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Paper no. 2015/29

The role of regional sectoral specialization on the geography of innovation networks: a comparison between firms located in regions in developed and emerging economies

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Forthcoming in the International Journal of Technological learning, Innovation and Development". Any references to this publication should be cited as Plechero, M.; Chaminade, C. (2015) The role of regional sectoral specialization on the geography of innovation networks: a comparison between firms located in regions in developed and emerging economies.

This version: August 2015

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http://www.circle.lu.se/publications

WP 2015/29

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Monica Plechero and Cristina Chaminade

Abstract

Recently, there has been a rise of contributions in innovation and economic geography studies on how firms from specific industries and regional innovation systems (RISs) rely on international networks to innovate. So far, the focus has been on single cases, firms located in well-known RISs and international linkages, without really distinguishing those with geographically close partners from those with partners from distant locations. Using primary firm-level data, this article compares the patterns of collaboration for innovation in a selection of Swedish, Norwegian, Chinese and Indian regions with an ICT cluster specialization. The results show that firms in RISs in emerging economies tend to link more to innovation networks with a real global character, particularly in relation to new-to-the-world innovation. It also shows that firms in the most successful RISs in ICT clusters rely more than others on networks with organizations in close proximity.

JEL codes: O18, O33

Keywords: Globalization; innovation networks; developed economies; emerging economies; China; India; Sweden; Norway; regional innovation system; cluster specialization; ICT; new-to-the-world innovation

The role of regional sectoral specialization on the geography of innovation networks: a comparison between firms located in regions in developed and emerging economies

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Biographical notes:

Monica Plechero is currently a researcher collaborating with DEAMS, University of Trieste and CIRCLE, Lund University. Her research investigates the determinants at regional and national levels of innovation performance, and which institutional conditions may favour innovation and global collaboration for innovation.

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1. Introduction

Since the 1990s, researchers in economic geography have largely highlighted how regional innovation systems (RISs)[1] may contribute to shaping a firm's innovation capability (Amin and Thrift, 1994; Asheim and Isaksen, 1997; Asheim et al., 2003; Cooke, 1992; Cooke et al., 1998; MacKinnon et al., 2002). Contributions in the literature have also shown how RISs often encompass specific cluster specializations (Amin and Thrift, 1994; Asheim and Isaksen, 1997; Saxenian 1994). Clusters themselves contribute to determining the type of regional system and may strongly affect the local socio-economic and institutional relations present in the region (Eraydin, 2005).

Recently, some authors have analysed empirically the relationship between firms in specific industries and RISs and some types of international innovation networks such as the ones aimed to source innovation (Blažek et al., 2011; Belussi et al., 2010; Giuliani and Bell, 2005; Isaksen and Onsager, 2010; Martin and Moodysson, 2013; Moodysson et al., 2008; Sotarauta et al., 2011; Tödtling et al., 2011). The research has shown how in some RISs with specific cluster specialization, international innovation networks may play a complementary role to local networks. With a few exceptions (e.g. Chaminade and Plechero, 2015) the existing studies have based the analysis on single cases and European regions. Therefore, although there is an increased interest from scholars in understanding the interaction of international networks with territorial dynamics and regional development (Cooke, 2013; Parrilli et al., 2013; van Egeraat and Kogler, 2013), the empirical analysis that also compares different regions outside Europe is still in its infancy. The existing studies have also tended to treat international networks as one single category, and therefore have not distinguished between international networks with geographically close partners and those with partners from geographically distant locations, or, in the words of Dicken (2007), between regionalization and globalization. The latter is the focus of this paper.

What remains overlooked so far by the literature is: 1) explicit attention to firms' *global* linkages, that is, linkages that are explicitly across Triad and non-Triad partners; 2) a systematic comparison of RISs in developed and developing countries—particularly emerging economies—in which firms may answer to different conditions and degrees of involvement in the formation of global innovation networks (GINs).

This paper contributes to filling these two gaps by comparing firms' patterns for global collaboration for innovation in different types of RISs in developed and emerging economies. Our main objective is to understand whether the degree of maturity or specialization of a RIS is related to the geography of the firms' innovation networks. Furthermore, we move beyond the existing literature, which treats international linkages as one geographical scale, distinguishing between truly global networks (involving Triad and non-Triad countries) and other international networks involving countries with a similar degree of development. Using firm-level data collected through a survey in 2009–2010 in two developed countries in Northern Europe (Norway and Sweden) and two emerging economies (China and India), we investigate specific patterns for global collaboration for innovation.

The paper is structured as follows. The next section discusses the theoretical framework. Section 3 describes the methodology, the data sources used for the analysis and the empirical analysis itself. Section 4 summarizes the main results. The final section concludes with some remarks on policy implications.

2. Main conceptual framework

2.1 Global innovation networks

Recently, scholars in the international business literature, economic geography and more in general in innovation studies have increased their interest in the globalization of innovation activities—in contrast to solely production—and to the surge of some forms of innovation networks across national boundaries (Barnard and Chaminade, 2011; Cantwell and Piscitello, 2005; Dunning and Lundan, 2009; Reddy, 2011; Sachwald, 2008; Saliola and Zanfei, 2009; Zanfei, 2000). Some works in economic geography (Balland et al., 2013; Cassi et al., 2012) have been particularly focused on looking at how networks in specific sectors evolve at international level. Although these studies are an attempt to capture the surge of global innovation networks, they focus on the organizational relations and the structural characteristics of the network using indicators such as co-patenting and co-funding projects, which are only common in specific activities and countries.

In this paper, we study the networks that involve actors located geographically in both developed and developing economies, and we refer to a global network only when the firm's most important innovation has required collaboration among actors belonging to the Triad (US, Europe and Japan) and outside the Triad. The paper investigates particularly GINs among actors involved in the development of new-to-the-world innovations. The treatment of GINs in this paper encompasses networks that include other organizations than firms, such as governments, universities and research institutes and laboratories, and investigates not only product and process innovation but also innovation related to supporting activities.

2.2 Local innovation networks and regional innovation systems

The main argument in economic geography is that innovative activities tend to remain geographically contained and concentrated in clusters and regions, more so than production activities, because of the sticky, intangible and embedded nature of knowledge (Asheim and Gertler, 2005; Audretsch and Feldman, 1996; Bathelt et al., 2004; Maskell and Malberg, 1999).

In general, firms located in RISs that have a strong organizational infrastructure (a high number of heterogeneous organizations located in the region), a dense network of supporting institutions and a high level of interaction among the local actors, usually rely on their local innovation network (Cooke et al., 2000; Tödtling et al., 2011). This may be explained in terms of organizational and institutional thickness (Amin and Thrift, 1994). In thick RISs the networks of innovation tend to be local (Tödtling et al., 2011), while in thin RISs the networks of innovation tend to be more international. The former case is particularly true if there is already a regionally constructed advantage in terms of a specific cluster agglomeration in the RIS (Asheim and Coenen, 2005). Moreover, successful RISs have a tendency to exploit knowledge resources in close proximity since seeking knowledge from abroad may be subject to transactional costs or distance decay (Bode, 2004, p. 51).

The *degree of specialization* of the region in a particular industry may also affect the involvement in global networks. Firms located in regions with a high degree of specialization in a certain industry may not have incentives to engage in global networks since all the specialized suppliers are co-located in the same region (Amin and Cohendet, 2004; Bathelt et al., 2004; Uzzi, 1997).

We may, therefore, expect that, when firms are located in strong RISs with a high industrial specialization, they will tend to rely more on regional networks than firms located in other RISs, despite their location in developed and emerging economies.

2.3 Local innovation networks versus global innovation networks: the local–global debate

During the last decade, increasing attention has been paid to the role of global sources of knowledge for the competitiveness of European firms and regions, pointing to the role of international innovation networks as complementary to local innovation networks (Asheim and Gertler, 2005;

Asheim and Isaksen, 2002; Bathelt, 2008; Gertler and Levitte, 2005; Moodysson, 2008; Martin and Moodysson, 2013).

The dynamics of local–global linkages from the point of view of the geography of knowledge flows have been investigated empirically mainly in relation to RISs in developed countries (Bathelt et al., 2004; Coenen et al., 2004, Martin and Moodysson, 2013; Moodysson, 2008; Moodysson et al., 2008; Plum and Hassink, 2011; Tödtling et al., 2011). We know, for example, that industries characterized by different knowledge bases portray very different geographies of their knowledge bases, at least in specific regions. In contrast, RISs in developing countries, where the socio-economic and institutional conditions may be very different (Wang and Tong, 2005; Yeung, 2009), have been overlooked. Indeed, RISs in emerging economies are usually considered to be less mature than those in developed economies because of their less efficient institutional, legal or knowledge infrastructure (Chaminade and Vang, 2008; Padilla-Pérez et al., 2009; Ptak and Bagchi-Sen, 2011).

The dependence of developing economies, in particular emerging economies, on global linkages and foreign technologies for sustaining indigenous innovation is clearly highlighted by other branches of literature in innovation and business studies (Bell, 2006; Fu et al., 2011; Hobday, 1995; Humphrey and Schmitz, 2002; Marin and Arza, 2009; Pietrobelli and Rabellotti, 2007). The evidence also shows that the dynamics of growth and development at the national and regional levels in emerging economies, in particular in East Asia, have often been well supported by firms' trans-local networks (Asheim and Vang, 2006; Fromhold-Eisebith, 2002; Ivarsson and Alvstam, 2005; Schiller, 2012; Wang and Tong, 2005).

Finally, the most recent literature shows that many companies—although present in the most dynamic regions in emerging economies—are nowadays addressing their asset-seeking strategies overseas with the aim of creating important global linkages with innovation environments in developed economies (through, for example, the offshoring of innovation in the most dynamic and innovative regions) (Athreye and Kapur, 2009; Barnard and Cantwell, 2008; Niosi and Tschang, 2009). While these contributions have predominantly highlighted that it is essential for local firms in an emerging economy to rely on global knowledge to overcome the limited resources available at the regional level, there is still a lack of studies that compare different RISs in developed and emerging economy contexts and their relation with more appropriate forms of global interactions, namely global collaboration for innovation, particularly in relation to new-to-the-world innovation.

On the basis of this premise, we expect that regions in emerging economies relate differently to GINs from those in developed economies, and in particular we expect that firms in RISs in emerging economies rely more on GINs than firms in RISs located in developed economies; although the lack of some other type of proximities (cognitive, social, organizational and institutional) may limit sophisticated interactions for innovation (Boschma; 2005; Giuliani and Bell, 2005).

3. Methodology

3.1 Sample and questionnaire

This paper is founded on a firm-based survey conducted in 2009–2010 across nine countries: Brazil, India, China, South Africa, Norway, Sweden, Germany, Estonia and Denmark, and related to a research project, INGINEUS, sponsored by the European Commission's 7th Framework Programme (FP7). Although the survey covered three industries (ICT, automotive and agroprocessing), each country focused on just one industry, which was of economic importance within its national or regional context. The survey questionnaire consisted of 14 questions covering background information on the main production activities of the firm, organizational type, firm size, market, sales information and R&D activity. The core of the questionnaire focused on the types of innovation; the geographic network and collaborations with customers, suppliers, universities, research institutions and governments; the offshoring of production and innovation; and the role of the institutional framework (mainly at the national and international levels) supporting or hindering the access to GINs.

In all the industries and across all the countries, 1,215 responses were collected. All the data collected referred to the years from 2006 to 2008. For this specific paper, we consider only the sample from the ICT industry and firms located in regions that are well known for their ICT cluster specialization, from both the EU developed countries (Norway and Sweden) and the emerging economies (China and India). ICT in the survey focused only on telecommunications equipment and software. In order to avoid too much diversity, we excluded from the survey other activities such as BPO. The following NACE 2 codes were included in the survey: 26.30 Manufacture of communication equipment; 62.01 Computer programming activities; 62.02 Computer consultancy activities; 62.03 Computer facilities management activities; 62.09 Other information technology and computer service activities.

Since the data were collected at the national level, the response rate to the questionnaire for ICT is available only at this level, and we cannot provide a regional figure: in China, the response rate was 2.7%, in India 25.2%, in Norway 11.9% and in Sweden 10.3%.

Table 1 below provides a summary of the responses received from the ICT industry in each region for the cleaned sample considered in this paper. To run an econometric analysis, we excluded regions with only a few cases or without an ICT cluster specialization. Table 2 shows the main sample statistics related to size, organizational form and ICT-specific activity.

[Insert Table 1 here]

As can be observed in Table 2, in Sweden and Norway a firm is typically a standalone small firm, with fewer than 50 employees, in computer programming. In China and India, firms are typically larger—medium and large companies. In China, the largest proportion of firms consists of headquarters or standalone firms, specializing in ICT equipment manufacturing, but also computer programming. In India, the majority of firms are also standalone, although there is a high proportion of subsidiaries in Pune and New Delhi (those subsidiaries can be both Indian and foreign multinationals). As expected, India specializes in computer programming and other IT services.

[Insert Table 2 here]

Table 2 clearly shows a high level of heterogeneity in the sample. In order to take this diversity into account, we employed an econometric estimation endowed with a series of controls capable of capturing the relation of different types of RIS with firms' innovation networks.

3.2 Variables

3.2.1 Dependent variable (collaboration for innovation)

In order to assess how firms belonging to different types of RIS may engage in collaboration for innovation at different geographical scales, we built *CollINN* as the dependent variable. This assesses the maximum geographical spread of the innovation network in which the firm has been actively engaged for the development of its most important innovation in the last three years. The network may include both other firms (clients, suppliers, competitors or consultancy companies) and other organizations (the government, universities, research institutes and laboratories). The variable *CollINN* is a categorical dummy where 0 indicates no collaboration for innovation, 1 collaboration at the regional level at most, 2 collaboration at the domestic level at most, 3 collaboration at the international level at most but not global (firms in Sweden and Norway collaborating with Triad regions and firms in China and India collaborating with non-Triad regions), and 4 truly global collaboration (i.e. spanning networks linking Triad and non-Triad areas in developed and developing locations).[2]

3.2.2 Independent variables

In order to explore the relation between RIS and the geographical spread of networks for collaboration for innovation, the regions with an ICT specialization in the sample were classified on the basis of two criteria that, even without detailed information about the specific RISs investigated in this paper, may help to distinguish two important basic typologies.

As the first step, we grouped the RISs located in developed economies (Norway and Sweden), distinguishing them from those located in emerging economies (China and India). Many RISs in this area represent the best examples of the efforts that regional governments put into building strong regional institutions and strengthening the efficiency of the regional innovation system (Asheim and Coenen, 2005; Cooke et al., 1998; STEP, 2003). In contrast, RISs in emerging economies, despite the rapid growth of some of them, do not show the high degree of integration and interaction that characterizes RISs in developed countries (Chaminade and Vang, 2008; Padilla-Pérez et al., 2009). In many emerging economies, a lack of institutional and legal infrastructure can be observed at both the national and the regional levels. At these levels, the questionable quality and number of knowledge infrastructures, as well as the presence of a certain level of corruption and inequality, make the development of well-functioning regional systems sustaining innovation difficult (Bai, 2013; Li, 2009; Ptak and Bagchi-Sen, 2011; van Kampen and van Naerssen, 2008). Therefore, in these contexts, the efficiency of RISs is often well below that of RISs in mature regions in developed economies because the institutions that govern and characterize these contexts are in general weaker.

On the basis of these considerations, we built *emergRIS*, a proxy capturing with 1 the case in which the RIS is positioned in an emerging economy and with 0 that in which the RIS is positioned in a developed economy.

As the second step, we grouped the RISs with a higher degree of specialization in ICT. In order to proceed with this classification, we wanted first to create some indicators that were able to define all the investigated RISs on the basis of some common criteria. Unfortunately, we suffered from a lack of objective indicators for emerging economies that could facilitate a comparison between different RISs. For this reason, we decided to rely mainly on the literature on qualitative research and industry reports and see whether a series of main studies on the argument could help us to group together the most successful RISs with an ICT cluster specialization. The information collected allowed us to single out the three most successful RISs (one for the Scandinavian area,[3] one for China and one for India).

Stockholm in the Scandinavian area and Bangalore in India are considered to be the RISs with the most important clusters in the ICT industry, not only in their specific countries[4] but also globally, since these regions benefit from strong organizational, institutional and infrastructural support in that industry (Hansen and Serin, 2010; Ptak and Bagchi-Sen, 2011). Stockholm, where the main specialization is computer equipment and telecommunications, employs around 100,000 people in this sector (9.86% of the total employment) (Hansen and Serin, 2010). On the European Regional Innovation Scoreboard[5] (RIS Scoreboard, 2009), Stockholm is also considered to be among the best RISs in Europe in terms of innovation performance and enablers such as public R&D expenditure and tertiary education. The region also includes the Kista Science Park, where around one-fifth of the total ICT companies in the region and the most important multinational corporations (MNCs) are located and are strongly integrated with other industries, academia and the regional government.

Bangalore is widely referred to as 'India's Silicon Valley', not only because of the quantity but also because of the quality and significance of the ICT industry. While Bangalore started as a low-cost provider of software services, it has been upgrading gradually and currently it is an important provider of high value-added services. The industrial structure combines both a large pool of small and medium enterprises (SMEs) and a large number of MNCs, many of which have located their

R&D centers there and have been the fundamental actors in the earlier development of this cluster, providing the first input for the circulation of local knowledge flows (Fromhold-Eisebith, 2002). With respect to other regional clusters in India, Bangalore indeed has a higher propensity to collaborate with regional actors, particularly with universities, consultants and R&D companies (Malik and Ilavarasan, 2011a; Parthasarathy and Rabganathan, 2011). The most important software firms and research initiatives related to the sector are also clustered in Bangalore, where the presence of professional institutions, universities and industry–university partnerships has further supported the local ICT technical and professional community (Asheim and Vang, 2006). In terms of research infrastructure, Bangalore is home to the Indian Institute of Science and the International Institute of Information Technology (IIIT-Bangalore) and has branches of several international universities, such as the University of Chicago, as well as other well-known higher education institutions, such as the Indian Institute of Management. Bangalore also has a strong culture of collective representation and collective action, and the government has been very active in developing the institutional framework supporting the ICT industry in this specific region (Fromhold-Eisebith, 2002; Parthasarathy and Rabganathan, 2011).

Beijing is considered to be the scientific and technological heart of China and thus is the leading science and technology region in terms of both its research infrastructure and its innovation performance (Guan et al., 2009). The region is also specialized in high-tech industries, the innovation performance of which is among the best in China, particularly in relation to the ICT hub (Chen and Kenney, 2007; Guan et al., 2009; Lv and Liu, 2011; Zhou et al., 2011). One of the most important IT science parks, the Zhongguancun Science Park (ZGC), is also located in Beijing. Beijing, with respect to other ICT hubs in China, has a higher degree of specialization in software and Internet services (Zhou et al., 2011). According to China’s Economic Census (2008), the Beijing region alone accounts for more than 6,000 software firms. Moreover, around one-third of professionals in China in advanced computing and software and around half of those in advanced intelligent systems integration and in semiconductors are working in Beijing (Lv and Liu, 2011).

The rest of the RISs analysed in the sample, although showing a certain ICT specialization and the presence of institutional support at the time at which the interviews were conducted, did not show the same presence of knowledge infrastructure, innovation dynamics and ICT occupation levels as the three aforementioned ICT-specialized RISs in general, or for each specific country area considered in particular (Scandinavia, China and India).

On the basis of the above considerations and the information and references presented in Appendix A, we built the proxy *ICTRIS*, capturing with 1 if the RIS is considered to be the RIS with the highest specialization in ICT in the different areas (Scandinavia, India and China), and 0 otherwise.

3.2.3. Control variables

The nature of innovation is an important variable for determining whether we are looking at a GIN or not. We built the proxy *worldnew*, a dummy variable giving a value of 1 to firms that have experienced new-to-the-world innovation in the past three years, and 0 otherwise. In this way, we can achieve a better evaluation of the global innovation network in which actors involved in new-to-the-world innovation participate.

Since ICT is a heterogeneous industry, we controlled for the specific type of activity that the firms in the survey described as their main area of activity. We then controlled for certain structural variables within firms (size and organizational type) that could affect the capabilities of the firms to develop networks. Finally, we also controlled for firm performance related to foreign sales. This is due to the fact that firms with international experience (even if simple) may be facilitated in developing global linkages (Dunning and Lundan, 2008; Johanson and Vahlne, 1977).

Appendix B summarizes this line of argument and presents the main statistics related to the variables. Appendix C presents the correlations between the variables.

3.3 The econometric analysis

To see whether there is a relation between the geographic spread of an innovation network and the different types of RIS, we ran an econometric analysis. We could exploit the information described above using an ordered logit model. However, the Brant test certified that the proportional odds assumption was violated. We thus applied the generalized form of the ordered logit model, which allows different coefficients to be estimated for different category switches.[6] The results of the relative equations are presented in Table 3.

[Insert Table 3 here]

4. Empirical findings

Equations 1 to 3 show that the probability of engaging in collaboration for innovation external to the firm is generally lower for firms located in a RIS in an emerging economy than for firms located in a RIS in a developed economy (the coefficient of the variable *emergRIS* is significant and negative). In other words, for a firm, being located in a RIS in an emerging economy is not particularly encouraging for creating external collaborations for innovation.

Despite the fact that firms in RISs located in emerging economies appear to be less open to external-to-the-firm innovation networks, Equation 4 also shows that RISs in emerging economies have a higher probability than those located in developed economies of linking to global partners (in the fourth equation, the coefficient is positive and significant at the 0.05 level). This is particularly evident when the external collaboration for innovation involves firms that develop new-to-the-world innovation: the interaction term worldnew*emergRIS has a coefficient that is non-significant for all the equations but the last, Equation 4, in which the coefficient is positive and significant at the 0.05 level. This means that firms in RISs in emerging economies have a higher probability of participating in GINs than those located in RISs in developed economies and that this probability is even higher if firms are involved in developing innovation with the maximum degree of novelty. For this type of innovation, the resources at the regional level may be insufficient, and, therefore, the firms may need to seek resources to generate innovation by collaborating with firms and other organizations that are located in more dynamic innovation environments, usually present in the Triad. This finding confirms that RISs in emerging economies rely more on GINs than RISs located in developed economies.

To corroborate this result through a simple exercise, we compared the RISs in emerging economies with those in developed countries regarding the type of partners in their GINs. In our sample, of the firms that have been engaged in collaboration for innovation at the global level—a total of 209—130 are connected only to other firms, while 79 also extend their ties to other types of organization, such as universities, governments and research laboratories. We performed a χ^2 test that shows different behaviours for firms that are part of RISs in developed economies versus those in emerging economies (χ^2 equal to 7.7365, *p*-value of 0.005). In particular, we observed that around 40% of firms that are part of RISs in emerging economies are indeed creating ties with a wider set of organizations, showing that firms in RISs in emerging economies seek collaboration strategies that allow them to enter more thoroughly into the dynamic environment and institutions that are present in the Triad.

Another interesting result from our empirical analysis is that being a firm located in a leading RIS specialized in ICT affords a higher chance of developing collaborations for innovation since the firm may count on a much more dynamic environment related to that cluster specialization (widespread ad hoc knowledge infrastructures, more attention from the government on developing policies for that particular industry specialization). Equation 1, related to the variable *ICTRIS*, shows that being a firm located in an ICT-specialized RIS implies having a higher probability of forming collaborations for innovation external to the firm. Despite there being no significant difference with respect to the other less successful RISs in their probability of forming international and global collaborations (Equations 3 and 4), Equations 1 and 2 together show that for the former the collaborations for innovation continue to be more tightly linked to their regional and domestic context. This finding confirms that firms located in highly ICT-specialized RISs tend to rely more on networks of innovation within a short geographical distance.

The results also show that the micro characteristics of the firms matter, particularly the international experience of the firm. Firms that have a significant share of sales activities abroad are also much more connected to wider networks, and particularly global innovation networks. This is also true for large firms. As expected, in general, headquarters have a higher probability of developing collaboration linkages, while firms that are standalone companies have a lower probability of establishing linkages that are international or global.

The results also show the expected heterogeneity in the ICT sector: in Equations 2 and 4, the coefficients capturing the effect of performing ICT consultancy rather than being specialized in other activities are significant and negative. Equation 4 shows that firms specialized in this activity have a lower tendency to be involved in GINs.

5. Conclusions

This paper is an exploratory attempt to compare the geography of knowledge flows between regions in developed and developed countries. It adds to the recent local–global debate by providing evidence of when and how a regional innovation system may support the emergence of strong international or even global linkages and when and how one could expect geographically closer interactions. Our paper also adds to the current empirical evidence by making a distinction between collaboration for innovation that has a clear *global* character (involving partners from Triad and non-Triad countries), and international collaboration for innovation (with a more limited geographical scope).

In relation to GINs, our data suggest that the level of maturity of RISs matters. In general, firms in RISs in emerging economies seem to rely much more on global networks than firms in RISs in developed countries. Not only do firms from the former type of RIS engage more in collaboration for innovation with global partners (partners that are located in the Triad), but the nature of the innovation (new-to-the-world types of innovation) in which some of the firms are involved, and the typology of partners engaged in the network (not only firms but also foreign universities, research laboratories or governments), show how in these systems there is a tendency for firms to develop asset-seeking strategies at the global level, aiming to take advantage of the most dynamic environments in developed economies. As these RISs are still in formation, firms seem to encounter a general difficulty in creating regional collaborations, and, therefore, they are probably reluctant to rely only on local networks of collaborators for generating innovation. This result is coherent with previous research on emerging multinationals that argues that these firms use the internal networks to compensate for their weak regional innovation systems (Chang and Hong, 2002; Khanna and Yafeh, 2007).

We also observe that the degree of specialization of the RIS matters for the geography of collaboration for innovation. Regional innovation systems with a higher degree of specialization in a certain industry, such as Stockholm, Bangalore or Beijing in ICT, seem to be more attractive for the establishment of regional or domestic networks, even when those RISs are located in emerging economies. What the results seem to suggest is that the relative liability of firms located in emerging economies in terms of their limited access to the resources needed for innovation may be compensated for if there is a high degree of specialization in a particular region, thus making local interactions more attractive, even though global linkages become crucial when the firm is engaged in new-to-the-world innovation.

The results of this analysis indicate that the structural characteristics of the firms remain very important in determining the capabilities of a system to link with GINs. Not all firms in the different types of RIS have equal possibilities to engage in GINs. It is mainly large firms, multinationals and firms with international experience that have the competences to engage in GINs.

Some policy implications can be drawn from this analysis. RISs in emerging economies may need better support from regional government to strengthen the general initiatives of collaboration and interactions with global partners, particularly if they are not located in a highly ICT-specialized region. This is particularly important when the firm attempts to develop new-to-the-world innovations. Collaboration with developed countries may speed up the time of technological learning of firms in emerging economies, but with the condition that firms possess the capabilities to interact with those partners (Bell, 2006; Giuliani and Bell, 2005). Policy initiatives may be directed towards strengthen the capacity of local firms to interface with partners from different institutional and cultural backgrounds, and to provide incentives for firms with higher interface capabilities to act as regional gatekeepers of global linkages and contribute to the diffusion of new knowledge in the local context.

This paper is of an exploratory nature. A more nuanced discussion of the role of RISs in engagement in global innovation networks requires access to reliable data at the level of the region. While this is possible in European regions, it remains a serious challenge in developing countries. Due to the lack of statistics at the regional level, one can only rely on proxy measures based on qualitative information or on data collected directly in the researched regions. This remains for further research.

Acknowledgements

The research leading to these results has received funding from the European Union's Seventh Framework Programme [FP7/2007–2013] under grant agreement no. 225368 (INGINEUS, Impact of Networks, Globalisation, and their Interaction with EU Strategies). The authors alone are responsible for its contents, which do not necessarily reflect the views or opinions of the European

Commission, nor is the European Commission responsible for any use that might be made of the information appearing herein. Additionally, financial support from the Swedish Research Council (Linneaus grant) is acknowledged.

We thank Bjørn Asheim, Helena Barnard, Susana Borras, Davide Castellani, Stine Haakonsson, Balaji Parthasarathy, Nick von Tunzelmann and Heidi Wiig Aslesen for their input and suggestions on a previous version of this manuscript.

Notes

[1] RIS is here intended as the local social, economic and institutional milieu where firms and knowledge provider organizations interact systematically to support knowledge and learning (Asheim and Gertler, 2005)

[2] In accordance with the definition of *global* collaboration used in this paper, we tried to ensure that a network was considered truly global in cases in which there was at least one interaction between an actor in the Triad and an actor in a developing economy outside the Triad. We consider global networks to be networks built between firms from RISs in the European Nordic countries cooperating with other firms and organizations outside the Triad (namely, in South America and/or Africa and/or Asia, with the exclusion of Japan and Australasia) and firms from RISs in India and China cooperating with other firms and organizations in the Triad (namely, North America, Japan and Australasia, or other EU regions). Even though this indicator is not precise in pointing to the exact geographical location of partners at the specific country level, it allows us to determine whether the type of collaboration in the network is really geographically spread among countries with different cultures and traditions and at different stages of industrialization.

[3] To enable a better comparison between regions in two very small countries such as Sweden and Norway, with regions in China and India, we grouped together the RISs in Norway and Sweden. This is highly plausible as the two countries have in common Nordic cultural, historical and linguistic characteristics and are very much integrated with one another.

[4] Stockholm can be considered the most important ICT hub in Scandinavia.

[5] The RIS Scoreboard classifies the main European regions according to different indicators of regional innovation performance related to regional enablers, output and firms' activities.

[6] The generalized ordered logit has a caveat, i.e. it generates a number of in-sample cases with a predicted probability of less than 0. If this number is limited (in our case, 12.8% of the resulting sample), this does not create a problem, but of course it is a parameter that should be minimized when choosing the model to employ. For example, among the ICT-related dummies, we chose to include only ICT consultancy, not only because its nature is really different from that of the other ICT-related activities, but also because it guarantees the minimum number of these cases. Another issue we had to control for was multicollinearity. We computed the variance inflation factor and found that the highest value was 2.03, certifying that there is no problem with correlation between regressors.

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[Insert Appendix A, B and C here]

Table 1 Sample breakdown by country and region

Country	RIS	No. of Firms
Sweden		**83**
	Stockholm	54
	The Scania Region	13
	Gothenburg	16
Norway		**49**
	Oslo & Akershus	39
	Vestlandet	10
China		**162**
	Beijing	134
	Shenzhen	28
India		**249**
	Bangalore	49
	Mumbai	42
	Pune	19
	Hyderabad	26
	New Delhi	72
	Chennai	41
Total Sample		**543**

Source: own elaboration of INGINEUS data

Table 2 Main sample statistics concerning firm size, organizational type and activity breakdown by region

REGION	No. of firms	SIZE in terms of employees (%)			Org. TYPE (%)			ACTIVITY (%)				
		Small <50	Medium ≥50 ≤249	Large ≥250	Headquarters	Subsidiary	Standalone	ICT equipment	Computer programming	Computer consultancy	Computer facilities management	Other information technology
Norway												
Oslo & Akershus	39	**89.74**	10.26	0	5.13	12.82	**82.5**	2.56	**35.90**	28.21	12.82	20.51
Vestlandet	10	**90**	0	10	10	0	**90**	20	**30**	10	20	20
Sweden												
Scania	13	**84.62**	15.38	0	0	0	**100**	7.69	23.08	**53.85**	0	15.38
Stockholm	54	**81.48**	14.81	3.70	5.56	9.26	**85.19**	1.85	**46.30**	31.48	3.70	16.67
Gothenburg	16	**87.50**	6.25	6.25	0	12.50	**87.50**	0	31.25	**43.75**	6.25	18.75
China												
Shenzhen	28	35.71	17.86	**46.43**	**50**	21.43	28.57	28.57	17.86	3.57	7.14	**42.86**
Beijing	147	38.06	**38.81**	23.13	32.09	19.4	**48.51**	35.82	**38.81**	1.49	6.72	17.16
India												
Bangalore	49	14.29	**46.94**	38.78	28.57	14.29	**57.14**	2.04	32.65	**38.78**	14.29	12.24
Mumbai	42	30.95	28.57	**40.48**	4.76	21.43	**73.81**	2.38	**47.62**	2.38	0	**47.62**
Pune	19	21.05	36.84	**42.11**	5.26	**57.89**	36.84	5.26	36.84	10.53	0	**47.37**
Hyderabad	26	3.85	**61.54**	34.62	7.69	34.62	**57.69**	0	15.38	7.69	0	**76.92**
New Delhi	72	6.94	45.83	**47.22**	29.17	**44.44**	26.39	0	13.89	1.39	2.78	**81.94**
Chennai	41	24.39	24.39	**51.22**	17.07	34.15	**48.78**	0	**51.22**	9.76	0	39.02
Total	543	39.41	31.86	28.73	20.26	23.20	55.54	11.79	34.07	13.81	5.52	34.81

Table 3 Generalized ordered logit model for collaboration for innovation

	Equation 1	Equation 2	Equation 3	Equation 4
Collaboration for innovation (CollabINN)	Probability of creating some collaborations (categories > 0) rather than not	Probability of creating collaboration with a reach wider than regional (>1) rather than narrower	Probability of creating collaboration with a reach wider than domestic (>2) rather than narrower	Probability of creating collaboration with a global reach, i.e. wider than international (>3)
emergRIS	**-1.470*** **	**-1.261*** **	**-0.554***	**0.981** **
	[0.403]	[0.342]	[0.313]	[0.407]
ICTRIS	**1.202*** **	**1.050*** **	0.324	0.309
	[0.280]	[0.240]	[0.214]	[0.222]
worldnew	0.821	0.775	**1.078** **	-1.296
	[1.095]	[0.598]	[0.477]	[0.847]
worldnew*emergRIS	15.188	0	-0.557	**1.927** **
	[561.789]	[0.690]	[0.559]	[0.891]
ICT consultancy	0.145	**-0.654** **	-0.267	**-0.527***
	[0.388]	[0.284]	[0.265]	[0.297]
Saleabroad	**0.946*** **	**1.243*** **	**2.120*** **	**1.914*** **
	[0.292]	[0.241]	[0.224]	[0.224]
Medium	0.501	0.443	**0.529** **	0.41
	[0.337]	[0.279]	[0.264]	[0.273]
Large	**0.665***	**0.617** **	**0.665** **	**0.680** **
	[0.350]	[0.312]	[0.290]	[0.293]
HQ	**0.859***	0.365	0.108	-0.068
	[0.454]	[0.374]	[0.325]	[0.309]
Standalone	0.084	-0.284	**-0.529** **	**-0.637** **
	[0.315]	[0.288]	[0.267]	[0.265]
Constant	**1.141*** **	**0.885** **	**-0.839** **	**-2.398*** **
	[0.399]	[0.369]	[0.354]	[0.458]
N	543	543	543	543
Ll	-616.033	-616.033	-616.033	-616.033
LR chi(2)	379.078	379.078	379.078	379.078
P	0	0	0	0
Pseudo R2	0.2353	0.2353	0.2353	0.2353

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

Appendix A Information and references related to the type of RIS

RIS	Information on RIS quality and ICT cluster	Main references
Stockholm	Most important ICT cluster in the Scandinavian area, mainly wireless and telecommunications. Among the most efficient RIS with strong institutional support in Europe. ICT employees: around 100,000 (ICT 9.86% of total employment). 1 university every 243,689 inhabitants; PhD students 0.33% of the total population; R&D staff (public and private) 1.88% of the total population. Kista Science Park with strong linkages among industry, government, research organizations (450 high tech companies; 1,100 researchers only in this area).	For Europe, particularly the Scandinavian area: RIS Scoreboard (2009) Transform (2006) Hansen & Serin (2010) Rekene project report (2011) Franzén & Wallgren (2010) Martin and Moodysson (2011) Statistic Norway (2008) Andersen (2011)
Oslo & Akershus	Primary region for ICT in Norway, mainly computer equipment and telecommunications. About 60% of the ICT companies in Norway are located in this area. ICT employees: 45,000 (ICT 7.55% of total employment). Employees in computer-related activities : around 26,655 (related companies: 4432). 1 university every 117,532 inh.; PhD students 0.20% of the total population; R&D staff (public and private) 2.28% of the total population.	
Vestlandet	Vestlandet has been indicated an important European ICT industrial area with a high regional innovation capacity. Employees in computer-related activities: around 4,068 (related companies: 1,322). The county of Hordaland, where ICT is mainly present, is considered in Norway to rank third in terms of IT employees.	
The Scania Region	ICT employees: around 23,000. Presence of Ericsson's R&D centers. Mainly IT and telecommunications innovative environment, but also RISs sustain other more important cluster specializations than ICT.	
Gothenburg	Gothenburg has a dynamic RIS thanks to the presence of important large MNCs and universities. ICT industry has recently grown but still in formation (mainly wireless technologies) with Ericsson and Volvo IT driving innovation. ICT employees: 22,000. ICT companies: 4,700.	
Beijing	Leading region in China in terms of both its research infrastructure and its innovation performance with a specialization in high tech industries ICT specialization mainly software and computer services strong linked with RIS ZGC Park: strong knowledge intensive area for ICT. Strong pool of professionals in ICT. ICT: more than 6,000 software firms.	For China: China Economic Census (2008) Guan et al. (2009) Wang et al. (2010) Bai (2011) Gao et al. (2010) Wang (1999) Chen and Kenney (2007) Zhou et al (2011)
Shenzhen	ICT manufacturing firms: around 3,000 (mainly electronic computers and telecommunications equipment). ICT employees: around 9% of total employment. RIS less integrated than in Beijing; lower innovation performances of firms. Less linkages between universities and research institutes and industry as in Beijing; RIS of a more recent formation	
Bangalore	RIS World leader in ICT (mainly software). The most important ICT cluster in India the sizeable ICT specialization and performance of Bangalore in terms of the number of firms, employment, innovation, exports and development of knowledge infrastructure is above the other Indian RIS mentioned below. RIS supporting development of ICT R&D and innovation. Better local knowledge interactions and innovation ecosystem than in the other RIS in India. In Karnataka state where Bangalore is located there are estimated to be more than 554,000 employees in the software industry. Software exports: over US$ 17 billion (34% of total in India in 2008/9).	For India: Malik and Ilavarasan (2011a, 2011b) Ptak and Bagchi-Sen (2011) MCCIA (2008) Grondeau (2007) Parthasarathy and Aoyama (2006) Parthasarathy and Rabganathan (2011) OECD (2010) Fromhold-Eisebith (2002) Asheim and Vang (2006)
Hyderabad	Software exports estimated to be around US$4.7 billion. Among the 6 most relevant ICT clusters in India	
Chennai	Software exports estimated to be around US$3.8 billion. Among the 6 most relevant ICT clusters in India	
Mumbai	Among the 6 most relevant ICT cluster s in India	
Pune	ICT employees: estimated 200,000. Software exports: estimated to be around US$3.5 billion. Among the 6 most relevant ICT clusters in India	
New Delhi	ICT exports: estimated to be between US$1 billion and US$3 billion. Among the 6 most relevant ICT clusters in India	

Appendix B Variables description and main statistics

Type	Variable	Description	Obs	Mean	Std. Dev.	Min	Max
Dependent	CollINN	Maximum geographic spread of the innovation network related to global collaboration for innovation Categorical variable: 0 no collaboration, 1 regional level at max; 2 domestic level at max; 3 international level at max; 4 global (among Triad and not Triad areas)	543	2.471455	1.476325	0	4
Independent	emergRIS	RIS in emerging economies =1, 0 otherwise	543	0.7569061	0.429347	0	1
	ICTRIS	Bangalore or Beijing or Stockholm =1, 0 otherwise	543	0.4364641	0.496404	0	1
Control	worldnew	Firms that have done new to the world innovation between 2006-2008 =1, 0 otherwise	543	0.2246777	0.417755	0	1
	worldnew*emergRIS	Interaction between the variables worldnew and emergRIS	543	0.1657459	0.372195	0	1
	ICT consultancy	Firms which ICT main area of focus ICT consultancy =1, 0 otherwise	543	0.1933702	0.395305	0	1
	salesabroad	Firms declaring a significant share of sales activity abroad =1, 0 otherwise	543	0.4622468	0.499032	0	1
	small (firm's size)	Firms with less than 50 employees =1, 0 otherwise	543	0.3941068	0.489109	0	1
	medium (firm's size)	Firms with employees between 50 and 249 = 1, 0 otherwise	543	0.3186004	0.466363	0	1
	large (firm's size)	Firms with 250 or more employees =1, 0 otherwise	543	0.2872928	0.452917	0	1
	HQ (firm's org type)	Headquarter of an enterprise group =1, 0 otherwise	543	0.2025783	0.402291	0	1
	standalone (firm's org type)	Subsidiary of an enterprise group =1, 0 otherwise	543	0.5653775	0.496164	0	1
	subsidiary (firm's org type)	Standalone of an enterprise group =1, 0 otherwise	543	0.2320442	0.422526	0	1

Appendix C Correlation between the variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13
(1)CollINN	1												
(2) emergRIS	0.1229*	1											
(3) ICTRIS	0.0007	0.0313	1										
(4) worldnew	0.1899*	-0.0241	-0.0823	1									
(5) worldnew*emergRIS	0.2034*	0.2526*	-0.0827	0.8280*	1								
(6) ICT consultancy	-0.0617	-0.2987*	0.0956*	-0.0289	-0.0803	1							
(7) salesabroad	0.4149*	0.2154*	-0.2127*	0.0850*	0.1033*	-0.0892*	1						
(8) small	-0.2373*	-0.5357*	0.0653	-0.0910*	-0.2480*	0.0918*	-0.2791*	1					
(9) medium	0.0601	0.2493*	0.0597	-0.0177	0.0566	-0.0245	0.0716	-0.5515*	1				
(10) large	0.1944*	0.3219*	-0.1320*	0.1165*	0.2095*	-0.0738	0.2277*	-0.5121*	-0.4341*	1			
(11) HQ	0.1371*	0.2215*	0.1108*	0.08	0.1327*	-0.0147	0.0382	-0.2283*	0.0881*	0.1559*	1		
(12) standalone	-0.2210*	-0.3410*	0.0375	-0.1066*	-0.2086*	0.1189*	-0.1558*	0.3194*	-0.0702	-0.2726*	-0.5749*	1	
(13) subsidiary	0.1289*	0.1895*	-0.1495*	0.049	0.1187*	-0.1255*	0.1466*	-0.1576*	-0.0013	0.1716*	-0.2771*	-0.6269*	1