firm-level primary data in three different sectors (automotive component, green biotech and software) collected in the Pune and Beijing regions in 2008. The data allows us to control for the role of the region in the specific mode of international linkages.

The first question we ask is of an explorative nature since we want to assess what type of international innovation linkages are predominant in firms belonging to the two specific regions. That is, if the Pune and Beijing regions are specialized in a specific mode of globalization of innovation.

The second question of a more explicative nature is instead devoted to understand if firm competences may explain the different propensity to develop international linkages for the globalization of innovation.

The paper is organized as follows: Section 2 discusses the main research questions and the theoretical background, section 3 illustrates Pune and Beijing regions, section 4 introduces the sample and the variables used in the econometric analysis, section 5 undertakes a quantitative analysis to investigate the inter-relationship of different firms' modes of globalization of innovation, the region and the competences of the firms, section 6 presents the main findings related to our research questions and section 7 concludes the paper.

2. Theoretical framework

2.1. Globalization of innovation and developing countries

In their seminal work, Archibugi and Michie (1995) point out the global nature of innovation activities. They argue that globalization is not only affected by technological development, but also itself impacts the way in which technological innovations are acquired, developed and commercialized.

They clearly distinguish three forms of globalization of innovation: the global exploitation of innovation, the global generation of innovation and the global technological collaboration. The *global exploitation of innovations* refers to the international commercialization of new products or services, and has its economic equivalent in the export of new products or services and in the international licensing of patents. The *global technological collaboration* alludes to the joint development of know-how or innovation with the participation of partners from more than one country. This collaboration may take a variety of forms, including R&D joint-ventures, R&D alliances, contractual R&D, etc. and may involve a variety of actors, including firms, research centers, universities, government, etc. Finally, the *global generation of innovation* refers mainly to the location of R&D activities in a different country, and is associated with R&D-related foreign direct investment.

The different forms of globalization of innovation are the consequence of two different strategies: asset exploiting and asset seeking (Castellani and Zanfei, 2006; Dunning and Lundan, 2009). Asset exploiting commonly refers to the development of new markets for existing products or services (Castellani and Zanfei, 2006), but is often used in the innovation literature to refer to the export of

innovations (Chen et al. 2009). Asset-exploiting strategies might entail a transfer of technology from the home base of the firm to the foreign market (Dunning and Lundan, 2009).
On the other hand, asset seeking alludes to the objective of acquiring science-based technologies and capabilities that are not available in the immediate environment. The global technological collaboration or the global generation of innovations may be considered as an asset-seeking strategy. It is important to indicate that even the asset-exploiting strategies may entail a certain degree of innovation, as products often need to be adapted to the local markets.

Over the last decade, scholars have collected abundant evidence of the increasing global character of the exploitation of innovation and the collaboration of innovation (Chesnais, 1988; Gugler and Dunning, 1993; Hagerdoorn and Schakenraad, 1990; Lukkonen et al., 1993). Although the three forms of globalization of innovation have increased over time (Archibugi and Iammarino, 2002), the global generation of technology in the early 2000s was still a marginal phenomenon almost exclusive to MNCs from developed countries locating R&D departments in another developed region in the world[1]. In other words, the technology clubs have remained almost unchanged over the last 50 years, with R&D competences concentrated in a handful of developed countries (Castellacci and Archibugi, 2008). However, in just one decade China and India changed from hosting 8% of the world R&D centers to hosting 18% (UNCTAD, 2005). The increasing location of R&D centers in China and India may be explained, among other factors, by the rapid accumulation of research capabilities in these two countries in general (Altenburg et al., 2008), and particularly in certain regions (Arora and Gambardella, 2005; Chaminade and Vang, 2008), as well as by the interest of multinational corporations in accessing these very dynamic Asian markets with products particularly developed for Chinese or Indian customers (Chen et al., 2009).

With few exceptions most of the evidence of the globalization of innovation is based on data-bases or cases from developed countries, that is, looking for example at the motivation of firms from Europe, Japan or US to locate innovation activities in other regions in the world, mainly the Triad.

In developing countries we might expect the framework of globalization of innovation to change at least in one respect. Although the indigenous generation of innovations is important in both developed and developing countries, firms in developing countries depend more frequently on foreign sources of knowledge and capital (FDI or linkages with MNCs) for their production and innovation processes (Loebis and Schmitz, 2005; Pietrobelli and Rabellotti, 2006; Schmitz 2007; Vang and Asheim, 2006). The *global sourcing of technology* becomes another form of globalization of innovation that is particularly important for developing countries. In this paper we define the global sourcing of technology mainly as the international acquisition of inputs for the innovation process, such as machinery, know-how and licences or training linked to the innovation process. We consider the global sourcing of technology as a knowledge or asset-seeking strategy, as it aims at augmenting the technological capabilities of the firms.

This paper investigates the role of the region as well as firm characteristics and competences in the three different modes of globalization of innovation that are most common in developing countries: the global sourcing of technology, the global collaboration in research projects and the global exploitation of innovation activities. These three modes of globalization of innovation indirectly point to a certain direction of the knowledge flow: from firms in the region to the rest of the world[2], from firms in the rest of the world to the region, and bidirectional cross-border knowledge flows involving firms in the region and firms and organizations in the rest of the world. The three modes of globalization of innovation represent a specific way of developing innovation activities: through

[1] Dicken (2007) argues that this limited form of "globalization" (within industrialized countries) would be better conceptualized as a regionalization of innovation activities.
[2] The rest of the world excludes the domestic market.

exploitation (when commercializing innovations in international markets), through sourcing (when acquiring international sources of knowledge to be used for innovation purposes) and through research collaboration (see fig. 1).

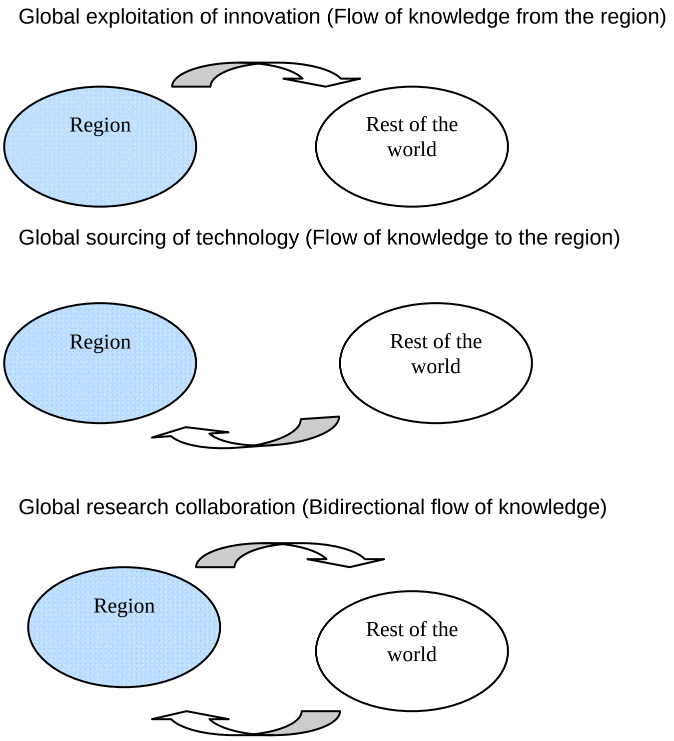

Fig. 1. The three different modes of globalization of innovation. *Source:* Own elaboration

The next section discusses how these three forms of globalization of innovation are indeed associated to some specific internal characteristics of the firms and to the regional environment where the firms are embedded.

2.2. Context and micro characteristics: what can sustain the globalization of innovation?

The international performance of a firm, ranging from the global exploitation of innovation to the global location of R&D facilities, may be explained by a combination of firm´s internal and external factors (Blanc and Sierra, 1999). In the international business literature internal factors such as size or the ownership structure of the firm, for example, have long been considered as determinants of the international performance of the firm (Bonaccorsi, 1992 cf Sousa et al., 2008; Calof, 1994; Dean et al., 2000; Fritch and Lukas, 2001; Kleiknetch and Van Reijnen 1992; Moen, 1999; Sousa et al., 2008; Vonortas, 1997).

While the resource-based theory of the firm (Barney, 1996; Penrose, 1959; Wernefelt, 1984) has put emphasis on the internal characteristics of the firm, and in particular on its competences as determinants of its performance -including its international performance- other authors have alluded to the importance of external factors (external to the firm) in sustaining and motivating the access to international markets. Among these factors, one should include the characteristics of the host or recipient economy (Sousa et al., 2008) but also the existence of a local, regional or supporting environment in the country or region in which the internationalized firm is located. This is much more in line with the literature on innovation systems which argues that firm´s economic and innovative performance is a direct function of the interactions that it establishes with other actors in its immediate environment (Cooke, 1996; Asheim and Gertler, 2005; Lundvall, 1992). Through interactive learning, the firms acquire the tangible and intangible competences needed for their innovation process.

So both external and internal factors or, in other words, the characteristics of the regional environment in which the firm is embedded as well as firm-specific characteristics are expected to have a significant effect on the capacity that the firm has to internationalize (Blanc and Sierra, 1999; Dunning, 2001), be it through a knowledge-exploitation strategy (global exploitation of innovation) or through a knowledge-exploration strategy (global sourcing, global collaboration or global generation).

2.2.1 Region

The role of the region facilitating innovation and internationalization has long been studied in Regional Innovation Systems (RIS) tradition. According to the RIS approach, regions are important in the acquisition and development of innovation capabilities (Asheim and Cooke 1999; Asheim and Vang, 2006; Asheim and Gertler, 2005).

As stressed by Asheim and Gertler (2005), for a proper understanding of the dynamic of innovation, it is necessary to look at the context where firms are located and in particular at the spatial proximity among firms and other organizations in a region. According to this view, regional proximity facilitates the access to unique knowledge and competences. Indeed, the local environment and the social context where firms are embedded create a favourable milieu for the transfer of tacit knowledge through direct face to face contacts, spontaneous mechanisms of learning, common cultural and traditional values, and interpretative schemes. Consequently, proximity sustains collective learning and the development of capabilities which remain difficult to imitate in other contexts because of their path-dependent, sticky and tacit nature (Asheim and Gertler, 2005; Bathelt et al., 2004; Maskell and Malberg, 1999).

On the one hand, the spatial proximity may favour a particular path of innovation through knowledge-sharing among actors, but on the other hand the competitiveness of a region is also determined by the actions of different actors and in particular the regional organizations, which may support and facilitate the local innovation processes and the absorptive capacities at collective level of the firms located in a region (Capello and Faggian, 2005). In this perspective regional organizations (e.g. local government agencies, intermediate organizations, universities, research centres, institutions) play an important role in developing a culture of innovation and consequently a culture of openness.

The creation of new knowledge and innovation is a combination of close and distant interactions (Bathelt et al., 2004; Coenen et al., 2004; Oinas, 1999; Owen-Smith and Powell, 2002; Owen-Smith and Powell, 2004; Scott 2002). From the point of view of some authors (Bathelt et al., 2004; Coenen et al., 2004), while local interaction springs from spontaneous mechanisms of knowledge-sharing, the creation of global pipelines and the internationalization of regions need to be planned and require the development of regional and local institutions and infrastructures collectively supporting the internationalization of firms.

The economic geography literature acknowledges in particular that regional factors contributing to innovation processes (such as regional labor markets; educational and R&D institutions, professional traditions, experiences, institutions, governance settings, culture) are sources of diversity between regions (Hotz-Hart, 2003). These differences change the ability of different regions (and not only of the single firms) to link to global knowledge flows (Ibidem)[3].

We therefore expect that

Hp 1. *The specific region in which the firm is embedded has an impact on the international linkages for the globalization of innovation*

2.2.2 Firm competences

Among the different theoretical approaches that have been used to explain the international behaviour of firms, the resource-based view of the firm links performance (domestic and international) to the resources and capabilities possessed by firms (Penrose, 1959; Teece, 1980; Wernefelt, 1984). It is argued that the strategy that the firm may pursue is contingent on the competences and the capabilities that the firms has or that it may acquire (March 1991; Penrose 1959; Wernefelt 1984).

These competences and capabilities are of most diverse nature, ranging from product development skills (Prasad et al., 2001), the qualification of the human resources or the previous international experience (Sousa et al., 2008), to the managers' or CEO profile (educational background, international experience or commitment) (Sousa et al., 2008). We focus on those that also affect the innovative performance of the firm, thus more related to the globalization of innovation: the qualification of the human resources, the firm´s level of technological competences and its organizational competences.

By qualified human capital we refer to skills, education, experience and training of individuals (Becker, 1998, p. 1). Qualified human capital is considered to be central for building the absorptive capacity of the firm (Cohen and Levinthal, 1990) and thus is a determinant of the ability of the firm to locate, acquire and use information and knowledge from other organizations, such as other firms, users or knowledge providers (i.e. research institutions) (Chaminade and Vang, 2008). Accordingly, we might expect that the qualification of human capital has a positive effect on the global sourcing of technology as well as on the global scientific collaboration. However, the links between qualification of human resources of the firm and the global exploitation of innovation are not so clear. Only the qualification of the managers of the firm seems to be a significant factor explaining the international performance of a firm in terms of its exports (Sousa et al., 2008).

We might then expect that:

Hp 2. *Firms with a high percentage of qualified human resources have a higher propensity to develop international linkages for the globalization of innovation, particularly for the global sourcing of technology and the global research collaboration.*

Other factors that influence the absorptive capacity of the firm may also be considered to be relevant for the adoption of at least two modes of globalization of innovation: the global sourcing

[3] The interplay between region and internationalization has been studied by international business scholars as well as by economic geographers, but from different perspectives. While the international business literature focuses on understanding why certain regions are more attractive for MNCs to locate production and innovation activities (Lewin et al., 2009), this branch of literature has not said much on the role of the region as a supporter of the accumulation of competences of firms that may internationalize. That is, while international business literature focuses mainly on the host region, the economic geography scholars focus for the most part on the home region.

of technology and the global research collaboration. R&D or, more explicitly, intramural investments in R&D are expected not only to serve the generation of innovation but also to facilitate the acquisition of knowledge from external sources (Cohen and Levinthal, 1989). The more the firm knows, the more it is able to learn and, therefore, the more that it will benefit from interaction with other sources of knowledge. R&D may therefore be considered directly related to the ability of the firm to benefit from global research collaboration and arguably, to a lesser extent, from global sourcing. We might expect that:

Hp 3. *Firms that invest in R&D have a higher propensity to engage in global research collaboration*

The degree to which firms may engage in research collaboration or international sourcing is also a function of the technological or cognitive distance between the partners engaged in the collaboration (Nooteboom, 2004; Gilsing et al., 2008). We might expect that firms in developing countries will benefit more from international research collaboration or sourcing when their technological distance to their partners is low. Furthermore, the level of technological competences is also related to the global exploitation of innovation (Prasad et al., 2001). That is, the higher the level of technological competences, the higher the propensity to engage in different forms of globalization of innovation. Moreover, we might expect that asset-seeking strategies (Global collaboration and global sourcing) are more demanding in terms of technological competencies than asset-exploiting strategies (global exploitation of innovation). Therefore, we expect that

Hp 4. *Firms with a high level of technological competences (machinery and equipment) have a higher propensity to develop international linkages for the globalization of innovation*

The development of new forms of organization and coordination to manage knowledge that is disperse is typical of asset-seeking strategies (Dunning and Lundan, 2009). We might therefore expect that higher organizational competences are related to strategies of global research collaboration and global sourcing.

Hp 5. *Firms with a high level of organizational competences have a higher propensity to develop at least strategies of global research collaboration and global sourcing*

These hypotheses are tested in section 6 using firm-based data collected in Pune and Beijing in 2008. The specific characteristics of these two regions are described in the next section.

3. Beijing and Pune

Beijing is considered to be the scientific and technological heart of China and thus the leading S&T region in terms of both its research infrastructure and its innovation performance (Guan et al. 2009)[4]. In total, 71 universities and 371 research institutes were located in Beijing at the end of 2003 (Beijing statistical Information Net, 2005 cf Chen and Kenney, 2007). These include some of Asia´s best known universities and research institutions like the Chinese Academy of Sciences (CAS), Peking University and Tsinghua Univesity. In 2005, CAS employed more than 37000 scientists and engineers, while in 2002 Peking University and Tsinghua University employed approximately 26000 scientists and technicians (Chen and Kenney, 2007). One of the most important IT science parks, the Zhingguancun Science Park (ZGC) is also located in Beijing, in the

[4] However, Beijing’s centrality as a knowledge center in China has been declining over time as other centers emerge as active players in the national innovation system, notably Shanghai and Guangdong (Hong, 2008)

Haidan district, and in close proximity to CAS, Peking University and Tsinghua University. Moreover, it is estimated that around 400 R&D centers from multinational corporations are located in Beijing and Shanghai, representing aprox. 50% of all R&D centers located in China in 2005-2006 (China Knowledge, 2009).

This large concentration of research institutes and universities in Beijing explains the high performance of the region in terms of innovation. With regards to the latter, almost 40% of S&T initiatives in mainland China are performed in Beijing (Research Group of Chinese S&T development strategy, 2002 cf Guan et al., 2009). In 2000, a quarter of the government S&T funds ended up in institutions located in Beijing and about 18% of all patents were also granted to Beijing (Chen and Kenney, 2007). Furthermore, it is considered as the most active municipality in terms of technology transfer from university to industry (Hong, 2008).

Industrially, Beijing has a specialization in high-tech industries. In recent years, approximately between one fourth and two thirds of the city’s total industrial added value has been attributable to high-tech business (Chen and Kenney, 2007; Guan et al., 2009).

Pune is increasingly attracting the attention of academics as a growing research and innovation center in India, gradually catching up with Bangalore[5]. Its proximity to Mumbai as well as the combined presence of foreign companies, research labs and good education and research institutions are considered to be attractive for multinational companies to establish their production and, more recently, R&D activities in Pune. In 2008, it was estimated that around 600 R&D centers of multinational corporations were established in India. Of those, approximately a hundred were set in Pune, and around 312 in Bangalore (Zinnov, 2009).

In 2007 the Pune region had 9500 manufactured units contrasted with 4529 in 1985, showing a continuous growth in particular in recent years. The majority of firms in the area are micro (4790), small and medium firms (4600), while large firms are few (1.15% of the total units) but account for 15% of the total employment (MCCIA, 2008). Pune is characterized by a strong presence of firms in the IT, auto-component, chemical and pharmaceutical industries. Biotechnology is also represented nowadays as an emerging sector in the local cluster (Basant and Chandra, 2007). The automotive industry, one of the oldest in Pune, had an expansion period between 1960 and 1990 and at the beginning of 2000. Between 2001 and 2005 more than 5000 SMEs manufacturing auto-related product were registered with the local District Industries Centre. The Pune region also has a long tradition in agro-processing and nowadays the food-processing industry is becoming a new important hub. Around 1700 firms and a total of 30000 employees belong to this last subsector (MCCIA, 2007). The IT industry and the biotech industry represent the two new drivers of the Pune Economy. For the IT industry in the area it is possible to count over 1000 IT and ITES companies and about 200 IT Parks (MCCIA, 2009).

The Pune area, like the Bangalore area, offers a large numbers of educational facilities such as important academic institutions and technology development centers (e.g. Tata Research Development Center) able to maintain a variety of linkages with the local industry (Basant and Chandra, 2007). The city of Pune counts 6 universities and 600 functional colleges and PG departments (MCCIA, 2008). The presence of a certain number of educational institutions in Pune allows good access to skilled labor, training and R&D facilities devoted to the needs of the local market. Technical and engineering education aimed at training, in particular, the employees in the ICT and auto-component industries in the area is ensured by the presence of engineering and professional colleges such as the Pimpri Chinchwad College of Engineering and the Modern

[5] Although still at a significant distance. Other important regions in India in terms of research and education are Delhi, Chennai, Hyderabad, Mumbai and Kolkota.

Education Society's college of Engineering. The colleges sustain the current growth of local expertise in the field of engineering services and design.

Other institutions are relevant for training and research in biotechnology and pharma, e.g. the Indian Drugs Research, the Agharkar Research Institute and the National Chemical Laboratory (NCL). The latest, funded in 1950 and part of the Council for Scientific and Industrial Research, is recognized as one of the most important research-oriented academic institutions in India in the field of chemical and biochemical sciences, and it is well known for its flourishing patent activity and the numerous contract researches, consultancies and training services offered not only to Indian firms but also to foreign MNCs companies (Basant and Chandra, 2007).

In sum, both Pune and Beijing can be considered as knowledge hubs in their respective countries, increasing significantly their international role both as recipients and transmitters of knowledge-intensive activities world-wide.

4. Data and variables

4.1. The sample

The empirical analysis is based on firm-level primary data collected through a survey in the Pune (India) and Beijing (China) regions in 2008. The survey targeted firms in three sectors in both regions: automotive component, green-biotech and software[6].

For the Pune area, we used a random sample out of different databases bought from Indian industry associations. The survey was conducted using face to face interviews, followed up by phone calls when necessary. For small and medium enterprises, in most cases the interviewee was the owner-manager, while in larger firms the interviewee was usually the R&D Head or his/her deputy. The response rate was around 40%.

In the Beijing area, we used a sample extracted from different databases from a market research company (Sinotrast) as well as from a software testing center (CSTC) for the software industry only. The survey was conducted mainly by phone with an average response rate of 20%. The firms from the CSTC database were contacted by email. The response rate in this last case was around 7%. Few interviews were conducted face to face. Like in Pune, the interviewee was mainly the owner for SMEs and the R&D managers for large firms.

In total, 1087 questionnaires were collected. After a first cleansing, the sample for the two specific regions was reduced to 884 firms[7]. 42% of the sample consisted of firms in the automotive components sector, 38% in the green-biotech sector and 20% in the software sector.

[6] According to Pavitt's view (Pavitt, 1984), the geography of knowledge flows is also influenced and characterized by different industrial patterns depending on the specific driver of technological change prevailing in a industry. For the project we decided to include a science-driven industry (green biotech); scale-intensive (automotive sector), and specialized supplier (software industry).

[7] We excluded, for example, the Chinese firms that were not located in the Beijing region.

Table 1 – Firms sample divided by region and industry

Sector	Region		
	Pune Region	Beijing Region	Total
Automotive component	273	98	371
Software	107	68	175
Green-biotech	218	120	338
Total	598	286	884

The survey asked firms about their innovation activities, internationalization strategies, competences and local-global linkages. For this specific paper, we only focus on the relationship between competences and the modes of globalization of innovation.

4.2. Firms' modes of globalization (the dependent variables)

To mark the distinction between different firms' modes of globalization of innovation in the two regions under analysis (Pune region and Beijing region), we have chosen to consider the nature of the international linkages in which the firms are involved in relation to their innovation activities. From the answers to the questionnaire we have selected three specific modes of globalization of innovation:

a) *Global exploitation of innovation* corresponding to the firm´s effective access to international markets with new products or services.

b) *Global sourcing of technology;* that is, the international acquisition of technologies and knowledge. This includes the international purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge; international acquisition of machinery and equipment; international training and international creative work performed by other companies and organizations and purchased by the enterprise.

c) Global research collaboration corresponding to international research activities conducted in collaboration with other international firms or with international universities and research centres.

In our econometric analysis we represent these three modes of globalization of innovation through three dependent variables[8] (see the description in tab. 2): The relative dummy variables (*GEXPLOIT*, *GSOURC*, *GRDCOLLAB*) equal 1 when the firm has conducted at least one of the activities belonging to that specific mode of globalization of innovation, and 0 otherwise.

Table 2 – The 3 dependent dummy variables

Dependent variables	Region			
	Dummy	Pune Region	Beijing Region	Total
Global exploitation of innovation	0	509	258	767
(GEXPLOIT)	1	89	28	117
	Tot	598	286	884
Global sourcing of technology	0	397	205	602
(GSOURC)	1	201	81	282
	Tot	598	286	884
Global research collaboration	0	368	241	609
(GRDCOLLAB)	1	83	23	106
	Missing value	147	22	169
Total		598	286	884

[8] The status of the enterprises and the activities undertaken refer to the year 2007.

4.3. Firms' competences (the independent variables)

For the purposes of this paper, we have selected a list of relevant variables measuring the competences of the companies:

Qualification of human resources

To capture the qualification of the human resources at the firm level we use as a proxy the percentage of employees with formal qualification equal to or higher than a university degree. In general firms in China and in India have a high percentage of employees with a university degree. Therefore, the dummy variables have been constructed with the aim of isolating the tails of the distribution, singling out the firms with employees without a university degree (*noEDU*) and those with more than 80% of employees with at least a university degree (*highEDU*)[9].

Quality of the technological resources

To proxy the quality of the technological resources of the firm, we asked the firms whether their machinery and equipment were more advanced than the average of the technological resources in the domestic industry. If so, we marked 1 in the relative dummy variable (high*MACHINEQUIP*).

Production organization techniques

To assess the firms´ organizational competence we asked them if they were using a series of complex organizational techniques. Because it is not possible to establish a hierarchy of production techniques, that is, it is not possible to say whether one organizational technique is more important than another, for the econometric analysis we have counted the number of complex organizational techniques currently used in the firm (quality control systems, just in time, continuous improvement, quality circles and team work, the use of internal manual)[10]. We have built 3 dummy variables based on this categorization; being 1 if the firm is included in that specific category and 0 otherwise. The firms in the sample usually use some system of production and only 20 firms in total do not use any.

Therefore, the categories that have been identified are:

LowSYSTEMPROD: if the firm uses from 0 to 2 systems of production
MediumSYSTEMPROD: if the firm uses between 3 and 4 systems of production
HighSYSTEMPROD: if the firm uses 5 or more systems of productions

Intramural R&D

In the questionnaire to the firms we used the definition of intramural R&D contained in the Oslo Manual. Intramural R&D is defined as "creative work undertaken within the enterprise to increase the stock of knowledge and its use to devise new and improved products and processes".
We constructed a dummy variable (*intraRD*) valuing 1 if the firm engaged in intramural R&D during 2007 and 0 otherwise.

Other technological competences

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[9] We have also tried to create two further subcategories: from 1% to 40% and from 40% to 80%. The division does not lead to any significantly different results in our analysis.
[10] This method has been applied by Padilla (2006)

Additionally to the previous variables, we consider the presence of an R&D department in the firm and the fact that the enterprise has registered patents during the year 2007. Again, the relative dummy variables (*RDdep and PATENT*) are equal to 1 if that is the case, and 0 otherwise.

Quality Management system standards

Quality certification of the firms in developing countries has often represented a standard of quality assurance and quality control, facilitating in most of the cases the establishment of partnership with global partners (Singh, 2009). Since almost all the firms in the sample have at least a quality certification (64,5%) and the different industries often use different quality certifications (making it impossible for us to assess a criteria to the quality) we have created a dummy variable (*highQCERT*) marking with a 0 firms which have less than two certifications[11], and 1 if they have two or more certifications.

4.4. The control variables

The data allow us to control for the region and the industry the companies belong to, but also for other variables related to the organizational form of the companies and their specific structural characteristics.

Region

To capture the role of different regional institutional conditions and regional capabilities supporting the access of the firm to international markets to exploit or source for innovation, we have created a dummy variable (*REGION*) equal to 1 if the firm belongs to Pune, and 0 to Beijing.

Sector

In our database we have analyzed firms belonging to three different sectors: automotive component, software and green biotech. These three industries have different characteristics in terms of the type of knowledge used for knowledge creation and innovation processes, modes of innovation and dynamics of global-local interactions (Asheim et al., 2007; Malerba 2002, 2005; Pavitt 1984).

To control for industry specificity we have created a set of dummy variables (*AUTO, SOFTWARE, BIOTECH*) equal to 1 if the firm belongs to the indicated sector, and 0 otherwise.

Organizational form

Another important characteristic to control for is the organizational form of the enterprise since different types of corporate strategies (depending also on the typology of the organizational form) can affect the attitude to establishing international linkages. In our analysis we distinguish between firms that are single plant units and firms that are headoffices or subsidiaries of an enterprise group. For our analysis we have created 3 dummy variables (*HEADOFFICE, SUBSIDIARY, SINGLE*) indicating with 1 when the firm is of that type, and 0 otherwise.

We have also accounted for the foreign and domestic ownership of the firm, assuming that firms owned or partially participated by foreign companies are more prone to have global linkages. We consider a firm as foreign-owned when it has a minimum of 30% of foreign capital. This

[11] In a previous analysis we divided these into 3 subcategories: 0 certification, 1 certification and 2 or more certifications. The division has no effect on the results.

benchmark has been previously used by Sabiola and Zafei[12] (2009). As a robustness check in a previous version of the model, we tested the regressions considering 50% as a threshold. The results are robust. The foreign-owned firms are indicated with a 1 in the dummy variable *FOREIGN*.

Firm's age

The year of the establishment of the enterprise can be considered a proxy for valuing its short or long experience in establishing links and relationship with other companies and therefore also with international partners. To control for the age of the firm we have created a continuous variable (*DATE*) indicating the specific year of foundation.

Size of the firm

We know from the literature (OECD, 2004) that SMEs tend to have lower capital, capabilities and visibility for establishing international linkages and for developing innovation. To control for size we have created three dummy variables (*SMALL, MEDIUM, LARGE*) based on the number of employees, less than 50, between 50 and 250, and more than 250, respectively. The variables are equal to 1 when the firm belongs to that specific size category, and 0 otherwise[13].

Firm's openness to foreign markets

We have also controlled for the openness of the firm to foreign markets since the degree of openness can facilitate or impede the establishment of exploration, exploitation and collaboration linkages with international partners. As a proxy (*EXPORT*) we use the firm's percentage of export sales.

5. The econometric analysis

Using the econometric analysis, we want to assess what type of international innovation linkages are predominant in firms belonging to the Pune and Beijing regions, and understand if different competences accumulated by the firms of the sample are associated with different propensities to develop these international linkages.

There are several options to analyze the relationship between different firms' modes of globalization of innovation, the region and competences of the firms. A first option is to consider three different equations estimated through three distinct logistic regression models and relative to each specific mode of globalization of innovation (global exploitation of innovation, global sourcing of technology and global research collaboration). These equations have the same regressor, but a different dependant variable related to each of the three modes. The three logistic regressions have been estimated and the results are presented in table 3. Model A estimates the regression for Global exploitation of innovation, Model B for Global sourcing of technology and model C for Global research collaboration.

In model 1 we include only the key variables related to the region and sectors. In model 2 we add the variables related to the competences and micro characteristics of the firms. In model 3 we

[12] Sabiola and Zanfei (2009) consider in addition whether the main stakeholder is a multinational firm. This information is not available for our database.
[13] In an initial version of the model, we tried to use the three variables separately and noticed that the only significant difference was between large and non-large companies. We thus use only the dummy large in our subsequent regressions.

interact REGION with two key dimensions: openness towards foreign markets (as proxied by EXPORT) and the organization form of the firm, represented by the variables FOREIGN and SUBSIDIARY.

Table 3 – Logistic regressions

Logit	Global exploitation of innovation GEXPLOIT			Global sourcing of technology GSOURC			Global research collaboration GRDCOLLAB		
	Model A1	**Model A2**	**Model A3**	**Model B1**	**Model B2**	**Model B3**	**Model C1**	**Model C2**	**Model C3**
REGION	0.649***	1.084**	2.175***	0.373**	-0.103	-0.232	1.017***	0.599	-0.218
	[0.241]	[0.432]	[0.543]	[0.172]	[0.316]	[0.369]	[0.263]	[0.535]	[0.735]
AUTO	-2.092***	-2.803***	-3.096***	-1.577***	-1.243***	-1.167***	-2.175***	-1.981***	-1.741***
	[0.279]	[0.508]	[0.521]	[0.171]	[0.346]	[0.353]	[0.305]	[0.589]	[0.602]
BIOTECH	-1.787***	-2.529***	-2.570***	-2.118***	-1.768***	-1.735***	-1.166***	-0.862	-0.816
	[0.349]	[0.471]	[0.468]	[0.253]	[0.332]	[0.333]	[0.399]	[0.540]	[0.547]
EXPORT		0.017***	0.029***		0.023***	0.020***		0.013**	0.011
		[0.005]	[0.007]		[0.004]	[0.006]		[0.005]	[0.008]
FOREIGN		-0.211	-0.195		0.308	-0.274		1.169***	1.573***
		[0.399]	[0.682]		[0.316]	[0.450]		[0.411]	[0.587]
HEADOFFICE		-0.453	-0.638		0.930**	0.898**		0.633	1.176
		[0.600]	[0.606]		[0.396]	[0.406]		[0.676]	[0.749]
SUBSIDIARY		-0.342	1.178**		0.34	0.521		0.911**	-0.271
		[0.332]	[0.555]		[0.253]	[0.395]		[0.368]	[0.654]
DATE		-0.022	-0.018		0.008	0.008		-0.029	-0.031*
		[0.017]	[0.017]		[0.012]	[0.012]		[0.018]	[0.019]
LARGE		0.234	0.252		1.082***	1.134***		1.008***	0.961***
		[0.341]	[0.348]		[0.283]	[0.285]		[0.365]	[0.370]
noEDU		-0.361	-0.274		0.097	0.123		0.37	0.139
		[0.551]	[0.556]		[0.335]	[0.334]		[0.598]	[0.616]
highEDU		-0.869**	-0.868**		-0.626**	-0.589**		-0.675	-0.668
		[0.351]	[0.358]		[0.280]	[0.283]		[0.434]	[0.442]
highMACHINEQUIP		0.907***	1.069***		0.932***	0.963***		0.486	0.485
		[0.304]	[0.315]		[0.239]	[0.240]		[0.346]	[0.355]
mediumSYSTEMPROD		0.853***	0.822**		-0.141	-0.134		0.439	0.482
		[0.324]	[0.328]		[0.249]	[0.252]		[0.397]	[0.414]
highSYSTEMPROD		1.629***	1.651***		0.714*	0.735**		1.604***	1.594**
		[0.532]	[0.553]		[0.377]	[0.375]		[0.616]	[0.621]
intraRD		1.382***	1.409***		-0.133	-0.135		0.34	0.361
		[0.353]	[0.357]		[0.247]	[0.249]		[0.377]	[0.382]
PATENT		0.268	0.355		0.02	-0.023		-0.388	-0.391
		[0.300]	[0.311]		[0.265]	[0.270]		[0.382]	[0.394]
RDdep		-0.854**	-0.866**		-0.174	-0.249		0.18	0.243
		[0.352]	[0.362]		[0.269]	[0.273]		[0.393]	[0.399]
highQCERT		0.789	0.975*		0.123	0.14		-0.495	-0.756
		[0.509]	[0.525]		[0.366]	[0.376]		[0.633]	[0.654]
EXPORT_REGION			-0.019**			0.003			0.007
			[0.009]			[0.008]			[0.011]
SUBSIDIARY_REGION			-2.029***			-0.394			2.134**
			[0.684]			[0.511]			[0.858]
FOREIGN_REGION			0.317			1.131*			-1.000
			[0.849]			[0.646]			[0.823]
Constant	-1.455***	41.857	31.609	-0.062	-15.977	-17.064	-1.687***	54.302	58.167
	[0.213]	[33.701]	[33.708]	[0.155]	[23.095]	[23.293]	[0.236]	[36.287]	[37.343]
N	884	699	699	884	699	699	715	571	571
Ll	-299.336	-197.436	-189.741	-484.85	-311.26	-309.034	-257.177	-148.056	-144.079

chi2	92.324	145.791	161.181	137.274	226.844	231.296	85.767	120.841	128.794
P	0	0	0	0	0	0	0	0	0
Pseudo-R2	0.1336	0.2697	0.2981	0.124	0.2671	0.2723	0.1429	0.2898	0.3089

*p<0.10, **p<0.05, ***p<0.01. Standard errors in parenthesis

The logit estimations in table 3, however, assume independence between the three equations, i.e. assume that the error of the estimate for each one of the three types of globalization of innovation is uncorrelated to the other types, a condition that may not be met. For this reason we have decided to couple the previous results with the use of a multinomial probit. In this case, we have pooled the three forms of globalization of innovation, creating a unique dependant variable using all the 7 possible combinations of the three global knowledge flows. The resulting dependent variable *GKNOWLEDGE* is described in table 4.

Table 4 – The dependent variable resulting from the combination of all the types of global flow of knowledge

GKNOWLEDGE	Region		
Dummy	Pune Region	Beijing Region	Total
0 no global activities[a]	232	170	402
1 only global exploitation	25	14	39
2 only global sourcing	78	47	125
3 only global collaboration	7	4	11
4 only global sourcing and exploitation	33	10	43
5 only global collaboration and sourcing	50	16	66
6 only global collaboration and exploitation	2	1	3
7 all the three types of activities	24	2	26
Total	451	264	715

[a] In “no global activities” we are considering both the firms that do not have any international activity as well as those that indicate that their sourcing or collaboration was mainly domestic or local.

As seen in table 4, the number of observations in some sets is inappropriate to obtain reliable estimates. On the one hand, firms active only in global research collaboration (subcategory 3) and firms active in both research collaboration and exploitation (subcategory 6) are seriously underrepresented. Only 11 firms fell into the former categories and only 3 in the latter. On the other hand, firms that are active contemporarily in all the three types of international linkages and placed in Beijing are underrepresented (only 2 firms). Thus, we have decided not to use such a dependent variable for running the mprobit, but to try to aggregate some of the underrepresented categories into wider sets. To do so, we first create one category grouping all combinations where global research collaboration was undertaken (subcategories 5, 6 and 7). The reason for that is twofold. Grouping these 3 sets would allow the construction of a subcategory in which research collaboration is central, even if in some cases this activity is coupled by global sourcing and global exploitation. In the remaining sets, the number of observations is enough to guarantee that we can keep separate firms without global linkages, firms with at least global exploitation linkages and firms with at least global sourcing linkages.

The 43 firms active in both sourcing and exploitation activities (subcategory 4) can be regrouped into either at least sourcing or at least exploiting. In order to avoid arbitrary grouping, we have decided to construct two different dependent variables (*GLOBALKNW_source* and *GLOBALKNW_exploit)* according to the two possible groupings, and then run two different multinomial probit regressions (mprobit I and mprobit II, respectively), for the two corresponding dependant variables. In mprobit I the 43 observations are included in the sourcing subcategory, while in mprobit II we allocate the 43 observations into the exploitation subcategory (see Table 5).

Table 6 presents the results of the two models mprobit I (for *GLOBALKNW_source*) and mprobit II (for *GLOBALKNW_exploit*), while section 6 expands and discusses them[14].

Table 5 – The dependent variables used for estimating the results in the two mprobit models

Dependent variables		**Region**		
	Dummy	Pune Region	Beijing Region	Tot
GLOBALKNW_source *(mprobit I)*	0 no global activities	232	170	402
	1 at least global exploitation	25	14	39
	2 at least global sourcing	111	57	168
	3 at least global collaboration	83	23	106
	Tot	451	264	715
GLOBALKNW_exploit *(mprobit II)*	0 no global activities	232	170	402
	1 at least global sourcing	78	47	125
	2 at least global exploitation	58	24	82
	3 at least global collaboration	83	23	106
	Tot	451	264	715

[14] For the three logit and the two mprobit models we have decided to always use the largest possible sample, in order to rely on the maximum amount of information. This means that our sample is different in some of the regressions. The smallest sample spans 571 observations, and the largest 884. To check the robustness of our results we also run the same econometric analysis using the smallest sample for all the regressions of all the models. The results are consistent.

Table 6 – Mprobit I and Mprobit II

	GLOBALKNW_source (Mprobit I)			GLOBALKNW_exploit (Mprobit II)		
Global exploitation of innovation	**Model D1**	**Model D2**	**Model D3**	**Model E1**	**Model E2**	**Model E3**
REGION	0.400*	0.569	1.242**	0.548***	0.900**	1.668***
	[0.225]	[0.402]	[0.482]	[0.191]	[0.354]	[0.434]
AUTO	-1.234***	-2.183***	-2.263***	-1.548***	-2.031***	-2.218***
	[0.234]	[0.460]	[0.463]	[0.199]	[0.390]	[0.402]
BIOTECH	-0.700**	-1.404***	-1.300***	-0.972***	-1.541***	-1.543***
	[0.311]	[0.428]	[0.437]	[0.273]	[0.383]	[0.394]
EXPORT		0.019***	0.034***		0.025***	0.036***
		[0.005]	[0.008]		[0.004]	[0.007]
HEADOFFICE		-0.237	-0.311		-0.131	-0.248
		[0.624]	[0.622]		[0.512]	[0.510]
SUBSIDIARY		-0.065	0.58		-0.093	0.870**
		[0.317]	[0.523]		[0.273]	[0.436]
FOREIGN		-0.093	-0.705		0.043	-0.065
		[0.434]	[0.743]		[0.359]	[0.532]
DATE		-0.025*	-0.021		-0.012	-0.008
		[0.015]	[0.015]		[0.013]	[0.013]
LARGE		-0.066	-0.104		0.356	0.359
		[0.390]	[0.406]		[0.309]	[0.317]
noEDU		-0.507	-0.48		-0.054	0.015
		[0.564]	[0.571]		[0.417]	[0.420]
highEDU		-0.974***	-1.022***		-0.784**	-0.820***
		[0.368]	[0.379]		[0.308]	[0.315]
highMACHINEQUIP		0.680**	0.800***		0.957***	1.099***
		[0.297]	[0.308]		[0.254]	[0.265]
mediumSYSTEMPROD		0.956***	0.940***		0.748***	0.749***
		[0.328]	[0.333]		[0.283]	[0.288]
highSYSTEMPROD		1.279**	1.256**		1.426***	1.476***
		[0.523]	[0.547]		[0.442]	[0.463]
intraRD		0.33	0.278		0.791***	0.793***
		[0.318]	[0.325]		[0.282]	[0.287]
PATENT		-0.019	0.132		0.022	0.143
		[0.322]	[0.333]		[0.274]	[0.282]
RDdep		-0.386	-0.388		-0.564*	-0.610**
		[0.331]	[0.340]		[0.289]	[0.297]
highQCERT		0.664	0.74		0.24	0.423
		[0.454]	[0.466]		[0.406]	[0.418]
EXPORT_REGION			-0.031***			-0.020**
			[0.011]			[0.009]
FOREIGN _REGION			1.534			0.785
			[0.956]			[0.740]
SUBSIDIARY _REGION			-0.966			-1.436**
			[0.660]			[0.559]
Constant	-1.254***	48.444	39.571	-0.784***	22.867	13.086
	[0.205]	[29.896]	[30.427]	[0.174]	[26.271]	[26.732]
Global sourcing of technology	**Model D1**	**Model D2**	**Model D3**	**Model E1**	**Model E2**	**Model E3**
REGION	0.346**	0.191	0.284	0.226	-0.106	-0.134
	[0.159]	[0.284]	[0.322]	[0.166]	[0.295]	[0.338]
AUTO	-1.095***	-0.882***	-0.910***	-0.843***	-0.741**	-0.698**
	[0.160]	[0.307]	[0.314]	[0.167]	[0.318]	[0.329]
BIOTECH	-1.197***	-1.238***	-1.257***	-1.088***	-1.061***	-1.056***

	[0.249]	[0.320]	[0.326]	[0.265]	[0.329]	[0.337]
EXPORT		0.023***	0.026***		0.020***	0.023***
		[0.004]	[0.006]		[0.004]	[0.006]
HEADOFFICE		0.780**	0.711*		0.866**	0.857**
		[0.360]	[0.366]		[0.366]	[0.374]
SUBSIDIARY		0.206	0.576		0.318	0.494
		[0.225]	[0.352]		[0.232]	[0.364]
FOREIGN		-0.037	-0.663		-0.078	-0.889*
		[0.309]	[0.442]		[0.321]	[0.481]
DATE		0.011	0.012		0.007	0.008
		[0.011]	[0.011]		[0.011]	[0.011]
LARGE		0.530**	0.548**		0.379	0.385
		[0.261]	[0.263]		[0.273]	[0.275]
noEDU		0.053	0.102		-0.007	0.02
		[0.285]	[0.285]		[0.288]	[0.289]
highEDU		-0.424*	-0.417		-0.422	-0.372
		[0.260]	[0.263]		[0.272]	[0.276]
highMACHINEQUIP		0.902***	0.950***		0.794***	0.855***
		[0.212]	[0.215]		[0.220]	[0.224]
mediumSYSTEMPROD		0.151	0.171		0.153	0.177
		[0.225]	[0.227]		[0.234]	[0.236]
highSYSTEMPROD		0.595*	0.634*		0.425	0.504
		[0.341]	[0.345]		[0.351]	[0.356]
intraRD		0.139	0.122		-0.142	-0.172
		[0.216]	[0.218]		[0.223]	[0.224]
PATENT		-0.071	-0.081		-0.112	-0.144
		[0.243]	[0.248]		[0.254]	[0.260]
RDdep		-0.26	-0.312		-0.184	-0.257
		[0.236]	[0.238]		[0.242]	[0.246]
highQCERT		-0.06	-0.001		0.071	0.081
		[0.316]	[0.324]		[0.322]	[0.330]
EXPORT_REGION			-0.008			-0.008
			[0.008]			[0.008]
FOREIGN _REGION			1.329**			1.675**
			[0.651]			[0.692]
SUBSIDIARY _REGION			-0.652			-0.334
			[0.456]			[0.473]
Constant	-0.267*	-22.574	-25.81	-0.508***	-15.637	-17.573
	[0.147]	[21.365]	[21.599]	[0.154]	[21.724]	[22.050]
Global research collaboration	**Model D1**	**Model D2**	**Model D3**	**Model E1**	**Model E2**	**Model E3**
REGION	0.755***	0.602	0.117	0.753***	0.643*	0.244
	[0.187]	[0.384]	[0.495]	[0.186]	[0.386]	[0.495]
AUTO	-1.882***	-1.947***	-1.868***	-1.878***	-2.003***	-1.934***
	[0.199]	[0.438]	[0.451]	[0.198]	[0.439]	[0.452]
BIOTECH	-1.277***	-1.181***	-1.158***	-1.278***	-1.217***	-1.193***
	[0.278]	[0.387]	[0.394]	[0.278]	[0.387]	[0.394]
EXPORT		0.023***	0.025***		0.023***	0.026***
		[0.004]	[0.007]		[0.004]	[0.007]
HEADOFFICE		0.694	1.020*		0.632	0.917*
		[0.520]	[0.554]		[0.520]	[0.551]
SUBSIDIARY		0.682**	0.044		0.655**	0.078
		[0.283]	[0.471]		[0.283]	[0.470]
FOREIGN		0.876***	0.817*		0.894***	0.866*
		[0.335]	[0.454]		[0.335]	[0.453]
DATE		-0.017	-0.018		-0.017	-0.019
		[0.013]	[0.013]		[0.013]	[0.013]

LARGE		0.929***	0.900***		0.932***	0.900***
		[0.300]	[0.304]		[0.300]	[0.303]
noEDU		0.408	0.274		0.421	0.299
		[0.431]	[0.445]		[0.430]	[0.443]
highEDU		-0.731**	-0.756**		-0.745**	-0.775**
		[0.328]	[0.334]		[0.327]	[0.332]
highMACHINEQUIP		0.836***	0.845***		0.859***	0.870***
		[0.267]	[0.273]		[0.267]	[0.273]
mediumSYSTEMPROD		0.581*	0.654**		0.637**	0.697**
		[0.311]	[0.323]		[0.313]	[0.324]
highSYSTEMPROD		1.472***	1.495***		1.526***	1.546***
		[0.465]	[0.472]		[0.467]	[0.475]
intraRD		0.364	0.386		0.426	0.45
		[0.292]	[0.298]		[0.294]	[0.299]
PATENT		-0.288	-0.276		-0.299	-0.267
		[0.307]	[0.313]		[0.306]	[0.311]
RDdep		-0.105	-0.1		-0.124	-0.116
		[0.304]	[0.308]		[0.304]	[0.308]
highQCERT		-0.469	-0.612		-0.453	-0.567
		[0.459]	[0.478]		[0.461]	[0.479]
EXPORT_REGION			-0.002			-0.004
			[0.009]			[0.009]
FOREIGN _REGION			0.152			0.170
			[0.687]			[0.683]
SUBSIDIARY _REGION			1.123*			0.997*
			[0.622]			[0.618]
Constant	-0.662***	31.054	34.144	-0.660***	31.989	35.504
	[0.170]	[26.366]	[26.979]	[0.169]	[26.263]	[26.825]
N	715	571	571	715	571	571
ll	-717.575	-469.822	-457.847	-750.553	-492.452	-478.237
chi2	132.61	200.279	210.502	142.402	203.152	217.848
p	0	0	0	0	0	0

*p<0.10, **p<0.05, ***p<0.01. Standard errors in parenthesis.

6. Empirical findings

6.1. Regional specialization in globalization of innovation

To assess what type of international innovation linkages are predominant in firms belonging to the Pune and Beijing regions we first analyze the characteristics of our sample. The descriptive statistics in tab. 7 clearly show that in the Pune region the percentage of firms involved in different forms of globalizing of innovation is in general higher. The difference is particularly evident for the *global exploitation of innovation* and *for the global research collaboration.* Even if the companies in the Pune region have a slightly higher percentage of activities devoted to global sourcing of technology, global sourcing remains a common strategy for both Indian and Chinese companies to pursue (The percentage converges towards 30%).

Table 7 - Percentage of firms belonging to the two different regions having international linkages related to exploitation of knowledge, exploration of knowledge and R&D collaboration

Type of international linkages	Pune Region (% on total answers)	Beijing Region (% on total answers)
Global exploitation of innovation	14.88%	9.79%
Global sourcing of technology	33.61%	28.32%
Global research collaboration	18.40%	8.71%

In order to understand why these two regions behave in a different way, we conduct the multivariate analysis described in section 5, using both logit and mprobit models.

In models A1, B1 and C1 of the logit regressions (tab. 3) the corresponding three types of knowledge flows (*GEXPLOIT*, *GSOURC*, and *GRDCOLLAB*) are related only to region and sectors. In this case, we observe a differential in the two regions and in the three sectors. In all the models the positive and significant coefficient of the variable *REGION* implies that firms in the Pune region use the three types of knowledge flows more intensively than those located in the region around Beijing. The same can be said for the firms belonging to the software industry with respect to the firms in the automotive and the biotech industries (both coefficients are negative and significant, showing that moving from the software sector, the baseline dummy, determines a negative effect). The results are also confirmed in the two mprobit models in tab 6 (model D1 and model E1), even if in this case we observe no significance for *region* in global sourcing of technology in model E1. This confirms the results shown in the statistical description of the sample, and underlines how industries with different knowledge bases and embedded in different regional contexts are differently associated to different degrees of globalization of knowledge (Asheim and Gentler, 2005; Moodysson, 2008; Moodysson et al., 2008). The sectoral specificity and the regional location impact therefore on the firms' number and type of international linkages.

This already allows us to derive a first hint on the possible confirmation of Hp 1. We see in fact that regions do have an impact on the propensity to establish international linkages of various nature. However, we need a different analysis to identify what may explain these observed differences. To do so, we introduce into the models the firms' characteristics and competencies. We do this in the next paragraphs and test Hp 1 in section 6.3.

6.2. Micro-level factors: how firms' competences impact on globalization of innovation

Regional differences may also reflect micro-level factors. If that is the case, aggregate observations at the level of the region or of the sector can also be decomposed into firm-level mechanisms. This means that the different modes firms use for the globalization of innovation can also be related to the micro characteristics of the firms. When we include, in the logistic regressions, the variables related to firms competencies plus other control variables related to the structural and organizational characteristics of the firms (models 2A, 2B and 2C), the variable region remains relevant only for the exploitation of innovation, and loses its significance for global sourcing of technology and global research collaboration. The results are by and large confirmed in mprobit II (model E2).

This amounts to saying that if we take into account the micro characteristics of the firms, the explanatory power of the variable REGION diminishes sensibly, which means that its effect is captured by the newly introduced variables. In other words, the specific characteristics of the firms located in the two regions explain mainly the observed differences between the two regions with regard to the modes of globalization of innovation[15].

Next, to understand which specific competences may be related to the propensity to globalize innovation in general, or to particular modes of innovation, we use our models´ results to test the other hypotheses introduced in section 2.

6.2.1. *The role of qualified human resources*

Hp 2. *Firms with a high percentage of qualified human resources have a higher propensity to develop international linkages for the globalization of innovation, particularly for the global sourcing of technology and the global research collaboration.*

The test leads to an opposite result for hypothesis 2.

Our results show that a high percentage of qualified human resources employed in the firm is not related to the development of globalization of innovation activities. On the contrary, we notice that a high degree of qualified human resources (the variable high*EDU*) is, in most cases, negatively correlated to the three modes of globalization of innovation, in particular to the global exploitation of innovation where there is a negative correlation in both the logit models (model A2) and in the multinomial probit regressions (models D2 and E2).

One can argue (e.g. Nooteboom 1992; 1999; 2007) that firms in developing countries operating in high tech sectors with elevated human capital, producing technology and innovation, could potentially compete with other MNCs leaders (also with those in developed countries). These firms, owning already advanced knowledge and having a short cognitive distance to their competitors, cannot have an interest in cooperating with the other (possibly foreign) leaders, since it is not convenient to share their core competences with them. Another possible explanation is that a high degree of human capital (more than 80%) itself represents a good condition for the enterprise to play a leading role in the region and maintain a competitive advantage in the local market. Moreover, a possible competitive position in the region may facilitate access to the regional pool of knowledge, diminishing at the same time the need for the development of international seeking strategies. In any case, none of the explanations seem to be fully satisfactory and these results need to be further investigated.

6.2.2. *The role of the R&D investments*

Hp 3. *Firms that invest in R&D have a higher propensity to engage in global research collaboration*

The test does not confirm hypothesis 3

[15] The main purpose of this paper is to investigate how firms' competences in the two regions interact with firms' propensity to engage in globalization of innovation. Structural and organizational characteristics of the firms are thus left at the margin of the discussion. Nevertheless, in the econometric analysis we also observe that:

- Firms with a higher degree of openness to the market are also those that are in general more specialized in globalization of innovation (the proxy *EXPORT* is always positive and significant in all the models).
- Firms with a foreign ownership or that are subsidiaries of other companies have more international R&D collaborations, while those firms that are headoffices of an enterprise group do more global sourcing of knowledge.
- Large firms are more likely to do global sourcing of technology and participate actively in international research collaboration with respect to SMEs.

In our econometric analysis we can see clearly that there is no significant relationship between investment in R&D and *global research collaboration,* considering both intramural R&D (*intraRD*) and the presence of an R&D department (*RDdep*) (model C2 of the logit regressions and models D2 and E2 of the two mprobit models related to the third mode of globalization of innovation).

However, firms undertaking intramural R&D activities seem to have a higher propensity to sell their innovative products and services in the global market. *Global exploitation of innovation* is significantly and positively correlated with intramural R&D activities (*intraRD*) in the logit model A2. Nevertheless, when considering the formal presence of an R&D department the relationship is still significant but becomes negative[16]. Model E2 in the mprobit also confirms these ambiguous results.

6.2.3. *The role of the technological and organizational competences*

Hp 4. *Firms with a high level of technological competences have a higher propensity to develop international linkages for the globalization of innovation*

The test confirms hypothesis 4.

Firms having a more advanced set of technological resources (captured by high*MACHINEQUIP*) are the ones that show a significant relation with global exploitation of innovation and global sourcing of technology. This result is confirmed in all the models. In the mprobit models a positive significant relation of these advanced technological resources with the global R&D collaboration is also present. The results show therefore that a higher level of technological competences results in a higher propensity to engage in different forms of globalization of innovation, and in particular in the global exploitation of innovation and global sourcing of technology.

Hp 5. *Firms with a high level of organizational competences have a higher propensity to develop at least strategies of global research collaboration and global sourcing*

The test confirms hypothesis 5.

We can observe some similar patterns between exploitation, sourcing and research collaboration with respect to the presence of complex organizational techniques in-house. The use of a large number of different systems of productions (more than 4, as captured by the variable *highSYSTEMPROD*) characterizes firms that participate actively not only in asset-seeking strategies (global research collaboration and global sourcing) but also in the exploitation of innovation. The significance of the correlation is confirmed in both the logit and the mprobit models, even if there is a loss of significance in model E2 relative to global sourcing of knowledge[17].

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[16] It seems therefore that firms with a R&D department in-house are less interested in exploiting innovation at global level. This is probably due to the fact that investing in R&D has a positive impact on the connection to the exploitation of global flows of knowledge, but when this is done in a more formal and structured way through a dedicated unit, it may push the firm to focus on its domestic market rather than scanning foreign markets.

[17] The effects for the confirmed hypotheses are substantial. For example, we have calculated the odds ratios for the logit models. For global exploitation of innovation the odds ratio of *highMACHINEQUIP* is 2.476 while for global sourcing of technology it is 2.540. The odds ratio for *highSYSTEMPROD* is 5.100 for global exploitation, 2.042 for global sourcing and 4.973 for research collaboration.

6.3. The implication of the firms micro-characteristics on the role of the region

Having discussed the role of firms' micro characteristics such as competences, we are now ready to return to Hp 1 and assess the role of regions in the creation of global linkages.

The analysis developed in subsection 6.2 shows that when micro-level factors are taken into account, the regional location per se does not explain the variance in the sample[18]. This statement does not mean that regional differences lose their relevance completely; it just means that the differences between Pune and Beijing are reflected for the major part in the different nature of the firms these Regional Innovation Systems host. To make the connection between the regional system and the firm-specific variables discussed above, we introduce interactions between *REGION* and some of the variables that better capture the essence of the firms' actions on the global markets: firm's openness to foreign markets (*EXPORT*) and their organizational form (i.e. *SUBSIDIARY* and *FOREIGN*) (see models A3, B3, C3, D3 and E3**)**.

With the introduction of the interaction we can observe the complementarities between the role of the region and firm-specific characteristics.

For example the positive effect that a high percentage of exports has in global exploitation activities diminishes if the firm is located in the Pune region. The same effect can be observed if the firm is a subsidiary of an enterprise group. In model A3, i.e., the logit related to the global exploitation of innovation, *EXPORT* and the *SUBSIDIARY* have positive direct effects, but negative interaction effects with the regional variable (*EXPORT_REGION*; *SUBSIDIARY_REGION*). The effect for both variables is confirmed in the mprobit II (model E3) and for *EXPORT_REGION* also in the mprobit I (model D3).

Another example is that being a subsidiary is not enough to foster research collaboration unless the firm is also located in the Pune region. In all the models related to global research collaboration (model C3, D3 and E3), *SUBSIDIARY* loses significance as a direct regressor but acquires a significant and positive effect when interacted with the regional dummy.

Finally, the positive effect of being a foreign-owned firm for global sourcing of technology is valid only for firms located in Pune. The interaction between *REGION* and *FOREIGN* is significant and positive both in the logit and in the two mprobit models (model B3, D3 and E3).

A first conclusion coming from the whole analysis is that the Pune region seems specialized in the three types of knowledge flows more than the region around Beijing. This is true in general, without taking into account the micro-level characteristics of the firms (competences and some structural characteristics). When included, these characteristics capture almost all the differences between the firms belonging to the two regions in their way of using the international linkages for the globalization of innovation. The only exception to this is that firms in the Pune region seem more specialized than the firms in Beijing in the exploitation of innovation[19].

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[18] This result echoes that found also by Padilla (2006). In this picture, global exploitation of knowledge represents a peculiar case, because in the relative equations the variable *REGION* most of the times remains significant.

[19] Guan et al. (2009) study the innovation strategies of firms in Beijing and confirm that firms in this region tend to confine their innovation activities more to the domestic sphere.

Our analysis also shows that the regional differences between Pune and Beijing are indeed mainly related to the differences in the software sector, in particular in the exploitation of innovation. Consistently with our conclusion, a recent article of Niosi and Tschang (2009) on Chinese and Indian firms in the software sector shows that while Chinese firms in the software industry tend to focus mainly on their domestic market, Indian firms are more devoted to expanding their market overseas.

With the introduction in the regressions of some interactions between the regions and some firm's characteristics (openness to foreign markets and firms´ organizational form), we notice that firms´ characteristics have a different impact in the two regions, meaning that regional differences continue to have a role, even in conjunction with specific firms' characteristics. Thus the analysis confirms hypothesis 1:

Hp1. The specific region in which the firm is embedded has an impact on the international linkages for the globalization of innovation

Table 8 summarizes the main results of the econometric analysis.

Table 8 – The relation between micro and meso factors and the three modes of globalization of innovation

	Global exploitation of innovation	**Global sourcing of technology**	**Global research collaboration**
Related economic activity/proxy	Exports of new products or new services	Acquisition of machinery and equipment Purchase or licensing of patents and non-patented inventions and know-how Training and creative work purchased by the enterprise	Research collaboration (including contractual R&D, R&D alliances, joint R&D projects)
International strategy	Asset exploiting	Asset or knowledge seeking	Asset or knowledge seeking
Main results from our survey	14.88 % firms in Pune 9.79 % firms in Beijing	33.61 % firms in Pune 28.32 % firms in Beijing	18.40% firms in Pune 8.71 % firms in Beijing
	Region (+) Sector: Software (+) High qualified human capital (-) Organizational competences (+) Technological competences (+) Intra mural R&D investment (+) Formal R&D department (-)	Sector : Software (+) Headoffice (+) Large firm (+) Organizational competences (+) Technological competences (+)	Sector: Software (+) Foreign ownership (+) Subsidiary (+) Large firm (+) Organizational competences (+)

7. Conclusion

If in the past most of the literature has studied the phenomenon of globalization of innovation from the point of view of developed countries, recent trends have shown how this phenomenon also involves emerging regions in developing countries. For our study we have investigated two regions: the Pune region in India and Beijing region in China that nowadays have started to show good performance in terms of innovation and internationalization. Through primary data collected during 2008 and adapting the taxonomy of Archibugi and Michie (1995) to the context of developing countries, we have investigated the role of the regions as well as of firms' competences in three different modes of globalization of innovation: global sourcing of technology, global collaboration in research projects and global exploitation of innovation activities.

From our analysis we have found that the *global sourcing of technology*, i.e., acquisition of technology and knowledge, is the most common strategy pursued by the firms in the sample. This clearly shows the dependence of firms in developing countries on foreign sources of technologies. Nevertheless, other activities of asset-seeking through research initiatives based on international collaborations (*global research collaboration*), and asset-exploiting corresponding to firms´ effective access to the international market with new products or services (*global exploitation of innovation*) are now activities that are being undertaken by a certain number of firms in these two new emerging regions; activities that are usually pursued mainly by firms in developed countries. Furthermore, the number of firms that report two or more modes of globalization of innovation may suggest that these three modes are largely complementary.

The international business literature and the innovation system literature have shown two different approaches to studying the propensity of firms to link to global knowledge flows. The former has mainly paid attention to the micro characteristics of firms leading to the exploitation of international linkages. The latter has paid more attention to the systemic characteristics of the phenomenon in order to explore its inclusive effect on the process of innovation and globalization. In our paper we have demonstrated that the two perspectives are complementary. The strategies of asset-exploitation and asset-seeking for the globalization of innovation are related not only to the internal characteristics of the firms, but to the regional and sectoral characteristics at meso level. These contribute to supporting the collective accumulation of competences needed to exchange knowledge with the rest of the world. Even more importantly, it is the interplay between regional factors and firm-level characteristics that turn out to be significant in explaining local firms' propensity to get involved in the different modes of globalization of innovation.

When comparing the two regions our main finding shows that the Pune region is specialized in the three types of knowledge flows, and in particular in the exploitation of innovation, more than the region around Beijing. Nevertheless, a deeper analysis of the micro characteristics of the firms shows that the three modes of globalization of innovation are also associated to different structural and competence characteristics. Firms with some specific technological and organizational competences show a higher propensity to develop international linkages, while firms with a high level of educated human resources seem to focus more on the domestic market. Moreover, in the three modes of globalisation of innovation we can notice some differences. The global exploitation of innovation is more dependent, for example, on regional factors and on technological competences.

Differences are also present in terms of structural characteristics of the firms. The size of the firm seems to matter only for asset-seeking strategies (global sourcing and global research collaboration), while foreign ownership of the firm remains significant only for pursuing global research collaborations.

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Appendix A

Definition of variables and descriptive statistics

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
GLOBALKNW_source	Dependent variable for the mprobit regression (mprobit I)	715	0.9692308	1.179495	0	3
GLOBALKNW_exploit	Dependent variable for the mprobit regression (mprobit II)	715	0.848951	1.117524	0	3
GEXPLOIT	Dependent variable for the logit regression	884	0.1323529	0.3390659	0	1
GSOURC	Dependent variable for the logit regression	884	0.3190045	0.4663547	0	1
GRDCOLLAB	Dependent variable for the logit regression	715	0.1482517	0.3555981	0	1
REGION	Dummy variable equal to 1 if the firm belongs to Pune, and 0 to Beijing	884	0.6764706	0.4680876	0	1
AUTO	Dummy variables equal to 1 if the firm belongs to the indicated sector	884	0.4196833	0.4937864	0	1
BIOTECH	Dummy variables equal to 1 if the firm belongs to the indicated sector	884	0.1979638	0.3986903	0	1
SOFTWARE	Dummy variables equal to 1 if the firm belongs to the indicated sector	884	0.3823529	0.4862372	0	1
EXPORT	Variable indicating the % of exportation outside the domestic market	884	18.71946	32.34494	0	100
HEADOFFICE	Dummy variable that takes value 1 when the firm is an headoffice of an enterprise group	881	0.0851305	0.2792344	0	1
SUBSIDIARY	Dummy variable that takes value 1 when the firm is a subsidiary of an enterprise group	881	0.3246311	0.4685028	0	1
SINGLE	Dummy variable that takes value 1 when the firm is a single unit	881	0.5902384	0.492069	0	1
FOREIGN	Dummy variables that take value 1 with a minimum of capital owned by foreign investors of 30%	869	0.1703107	0.376122	0	1
DATE	Variable indicating the specific year of the enterprise establishment	850	1996.535	9.930112	1926	2008
LARGE	Dummy variables equal to 1 if the firm has more than 250 employees	880	0.1420455	0.3492953	0	1
SMALL	Dummy variables equal to 1 if the firm has less than 50 employees	880	0.5011364	0.500283	0	1
MEDIUM	Dummy variables equal to 1 if the firm has between 50 and 250 employees	880	0.3568182	0.4793329	0	1
noEDU	Dummy variable equal to 1 if the employees with at least a university degree are 0%	834	0.1594724	0.3663358	0	1
EDU	Dummy variable equal to 1 if the employees of the firm with at least a university degree are between 1 and 80%	834	0.5431655	0.4984322	0	1
highEDU	Dummy variable equal to 1 if the employees of the firm with at least a university degree are more than 80%	834	0.2973621	0.4573715	0	1
highMACHINEQUIP	Dummy variable equal to 1 when the set of the machinery and equipment of the firm is more advanced than the average of the technological resources in the domestic industry	813	0.2595326	0.438648	0	1
lowSYSTEMPROD	Dummy variable equal to 1 if the firm uses between 0 and 2 systems of productions	884	0.4671946	0.4992051	0	1
mediumSYSTEMPROD	Dummy variable equal to 1 if the firm uses between 3 and 4 systems of productions	884	0.3868778	0.487311	0	1
highSYSTEMPROD	Dummy variable equal to 1 if the firm uses 5 or more systems of productions	884	0.1459276	0.3532335	0	1
intraRD	Dummy variable equal to 1 if the firm engaged in intramural R&D during the year 2007	884	0.4920814	0.5002203	0	1
PATENT	Dummy variable equal to 1 if the firm registered patents during the year 2007	884	0.1628959	0.3694797	0	1
RDdep	Dummy variable equal to 1 if the firm has an R&D department	841	0.5350773	0.4990649	0	1
highQCERT	Dummy variable equal to 1 if the firm has two or more types of quality certifications	884	0.1052036	0.3069893	0	1

Appendix B

Correlations between main variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) GLOBALKNW_source	-													
(2) GLOBALKNW_exploit	0.9198*	-												
(3) GEXPLOIT	0.3421*	0.5422*	-											
(4) GSOURC	0.8880*	0.6932*	0.2627*	-										
(5) GRDCOLLAB	0.7188*	0.8036*	0.1363*	0.4374*	-									
(6) REGION	0.1448*	0.1560*	0.0703*	0.0531	0.1316*	-								
(7) AUTO	-0.3080*	-0.3401*	-0.2172*	-0.2083*	-0.2517*	0.1079*	-							
(8) BIOTECH	-0.1345*	-0.1136*	-0.1103*	-0.2060*	-0.0747*	-0.0691*	-0.4225*	-						
(9) SOFTWARE	0.4012*	0.4189*	0.3109*	0.3804*	0.3034*	-0.053	-0.6691*	-0.3909*	-					
(10) EXPORT	0.5324*	0.5208*	0.2732*	0.4978*	0.3966*	0.1390*	-0.3052*	-0.1150*	0.4042*	-				
(11) HEADOFFICE	-0.0028	-0.0209	-0.0235	-0.0262	-0.0264	0.2017*	0.0865*	0.0847*	-0.1570*	-0.052	-			
(12) SUBSIDIARY	0.3018*	0.2904*	0.1144*	0.2570*	0.2671*	0.1981*	-0.0988*	-0.0742*	0.1609*	0.3386*	-0.2115*	-		
(13) SINGLE	-0.2880*	-0.2675*	-0.0956*	-0.2298*	-0.2422*	-0.3031*	0.0449	0.0226	-0.0641	-0.2928*	-0.3661*	-0.8321*	-	
(14) FOREIGN	0.4110*	0.4142*	0.1707*	0.3808*	0.3675*	-0.0009	-0.1962*	-0.1339*	0.3103*	0.5593*	-0.0962*	0.3318*	-0.2601*	-
(15) DATE	0.1109*	0.1010*	0.0557	0.1274*	0.0797*	-0.1153*	-0.2226*	-0.1105*	0.3161*	0.1298*	-0.2142*	0.0329	0.0893*	0.1873*
(16) LARGE	0.2382*	0.2437*	0.1590*	0.2277*	0.2183*	0.0034	-0.0705*	0.0093	0.0641	0.1501*	0.0163	0.2145*	-0.2135*	0.0959*
(17) SMALL	-0.2733*	-0.2805*	-0.1554*	-0.2509*	-0.2248*	0.0963*	0.1108*	0.0359	-0.1423*	-0.2469*	-0.0466	-0.2742*	0.2876*	-0.2259*
(18) MEDIUM	0.1014*	0.1045*	0.0463	0.0960*	0.0663	-0.1029*	-0.0643	-0.0442	0.1018*	0.1483*	0.0368	0.1302*	-0.1449*	0.1665*
(19) noEDU	-0.1359*	-0.1527*	-0.1083*	-0.0943*	-0.0960*	0.1244*	0.4197*	-0.2003*	-0.2561*	-0.1516*	-0.0079	-0.0543	0.0562	-0.1357*
(20) EDU	0.1432*	0.1562*	0.0639	0.1008*	0.1263*	0.1811*	0.0827*	0.047	-0.1228*	0.0926*	0.004	0.1211*	-0.1173*	0.1037*
(21) highEDU	-0.0472	-0.0479	0.0171	-0.0343	-0.0615	-0.2970*	-0.4262*	0.1093*	0.3390*	0.0205	0.002	-0.0883*	0.0827*	-0.0043
(22) highMACHINEQUIP	0.1961*	0.1852*	0.1963*	0.2214*	0.0728	-0.2938*	-0.0996*	-0.0284	0.1261*	0.0427	-0.0256	0.0042	0.0109	0.1043*
(23) lowSYSTEMPROD	0.0854*	0.0750*	-0.0312	0.045	0.1042*	0.3956*	-0.1256*	-0.0954*	0.2057*	0.0900*	-0.0577	0.045	-0.0101	0.038
(24) mediumSYSTEMPROD	-0.0567	-0.0425	0.0462	-0.0603	-0.0698	-0.0117	0.0493	0.0367	-0.0801*	-0.0573	0.1167*	0.0264	-0.0913*	-0.0496
(25)highSYSTEMPROD	-0.0395	-0.0445	-0.0196	0.0196	-0.0476	-0.5429*	0.1095*	0.0841*	-0.1802*	-0.0481	-0.0796*	-0.1001*	0.1405*	0.0149
(26) intraRD	0.0072	0.0331	0.1564*	-0.0037	-0.0332	-0.2044*	-0.2135*	0.1300*	0.1102*	-0.0766*	0.0404	-0.0253	0.0011	-0.0627
(27) PATENT	0.1317*	0.1279*	0.1260*	0.1384*	0.0619	0.0104	-0.1641*	-0.027	0.1887*	0.1880*	0.0082	0.1590*	-0.1560*	0.1641*
(28) RDdep	0.1308*	0.1355*	0.0905*	0.1077*	0.1137*	-0.3672*	-0.3401*	0.1087*	0.2569*	0.0812*	0.0519	-0.0069	-0.0229	0.0505
(29) highQCERT	-0.0706	-0.0693	-0.0034	-0.0369	-0.0696	0.2214*	0.2613*	-0.0316	-0.2394*	-0.0546	0.0953*	0.1517*	-0.1985*	-0.0465

Variable (continue)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
(15) DATE	-														
(16) LARGE	-0.1416*	-													
(17) SMALL	0.0727*	-0.4078*	-												
(18) MEDIUM	0.0279	-0.3031*	-0.7465*	-											
(19) noEDU	-0.06	-0.0326	0.1927*	-0.1773*	-										
(20) EDU	-0.0642	0.0106	-0.0824*	0.0783*	-0.4750*	-									
(21) highEDU	0.1172*	0.0146	-0.0649	0.057	-0.2834*	-0.7094*	-								
(22) highMACHINEQUIP	-0.0112	0.1992*	-0.2493*	0.1156*	-0.069	-0.0125	0.0692	1							
(23) lowSYSTEMPROD	0.0879*	-0.1321*	0.2439*	-0.1583*	0.0574	0.0372	-0.0864*	-0.2072*	-						
(24) mediumSYSTEMPROD	-0.1167*	0.0839*	-0.1441*	0.0892*	-0.0084	-0.0757*	0.0893*	0.0484	-0.7438*	-					
(25) highSYSTEMPROD	0.0368	0.0706*	-0.1455*	0.1004*	-0.0691*	0.0527	-0.0021	0.2226*	-0.3871*	-0.3283*	-				
(26) intraRD	-0.0125	0.0962*	-0.2000*	0.1386*	-0.2312*	-0.0203	0.2073*	0.2108*	-0.2913*	0.2263*	0.0995*	-			
(27) PATENT	0.0686*	0.0664*	-0.1423*	0.1001*	-0.1168*	0.0255	0.0658	0.0773*	-0.0201	0.0710*	-0.0695*	0.1173*	-		
(28) RDdep	0.0271	0.1424*	-0.2683*	0.1762*	-0.2914*	-0.0136	0.2472*	0.2944*	-0.3181*	0.1817*	0.1969*	0.4704*	0.0993*	-	
(29) highQCERT	-0.1817*	0.1566*	-0.1523*	0.0449	0.0828*	0.0285	-0.0974*	-0.0076	-0.1142*	0.1894*	-0.1000*	-0.0351	0.0285	-0.0323	-

*P<0.05

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