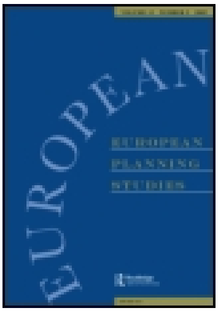

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Do Regions Make a Difference? Regional Innovation Systems and Global Innovation Networks in the ICT Industry

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ABSTRACT *Access to global innovation networks (GINs) has been unequal across the regions of the world. While certain regions are considered knowledge hubs in GINs, others still remain marginalized; this points to the role of regional innovation systems (RISs) in the emergence and development of GINs. Using firm-level data collected through a survey and case studies in 2009–2010, this paper systematically compares the patterns of global networks in the information and communications technology industry in a selection of European, Chinese and Indian regions. The results show that GINs are more common in regions which are not organizationally and institutionally thick, suggesting that GINs may be a compensatory mechanism for weaknesses in the RIS.*

Introduction

Globalization has come hand-in-hand with an increased role played by certain regions in the global economy (Amin & Thrift, 1994; Asheim & Isaksen, 1997; Chaminade & Vang, 2008; Cooke, 1992, 2001). Despite the opportunities offered by information and communication technologies (ICTs) for the transfer of (codified) knowledge, and the role that relational proximity may play in linking actors who are geographically distant (Boschma, 2005), global processes are still "pinned down" in certain regions around the globe (Amin & Thrift, 1994), making the access to global knowledge flows remain an unequal phenomenon across regions. In particular, it seems that only some regions are powerhouses or knowledge hubs in global innovation networks (GINs) (Chaminade & Vang, 2008).

Observed differences between sub-national regions around the globe could be explained by the different configurations of their regional innovation systems (RISs). A RIS can be

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defined as the "wider setting of organisations and institutions affecting and supporting learning and innovation in a region" (Asheim, 2009, p. 28). Already in 1994, Amin and Thrift had proposed a typology of RISs based on their institutional and organizational thickness which has given rise to a line of research that looks at the role of institutions in RIS and their influence in the geography of knowledge flows (Amin & Thrift, 1994; Asheim *et al.*, 2011; Tödtling & Trippl, 2005; Tödtling *et al.*, 2011). What has been missing so far, however, is an operationalization of the typology developed by Amin and Thrift (1994), and in-depth empirical investigations are rare. Within this stream of literature, it has been only very recently that certain authors have empirically analysed the relationship between RISs and certain forms of global interaction (Blažek *et al.*, 2011; Martin & Moodysson, 2013; Sotarauta *et al.*, 2011; Tödtling *et al.*, 2011 With few exceptions (Chaminade, 2011), the existing studies are mainly based on the analysis of cases and European regions, and principally aim to investigate how regions are linked with different geographical markets and technological sources of knowledge. We are therefore only just starting to grasp how different RISs are linked to different modes of GINs. A GIN can be defined as a "globally organized web of complex interactions between firms and non-firm organizations engaged in knowledge production related to and resulting in innovation" (Barnard & Chaminade, 2011, p. 3).

This paper, which is exploratory in nature, contributes to this latest line of research by extending the analysis to regions across the globe, particularly in emerging economies, and by looking at two modes of GIN: international collaboration for innovation, and international offshoring of innovation.

Using firm-level data collected through a survey in 2009–2010 in three European countries and two emerging economies (China and India), the paper addresses the relationship between different types of RIS—in terms of innovation dynamics and organizational and institutional thickness—and access to GINs across the globe.

The paper is structured as follows. The next section discusses the theoretical framework. The section on methodology describes the data sources used for the analysis and the method. The section following it describes the empirical analysis and summarizes the main results. The last section concludes with some remarks on policy implications.

Main Conceptual Framework

Globalization of Innovation: The Surge of GINs

Global production networks and the internationalization of production activities have been widely studied by scholars in economic geography (Coe *et al.*, 2008; Dicken *et al.*, 2001; Henderson *et al.*, 2002) and in international business (Cantwell & Piscitello, 2002, 2005, 2007; Dunning, 2001; Dunning & Lundan, 2009). But it is only recently that scholars in these fields of research have started to pay attention to the globalization of innovation activities and to the surge of GINs (Alvstam & Shamp, 2005; Archibugi & Iammarino, 2002; Barnard & Chaminade, 2011; Freeman *et al.*, 2010; Plechero & Chaminade, 2013; Zanfei, 2000).

GINs can be formed for the commercialization of new products and services in international markets, for the acquisition of embedded technologies, and for generating innovation through research collaboration or the offshoring of innovation (Archibugi & Michie, 1995; Plechero & Chaminade, 2013). The different types of GIN reflect different internationalization strategies which depend on whether the firm aims to exploit advantages that already exist (i.e. it is asset-exploiting) or to create new ones (i.e. it is asset-seeking) (Castellani & Zanfei, 2006; Dunning & Lundan, 2009). Asset-exploiting commonly refers to the development of new markets for existing products or services (Castellani & Zanfei, 2006), and it is often used in the innovation literature to refer to the export of innovations (Chen *et al.*, 2009). Asset-seeking strategies, on the other hand, usually refer to the acquisition of the knowledge and capabilities needed for the innovation process (Castellani & Zanfei, 2006; Dunning & Lundan, 2009), and can be pursued when GINs are established with the aim, for example, of sourcing and generating innovation.

International business literature has mainly limited its studies of the interplay between the region and the internationalization process to the spillovers of MNCs at the regional level (Cantwell & Piscitello, 2002; Jaffe *et al.*, 1993; Marin & Bell, 2006) or the characteristics of the host regions which are the preferred locations for foreign direct investment (Cantwell & Piscitello, 2007; Cantwell & Santangelo, 2002). The relationship between the dynamics of the home region in which the firm is embedded, and the decision to link internationally, has instead mainly been left to the economic geography discipline.

Types of RISs and Globalization

Over the last decade scholars in economic geography have been paying increasing attention to the role of global sources for the competitiveness of European firms and regions (Asheim & Gertler, 2005; Moodysson *et al.*, 2008). The main argument is that extra-regional sources of innovation are fundamental if long-term lock-in problems are to be avoided (Amin & Cohendet, 2004; Bathelt *et al.*, 2004; Tödtling & Trippl, 2005, 2011; Uzzi, 1997). Firms need regular access to knowledge produced elsewhere, especially when their activities require certain knowledge capabilities and resources that are not present in their regional pools at the quantity, cost or level that they require (Asheim, 2009; Asheim & Gertler, 2005; Asheim & Isaksen, 2002; Bathelt *et al.*, 2004; Gertler & Levitte, 2005; Moodysson, 2008). Scholars in this field of research have mainly studied how market and technological sources of knowledge may enter the region, and have paid particular attention to the conditions (type of RIS or structure of the knowledge base of the region[1]) favouring the flow of knowledge at different geographical levels. According to economic geographers, the degree to which innovation activities become globalized depends therefore not only on the strategy of the firm (as scholars in international business argue) but also on some "meso" conditions and the specific typology of RIS.[2]

The literature has largely demonstrated that different type of RIS may facilitate or hamper the exchange of knowledge (Asheim & Isaksen, 2002; Asheim *et al.*, 2011; Cooke, 1998, 2004; Cooke *et al.*, 1997; Morgan, 2007), shape the geography of the knowledge flows of a particular RIS (Amin & Thrift, 1994, Tödtling *et al.*, 2011) and be the main engine of change within the RIS (Boschma & Frenken, 2006, 2009).

In particular, the ability to upgrade regional assets using global networks requires the presence of local institutions which are able not only to sustain innovation but also to stimulate the local–global relationship (Bathelt *et al.*, 2004; Coe *et al.*, 2004). Innovation in general, and knowledge sharing in particular, is a social process that is shaped by institutions and that may depend on the specific organizational and institutional thickness of an RIS[3] (Amin & Thrift, 1994; Hollingsworth, 2000; Tödtling & Trippl, 2011).

RISs can be organizationally and institutionally thick or thin according to how different elements combine in them (Amin & Thrift, 1994). An RIS is organizationally and institutionally thick when there is a strong organizational infrastructure (i.e. there is a high number and wide diversity of organizations in that particular RIS, from firms to universities, research centres, financial institutions, chambers of commerce and government agencies), high levels of interaction among the local actors, a culture of collective representation, and shared norms and values which serve to constitute the social identity of a particular locality (Amin & Thrift, 1994). According to Cooke *et al*. (2000), organizationally and institutionally thick RISs are often located in metropolitan areas. Firms in thick RISs benefit from a dense network of support institutions and interactions take place often; in general, these regions, if not fragmented, also show high levels of innovation dynamics (Tödtling *et al*., 2011). Therefore, there is a strong relationship between organizational and institutional thickness and innovation. We will use the term "thick RIS" to refer to a RIS that is highly innovative as well as organizationally and institutionally thick.

Organizationally and institutionally thin RISs are instead usually to be found in less urbanized regions, and are characterized by the strong presence of small and medium enterprises (SMEs). They often have limited innovative capacity, lack support organizations and have a low level of agglomeration when compared to thick regions. According to Asheim *et al*. (2011, p. 1137),

> Less urbanized or peripheral regions, (...) are usually characterized by weakly developed RIS subsystems such as a lack of dynamic firms and knowledge-generating organizations. There is often a "thin" and less specialized structure of knowledge suppliers and educational institutions. Also, networks are rather weakly developed, in particular, those to more specialized knowledge suppliers such as universities and research institutes. As a consequence, innovation activities are often at a lower level and of more incremental nature compared with those of a well-developed "thick" RIS.

Although the typology of RIS according to their institutional and organizational thickness is well established in the literature (Asheim *et al*., 2011; Tödtling & Trippl, 2005; Tödtling *et al*., 2011), the operationalization and the empirical studies on the organizational and institutional thickness of a particular RIS are scarce, largely due to the difficulties of measuring most of the intangible elements that define the institutional thickness, and they are thus based on qualitative information collected in a specific location like Birmingham (Coulson & Ferrario, 2007) or Vienna and Salzburg (Tödtling & Trippl, 2005).

Despite the advances in economic geography in relation to the role that regional conditions play in the geography of knowledge flows, we are only just starting to grasp how different regions access GINs. An empirical study of ICT firms in Austria recently conducted by Tödtling *et al*. (2011) shows that while in a thick RIS (Vienna) firms will tend to establish more domestic linkages, in a thin RIS (Salzburg) firms will tend to establish more international linkages, not only because of the specificity of the industry and activity involved but also probably to overcome the limitations of the innovation system in which they are embedded. We may, therefore, expect that firms located in thick regions will engage more in local interactions than firms located in less favoured regions.

In general there are few attempts in the literature to analyse which type of regional system and regional institutional conditions influence access to GINs. First, this has only been done through cases and only in Europe. Second, the networks that have been investigated are mainly related to global sources of innovation, which underlines not only a passive role of the region as the mere recipient of innovation but also a limited type of GIN. Networks related to more active forms of engagement in GINs, like international collaborations for innovation and international offshoring of innovation, for example, are overlooked.

The extent to which a relationship exists between a specific type of RIS and GINs, and the positive or negative nature of that relationship, are investigated in this paper. This is done for a variety of regions across the globe and for one industry (ICT), thus following on the work by Tödtling *et al*. (2011).

Methodology

Sample

This paper is based on the INGINEUS database built for the multi-country research project INGINEUS sponsored by the 7th Framework Programme (FP7) of the European Commission with the purpose of gathering new data on GIN that could not be covered by existing databases such as the Community Innovation Survey. The database related to the specific ICT sector relies on a novel firm-based survey conducted for the project in 2009–2010 in five countries (India, China, Norway, Sweden and Estonia). In total, 936 responses were collected. To increase cross-country comparability the ICT sector comprises telecommunication equipment and software[4] and the firms selected are firms with more than five employees.

Due mainly to cultural, institutional and infrastructural differences each country team responsible for the survey in their respective country could not always use the methodology decided in common for gathering the sample and conducting the survey.[5] In Sweden, Norway and Estonia the selection of the sample has been done using official national public registers and the survey has been conducted electronically through a web-based survey tool. In India the database used is the NASSCOM that targets only regions in which there is an ICT specialization. In India the low electronic response rate obtained in similar previous national surveys made it preferable to use face-to-face interviews. In China due to the vastness of the geography and difficulty in having official statistics, different databases at the regional level owned by two research companies (Sinotrust and CVISC) have been used and the survey was conducted mainly by phone. Therefore, while in Estonia, Norway and Sweden the response rate has been very similar (respectively 14%; 11.9% and 10.3%), in China the response rate has been much lower 2.7% and in India much higher 25.2%. Where the data allowed we checked for the response bias and found that not respondents and respondents have no significant differences in terms of size and the specific ICT-related activity. Nevertheless, we have to acknowledge the existence of possible biases in terms of non-response and regional representativeness due to the different country sample selection. For this specific paper we consider only the regions for which the number of answers could be considered to be at least sufficient for running an empirical analysis.[6]

Table 1. Sample breakdown by country and regions

EU countries			Emerging economies		
Country	Region	No. of firms	Country	Region	No. of firms
Estonia		14	China		217
	Tallinn	14		Shenzhen	35
Norway		83		Shanghai	35
				Beijing	147
	Oslo and Akershus	63			
	Vestlandet	12			
	Nord-Norge	8			
Sweden		90	India		303
	Skåne region	16		Bangalore	50
	Stockholm	57		Trivandrum	20
	Göteborg	17		Mumbai	70
				Pune	20
				Hyderabad	26
				New Delhi	76
				Chennai	41
Total sample					707

Source: Authors' own elaboration of INGINEUS data.

Table 1 offers a summary of the responses received from the ICT industry in each region and in each country considered in this analysis. Smaller countries also have a lower number of firms representing the specific regions.[7]

Questions and Indicators Selected for the Analysis

The survey questionnaire consisted of 14 questions covering some background information on the main production activities of the firm, its organizational type, its size, its market, sales information and its R&D activity. The core of the questionnaire focused on the types of innovation, the geographic network and collaboration with customers, suppliers, universities, research institutions and government, the offshoring of production and innovation and the role of the institutional framework (mainly at national and international level) supporting or hampering access to GINs. All data collected referred to the years 2006–2008.

For this paper, we built some proxies to capture the firm's external network in terms of the geographical level of interactions and external relations (networks)[8] and the firm's innovation performance (Inno_Perform), by aggregating some of the survey questions. We also used some structural variables (size and organizational type of the firm) that may affect the capabilities of the firm to develop networks. Table 2 shows the indicators built on the survey questions and selected for the statistical and econometric analysis of this paper.

The Classification of Regions in Relation to Tiers

In order to assess the relationship between GINs and different types of RIS, all the cases in the sample were codified as belonging to a RIS classified as Tier 1, Tier 2 or Tier 3 accord-

Table 2. List of indicators from the survey questions used in the analysis

Indicator	Description	Details
Networks	Indicator capturing the firm's external network (in terms of geographical level of interactions and external relations)	Pseudo continuous variable built by factor reduction of the following variables: (a) Sources of technology (internal to the firm or external such as MNCs not formally connected, non-MNC firms and public industry organizations) (b) Collaboration for innovation with different types of partners such as clients, suppliers, competitors, consultancy companies, government and universities in different geographical locations (regional, domestic and international) (c) Linkages (e.g. research relationships) with different types of foreign organizations (clients, suppliers, competitors, consultancy companies, government and universities) (Min −1.32366; Max 2.79244) Factor analysis: VE = 46.89
Innovation performance (Inno_Perform)	Indicator capturing firm's innovation intensity	Pseudo continuous variable built by factor reduction of the following variables: (a) Presence of significant R&D activity (b) Full-time employees for R&D (c) Experience in world level innovation (Min −1.04059; Max 2.67445) Factor analysis: VE = 61.26
Collaboration for innovation	Indicator showing the maximum geographical spread of the firm's collaboration for innovation with external actors. International collaboration for innovation = geographical spread of collaboration that includes actors from international locations, including distant ones like China or India for European firms	0 = no collaborations 1 = max regional collaborations 2 = max domestic collaborations 3 = max collaboration in other international locations
Offshoring of innovation	Indicator showing if the firm has offshored innovation activities for the purposes of serving home country or global markets in a location outside the firm's home country	0 = no offshoring innovation 1 = offshoring innovation

(*Continued*)

Table 2. Continued

Indicator	Description	Details
Organizational form	Indicator capturing the firm's organizational form	Dummy variables Standalone = 1 if standalone, 0 otherwise Subsidiary = 1 if MNC subsidiary, 0 otherwise Headquarter = 1 if MNC, 0 otherwise
Size	Indicator capturing the firm's size (in terms of full-time equivalent employees)	Dummy variables Small = 1 if FTE $\leq$ 49, 0 otherwise Medium = 1 if FTE between 50 and 249, 0 otherwise Large = 1 if FTE $\geq$ 250, 0 otherwise

Abbreviation: FTE – full time equivalent.

ing to its innovation dynamism and organizational and institutional thickness. To define the three Tiers we combined quantitative (when available) and qualitative information, particularly in relation to ICT. That is, we consider an RIS to be thick or thin in relation to the institutional and organizational endowment for the ICT industry.

The European Regional Innovation Scoreboard 2009 (RIS Scoreboard, 2009), which classifies European regions according to different indicators of regional innovation performance related to the activities and output of firms in the region, can already be a good proxy for evaluating the degree of innovation dynamics of some of the RISs. Unfortunately, the indicators were basically available only for the three Norwegian regions and partially for the Stockholm region in Sweden.[9] While the Oslo & Akershus, Vestlandet and Stockholm regions perform well above the average of all the regions in the EU, the Nord-Norge region of Norway, for example, is much less dynamic in relation to the innovation output of its firms.[10]

To capture the organizational structure of the RIS (which is linked to the organizational and institutional thickness) we used the number of ICT firms in a particular region, the number of employees of the ICT industry in that region and, in some cases, the volume of exports in ICT compared, for example, to the average of the country, when that information was available. This latter information was used as a general proxy for assessing the organizational infrastructure of the region and, together with the innovation dynamic indicators, is the only pseudo-quantifiable measure we can consider. In general, statistics broken down at the level of the industry are scarce or even not available at all for the regions of developing countries.

Qualitative information was also collected through a literature review, cluster reports and consultation with country experts directly involved in the project. The qualitative information used in the analysis refers to the:

- Availability and quality of specialized universities, research centres and ICT specific intermediate organizations in the region.[11]
- The degree of ICT specialization in the regions, also in comparison with the country average.

- Other related elements used to assess the institutional thickness (levels of interaction, culture of collective representation and shared norms and values).

All the sources of information used for the classification into tiers are included in Table A1 in the appendix.

Basically, regions with the highest regional innovation dynamics and the highest concentration of educational facilities, firms and employment in the ICT industry and which had frequent interactions and a strong identity in that particular industry in that country were considered to have a Tier 1 RIS. Regions with an average number of firms and employment in that industry compared to the rest of the country, with some specialized supporting institutions and with weaker interactions, culture and shared norms, were classified as having a Tier 2 RIS. Those regions that had no specialization in that particular industry, and/or had a weaker institutional setting or weaker innovation dynamic compared to other regions in that country, were classified as having a Tier 3 RIS. The final classification of the regions into tiers was checked once again with industry experts in each country.

Table 3 summarizes which regions were classified as having a Tier 1, which a Tier 2 and which a Tier 3 RIS.

Tier 1 RISs are considered to be thick RISs. They are usually located in metropolitan areas with strong specialization and innovation in the ICT industry. For example, Stockholm in Sweden and Bangalore in India are considered to be the most important regions in the ICT industry not only in their specific countries, but also globally, since these regions can also count on strong organizational, institutional and infrastructural support in that industry (Hansen & Serin, 2010; Ptak & Bagchi-Sen, 2011).

On the other side of the spectrum, Tier 3 RISs are usually thin (peripheral) RISs for the ICT industry (Tödtling & Trippl, 2005). The number of firms specializing in ICT is low and/or there are not many specialized support organizations in ICT; this is the case for Trivandrum in India, Shanghai in China[12] and Nord-Norge in Norway.

In the middle, we can consider another category: Tier 2 RISs. These are usually secondary regions in the country, in which there is a significant number of firms which specialize in ICT, and there are also support institutions, but the regions are not yet very well networked and, in general, do not show the same institutional thickness or innovation

Table 3. Classification of regions by tiers

Tier 1	No. of firms	Tier 2	No. of firms	Tier 3	No. of firms
Stockholm	57	Göteborg	17	Nord-Norge	8
Oslo and Akershus	63	Skåne region	16	Trivandrum	20
Vestlandet	12	New Delhi	76	Shanghai	35
Tallinn	14	Mumbai	70		
Bangalore	50	Chennai	41		
Beijing	147	Hyderabad	26		
		Pune	20		
		Shenzhen	35		
Total	343		301		63

Source: Authors' own elaboration of INGINEUS data.

dynamics as those RISs considered to be Tier 1. One example could be the Skåne ICT region , which employs around 23,000 people; this is still very far from the number (over 100,000) of people employed in ICT in the Stockholm area (Tier 1), which is considered to be the hub of the ICT industry in Sweden. Moreover, although the organizations supporting firms are performing very well, there are not so many organizations which specifically support ICT as there are in Stockholm, since the region has other, more developed industries like the life sciences or the food industries (Martin & Moodysson, 2013). Some examples for India are Chennai, Hyderabad and Pune, which recently had an increase in ICT industry development, and some metropolitan areas such as New Delhi and Mumbai. Even though these regions perform well in terms of ICT, they are still below the great ICT specialization and performance of Bangalore (Grondeau, 2007; OECD, 2010; Ptak & Bagchi-Sen, 2011) in terms of number of indigenous and multinational firms, employment, innovation and exports.

Table 4 shows the specific characteristics of firms within different RISs in terms of innovation performance, organizational form and size.

In relation to innovation performance (Inno_Perform), firms in a Tier 1 RIS are on average the most innovative, while firms in a Tier 3 RIS are the least. In terms of organizational type, firms in a Tier 1 RIS are more likely to be headquarters of multinationals (20.66% of all the firms in regions with that tier) than firms in Tier 2 and 3 RISs. Regions with a Tier 3 RIS have a very low percentage of MNC headquarters, but a very high percentage of subsidiaries. Regions with a Tier 2 RIS represent something between the other two types of RIS, because there is a good presence of MNC headquarters but also a good presence of subsidiaries.

Concerning the size of firms, while the distribution of size in regions with Tier 1 and Tier 3 RISs is similar (the majority of firms are small enterprises with less than 50 employees), in regions with a Tier 2 RIS we can note that there is a much higher percentage of large firms (around 40% of all the firms in that RIS type). The structural characteristics of the region, in terms of the size and organizational form of the predominant firms in that RIS, will have an impact on the propensity to engage in GINs in general and in asset-seeking strategies in particular. In order to take into account the structural characteristics of those firms, we introduce a series of controls in the econometric analysis presented below.

Table 4. Structural characteristics and innovation performance of firms in regions classified as having a Tier 1, Tier 2 and Tier 3 RIS

	Size (% of total answers)			Organizational form (% of total answers)			Innovation performance
Tier	Small	Medium	Large	Headquarter	Subsidiary	Standalone	Inno_Perform (mean)
Tier 1 RIS	50.79	30.91	18.30	20.66	15.74	63.61	0.241969
Tier 2 RIS	26.12	33.58	40.30	16.27	31.86	51.86	0.101619
Tier 3 RIS	48.39	29.03	22.58	6.67	45.00	48.33	0.004852
Total	40.34	31.84	27.82	17.42	25.61	56.97	Sample mean 0.159043

Source: Authors' own elaboration from INGINEUS data.

The Role of RIS in Global Networks

Types of RIS and the Firm's Networks

To analyse whether there is a relationship between the different types of RIS (Tiers 1, 2 and 3) and the probability of engaging in networks that are geographically spread and involve different actors, we run an econometric analysis using as dependent variable a categorical variable (TIER) which takes the value 1 for the Tier 1 RIS type, 2 for the Tier 2 RIS and 3 for the Tier 3 RIS. The tiers are ordered on the basis of their RIS thickness, where Tier 1 has the highest level of organizational and institutional thickness and innovation dynamics and Tier 3 the lowest. We can exploit this information regarding their order using an ordered logit model. However, the Brant test certified that the effect of the regressors on the probability of moving from one category group to the next depends on the tier of origin, violating the proportional odds assumption. We thus applied the generalized form of the ordered logit model, which relaxes this assumption allowing for different coefficients to be estimated for different categories (Williams, 2006. For an application see, among others, Pierre & Scarpetta, 2006). The main independent variable is Networks, a proxy capturing the firm's external network in terms of the geographical level of interactions and external relationships, as described in Table 2. We control for size, organizational form and innovation performances of the firms (Inno_Perform). Table 5 plots the results.

As the table shows, the coefficient of Networks is significant and positive in model I, and significant and negative in model II. This means that firms in regions with a Tier 2 RIS collaborate with a larger number of external and geographically spread networks than firms in regions with a Tier 1 or Tier 3 RIS. Moreover, the results also show that while a larger number of innovative firms tend to concentrate in regions with a Tier 1 RIS (as the significant and negative coefficient of Inno_Perform in model I shows), these firms are less likely to participate in networks that are more spread and involve different actors than firms in regions with a Tier 2 RIS. We also observe that the specific structural characteristics of the firm (size and organizational form) do matter when placing the firm in a region with a specific tier. Table A2 in the appendix presents the main statistics related to the variables and the correlation between the variables.

This first analysis shows only that a relationship between the different types of tiers and the spread of the network exists.[13] To assess if these networks are indeed international and related to firms' active involvement in innovation, we look specifically at the relationship between tiers and, on the one hand, networks related to international collaboration for innovation and, on the other hand, networks related to offshoring of innovation. To test if the differences between firms in different RIS Tiers are significant in terms of GINs we use a χ^2 test.

Types of RIS and International Collaboration for Innovation

As we can observe from Table 6, firms in all the RIS tiers show a good involvement in international collaboration for innovation, but firms in Tier 2 RIS show the highest percentage of involvement:[14] Around 51% of firms in Tier 2 RIS are involved in international collaboration, against around 42% of firms in Tier 1 RIS and 35% of Tier 3 RIS. Firms in Tier 1 RIS instead show the highest percentage of collaboration for innovation that is not international (approximately 40% of firms in this RIS type have collaborated for inno-

Table 5. Generalized ordered logit model

Model I (from Tier 1 to Tiers 2 and 3)	
Networks	0.288***
	(0.092)
Inno_Perform	−0.352***
	(0.098)
Medium	0.712***
	(0.218)
Large	1.186***
	(0.258)
Headquarters	−1.133***
	(0.278)
Standalone	−0.800***
	(0.222)
Constant	0.205
	(0.223)
Model II (from Tiers 1 and 2 to Tier 3)	
Networks	−0.458***
	(0.169)
Inno_Perform	−0.015
	(0.160)
Medium	−0.055
	(0.349)
Large	−0.357
	(0.421)
Headquarter	−1.743***
	(0.551)
Standalone	−1.472***
	(0.335)
Constant	−1.297***
	(0.305)
N	579
Ll	−482.706
LR χ^2 (12)	108.69
P	0
Pseudo R^2	0.1012

Note: Standard errors in parentheses.
*$p < .10$.
**$p < .05$.
***$p < .01$.

vation only at a regional or, at most, at a national level, against around 22.5% of firms in Tier 2 and 24% of firms in Tier 3). Regions with a Tier 3 RIS also have fewer firms involved in any type of collaboration for innovation (more than 40% of the firms in such RIS tier did not develop any type of collaboration in the years 2006–2008). The differences between the figures for the three tiers in terms of collaboration for innovation are robust since the χ^2 test is significant at the 1% level ($p < .01$).

Regarding the structural characteristics of the firms located in a particular RIS, we checked what type of firm in the different RIS tiers performs better in international collaboration for innovation. While firms in Tier 1 RISs are mainly the headquarters of MNCs that are engaged in international collaboration (around 52% of all the headquarters are in

Table 6. Maximum geographical spread of collaboration for innovation by tiers

	Tier 1	Tier 2	Tier 3	Total
No collaboration				
No. of firms	61	79	26	166
% row	37.75	47.59	15.66	100
% column	17.78	26.25	41.27	23.48
Regional collaboration				
No. of firms	33	25	5	63
% row	52.38	39.68	7.94	100
% column	9.62	8.31	7.94	8.91
National collaboration				
No. of firms	104	43	8	157
% row	66.24	27.39	6.37	100
% column	30.32	14.29	15.87	22.21
International collaboration				
No. of firms	145	154	19	321
% row	45.17	47.98	6.85	100
% column	42.27	51.16	34.92	45.40
Total				
No. of firms	343	301	63	707
% row	48.51	42.57	8.91	100
% column	100	100	100	100

Source: Authors' own elaboration of INGINEUS data.
Note: Pearson χ^2 (6) = 38.8719, Pr = 0.000.

Tier 1), in regions with Tier 2 and Tier 3 RISs international collaboration is done mainly by subsidiaries (around 70% of the subsidiaries in Tier 2 and around 44.5% of the subsidiaries in Tier 3 are involved in international collaboration). This is interesting if we take into account the fact that the variable "collaboration for innovation" captures external networks, and not the networks between the subsidiary and the headquarters. In terms of size, large firms perform better in all the tiers. In particular in Tier 2 RISs around 68.5% of the large firms collaborate for innovation at a global level. In Tier 1 and Tier 3 RISs, the percentage is lower, being, respectively, 53.5% and 43% of large firms.

Types of RIS and International Offshoring of Innovation

As another proxy for the global generation of innovation we consider the firms that in our sample have done international offshoring of innovation activities. As can be observed from Table 7, Tier 2 RISs host a higher proportion of firms offshoring innovation activities abroad than Tier 1 and Tier 3 RISs (around 28% of firms in Tier 2 as against around 20.5% of firms in Tier 1 and 18% of firms in Tier 3).

The differences between the three tiers in terms of offshoring innovation are robust since the χ^2 test is significant at the 5% level ($p < .05$).

In the same way as we did for collaboration for innovation, we also checked for the structural characteristics of the firms located in each tier for offshoring of innovation. In regions with Tier 1 and Tier 2 RISs, it is mainly the MNC headquarters that are involved in the generation of innovation (around 35% of the MNC in Tier 1 and 48% of the MNC in Tier 2 are offshoring innovation abroad), despite the fact that regions with a Tier 2 RIS

Table 7. Offshoring of innovation by tier

	Tier 1	Tier 2	Tier 3	Total
None				
No. of firms	243	212	50	505
% row	48.12	41.98	9.90	100
% column	79.41	71.62	81.97	76.17
International offshoring				
No. of firms	63	84	11	158
% row	39.87	53.16	6.96	100
% column	20.59	28.38	18.03	23.83
Total				
No. of firms	306	296	61	663
% row	46.15	44.65	9.20	100
% column	100	100	100	100

Source: Authors' own elaboration of INGINEUS data.
Note: Pearson χ^2 (2) = 6.2745, Pr = 0.043.

host more subsidiaries than headquarters. In regions with a Tier 3 RIS it is instead the subsidiaries that are involved (probably indirectly through their MNC headquarters) in this type of network (33% of subsidiaries in Tier 3). As for collaboration for innovation in terms of size, in all the three RIS tiers the large firms perform better than SMEs; this is particularly the case in Tier 2 RIS (50% of large firms in Tier 2 31% of firms in Tier 1 and 28.5% of firms in Tier 3).

Conclusions

This paper contributes to the recent literature linking the institutional and organizational thickness of an RIS to the geography of knowledge flows by analysing RISs in both developed and emerging economies. Our data confirm that the type of RIS matters for GINs, and that the organizational and institutional thickness of an RIS, and its innovativeness, are crucial elements for explaining the access to some modes of global generation of innovation: international collaboration for innovation and offshoring of innovation. Table 8 summarizes our results. The findings underline the fact that firms in regions with RISs that are neither too thick nor too thin engage more in GINs. What the results seem to suggest—in line with Barnard and Chaminade (2011)—is that engaging in GINs is costly and hard to maintain, and that firms engage in different forms of GIN only when they cannot find the resources they need to innovate in their close proximity. Firms that are located in thick regions, those with a Tier 1 RIS, tend to network for innovation with other firms and organizations that are in close proximity, or with domestic actors, so they may not have a strong need to develop asset-seeking strategies at the global level. This is in line with Bode (2004, p. 51) and Tödtling *et al*. (2011) who assert that innovative and well-functioning RISs have a tendency to exploit knowledge resources which are nearby, since knowledge from abroad is subject to transactional costs or distance decay.

When the need for extra-regional asset-seeking strategies exists (as in regions with a Tier 3 RIS) firms may not have the capability or the absorptive capacity to engage in

Table 8. Summary of results

	Characteristics of firms in each tier	Insertion in GINs
Tier 1 – THICK RIS – innovative, and organizationally and institutionally thick RIS	The higher proportion of MNCs headquarters is located in this tier, but also a high proportion of SMEs. Firms in Tier 1 RIS are on average the most innovative	Local and domestic collaborations for innovation are more important for firms in this tier. The large number of MNCs sustains the GIN in particular: 52% of MNCs are engaged in international collaboration, and 35% in international offshoring of innovation. Firms in this tier are somehow very innovative and networked, but not so global (gIN)[a]
Tier 2 – NEITHER THICK NOR THIN RIS Some elements of a Thick RIS but not all of these are fully developed	The higher proportion of large firms is in this Tier 2. Good distribution of both subsidiaries and MNC headquarters in the Tier. Firms in Tier 2 RIS are on average less innovative than firms in Tier 1 RIS, but more innovative than firms in Tier 3 RIS	Firms located in Tier 2 RIS show a higher propensity to engage in external and geographically spread networks and in GINs related to collaboration for innovation and offshoring of innovation. Larger firms in this tier perform better in GIN than SMEs. They also perform better than the large firms in Tier 1 and Tier 3 RISs. 68.5% of large firms in this tier are engaged in international collaboration, and 50% of them in offshoring of innovation. Subsidiaries perform well in international collaboration for innovation, and MNC headquarters in offshoring of innovation Firms in regions with this tier are global, innovative and networked, although not as innovative as those in Tier 1 RIS (GiN and GIN)
Tier 3 – THIN RIS – not so innovative, and organizationally and institutionally thin RIS	Small proportion of MNC headquarters, but larger proportion of subsidiaries and standalone firms. Half of the firms are also small. Firms in Tier 3 RIS are on average the least innovative	Firms in Tier 3 RIS show the smallest propensity to engage in external and geographically spread networks. A very high percentage of firms in this tier are not involved in collaboration for innovation at all. Even though the proportion of firms engaged in international collaboration is less than in Tiers 1 and 2 RISs, there are more firms engaged in international collaboration than there are firms engaged only in domestic and local collaboration. The firms in this tier are also more engaged in offshoring innovation activities than firms Tier 1 RIS. It is the subsidiaries that engage (mainly indirectly) in GINs in this tier: 44.5% of the subsidiaries are engaged in international collaboration and 33% in offshoring. In comparison with the other two tiers, firms in Tier 3 RIS are mostly not networked, not innovative and not global (gin)

[a]We use lower or upper case letters here to refer to a high or low degree of being global, being innovative and being networked.

GINs. As the data show, firms in regions with a Tier 3 RIS are the least innovative, and a large percentage of them (around 41%) are not involved in any type of collaboration at all. The firms in regions having this type of RIS which are involved in global generation of innovation are mainly subsidiaries of MNCs located abroad, and are therefore probably only indirectly involved in the participation in GINs by the MNC's headquarters.

Firms in regions with a Tier 2 RIS, which is neither too thick nor too thin in terms of innovation and institutions, instead have the need to engage, and the possibility of engaging, in GINs. Indeed, firms located in these regions show a higher propensity to engage in geographically spread networks for collaboration in innovation and in international offshoring of innovation. Our results confirm therefore the Tödtling *et al*. (2011) study about thin and thick regions and their propensity to link internationally, but show also that too much regional organizational and institutional thinness, as in the case of Tier 3 RIS, may represent a disadvantage.

We also observe that the structural characteristics of the firms present in the region are very important in determining the capabilities of a system of linking with GINs. The analysis suggests that not all firms in a region have equal possibilities of engaging in GINs; it is mainly the large firms and the multinationals (either headquarters or subsidiaries) that have the competences to engage.

These results have important policy implications. A Tier 3 RIS may need extra effort to support and stimulate the system, both in terms of absorptive capacity and in terms of international but also domestic and local linkages (for example by creating incentives for sustaining general networking and the presence of foreign MNCs). In a Tier 2 RIS policies may instead be dedicated to sustain in a more efficient way the global knowledge linkages already present, so that there can be a more positive knowledge spillover effect on the regional industrial structure particularly from those firms involved in GIN that may act as key players and knowledge gatekeepers in the region. Policy-makers in Tier 1 RISs instead need to pay attention to possible situations of lock-in derived from a system of endogenous development that is too strong and that may require more government initiatives related to opening the region to external global knowledge flows. Most of the Tier 1 RIS analysed in this paper represent indeed the regional capitals for the ICT industry at national, and some at global, levels. Looking at their potential role in the global ICT industry, opening to external knowledge linkages is a strategy that can benefit the whole industry.

This paper is only a first attempt to provide an analysis of RISs in both developed and emerging economies. As any explorative analysis using novel, dedicated survey data, ours has some limitations. First, the lack of available quantitative data on the organizational and institutional thickness, the type of questions used in the survey and the different distribution of firms in regions in the three tiers (with a smaller sample for Tier 3) limits the possibility of doing a more sophisticated econometric analysis. Second, due to the difficulty in running the same survey in different countries, the sample may not be completely representative of the population in the RIS under analysis in terms, for example, of size and organizational form, and this may influence the results of the analysis. Due to these limitations, the analysis is exploratory in nature. The value of our study lies in providing unique insights into the links between regional diversity and GINs with a wider geographical scope.

Despite the limitations, the results are in line with recent studies on the relationship between institutional thickness and the geography of knowledge networks (Tödtling *et al*., 2011) for a larger number of regions and countries. Further research is needed in order to create a more fine-tuned typology of RIS that may count for the variation that exists also inside each tier category, and to explore the differences between tiers and level of development, i.e. to investigate whether categories of tiers in developed countries differ from those in developing countries.

Notes

1. RIS scholars argue that the nature of the knowledge prevailing in a certain industry may change the probability of there being links with global knowledge (Asheim & Coenen, 2005). Industries and activities characterized by analytical knowledge bases, like biotechnology, often rely on codified knowledge that is easier to transfer from and to geographically distant locations. On the other hand, industries characterized by synthetic knowledge bases, like some segments of the automotive industry, are dominated by tacit knowledge and practical skills, which makes their internationalization more difficult.
2. For an overview of different typologies of RIS see Tödtling and Trippl (2011).
3. The institutional thickness of a RIS can be defined as a combination of factors, including a strong organizational structure, high levels of interaction, a collective representation by many bodies, a common industrial purpose and shared cultural norms and values (Amin & Thrift, 1994).
4. NACE codes 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.
5. EU (2009) contains the detailed methodological aspects related to the sample and the survey conducted in each country.
6. We have excluded regions with only a few cases.
7. For more information about the data, refer to the public methodological report available at http://ingineus.eu/UserFiles/INGINEUS_D2.2_MethodologyReport%281%29.pdf.
8. The specific variable "networks" was used in another empirical analysis based on the same data. For further details see De Fuentes and Chaminade (2011).
9. For Sweden, there is no detailed information about the Skåne region and Göteborg area. For Tallin in Estonia the RIS is aggregated at the level of the country, so it is impossible to distinguish the regional performance of firms located in the Tallin area from that of firms in other regions in the country.
10. The indicator for the output is only available for the year 2004.
11. In most cases, when the information is available it does not refer to a particular industry.
12. China is a very dynamic country. At the time that this research was conducted, Beijing and its neighbouring provinces were considered to have a Tier 1 RIS for ICT while Shanghai, being the automotive hub, was considered only a peripheral region for ICT. This may be changing very rapidly as more and more ICT companies are establishing subsidiaries in Shanghai as well.
13. Due to the presence of many dummy variables, the econometric models with TIER as independent variable and Networks as dependent variable were less reliable. With our analysis we cannot really assess the 'direction of the causality' of the relationship but only certify that a correlation exists.
14. Even when we tried to separate the international collaboration for innovation done with other firms and related specifically to the insertion in "global value chain" (e.g. suppliers, clients) from the collaboration for innovation done with other organizations (consultancy companies) or knowledge providers (universities and research organizations), the results do not change. Firms in regions with a Tier 2 RIS still have the highest percentage of involvement in international collaboration for innovation.

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Appendix

Table A1. Information and references related to the type of RIS tier in the different regions

	Some information	Main references for the information collected on RIS quality and ICT regions
Tier 1 RIS		
Tallin	ICT employees at the regional level make up 60–70% of the ICT employees in the whole country	Kalvet (2004)
Oslo and Akershus Vestlandet	Around Oslo there are three ICT clusters. About 60% of ICT companies are located there. This area accounts for approximately 45,000 employees in this industry (ICT provides 7.55% of total employment)	RIS Scoreboard (2009) Transform (2006) Hansen and Serin (2010) Rekene project report (2011)
	Vestlandet is considered to be in the vanguard in EU for ICT industry, growth and GDP, with a high level of regional innovation performance, in particular for the enablers	
Stockholm	The Stockholm area employs around 100,000 people in the ICT industry (ICT provides 9.86% of total employment) and is considered a leading region in the EU	RIS Scoreboard (2009) Transform (2006) Hansen and Serin (2010)
Beijing	A leading region in China in terms both of its research infrastructure and of its innovation performance, with a specialization in high tech industries. It includes more than 8129 software firms	National Bureau of Statistics of China (2009) Guan *et al.* (2009)
Bangalore	RIS world leader in ICT (mainly software)	Malik and Ilavarasan (2011)
	In Karnataka state where Bangalore is located, there are around 554,000 employees in the software industry (2009). Software exports were above 17 billion US$ (34% of total in India) in 2008/2009	Ptak and Bagchi-Sen (2011)
Tier2 RIS		
The Skåne region	The Skåne region employs around 23,000 people in the ICT industry	Hansen and Serin (2010)
Göteborg	The ICT industry in Göteborg grew recently with Ericsson and Volvo IT driving innovation. There are around 4700 ICT companies with 22,000 employees	Franzén and Wallgren (2010)
Schenzhen	Around 3000 ICT manufacturing firms, high concentration of ICT firms in the region, but less technological interaction	Wang *et al.* (2010)

(*Continued*)

Table A1. Continued

	Some information	Main references for the information collected on RIS quality and ICT regions
Hyderabad; Chennai; Mumbai; Pune; New Delhi	All these regions are increasing their role in the ICT industry and developing services and infrastructure supporting the industry in the RIS. The RISs of Mumbai, Pune, New Delhi and Hyderabad are becoming stronger	Ptak and Bagchi-Sen (2011)
	In Pune the ICT industry is increasing. In this region there are 200,000 employees in the ICT industry and exports software earning around 3.5 billion US$	Malik and Ilavarasan (2011)
	Hyderabad's ICT export is estimated to be around 4.7 billion US$	MCCIA (2008)
	New Delhi's export of ICT is between 1 and 3 billion US$	Grondeau (2007)
	Chennai's software export is estimated around 3.8 billion US$	OECD (2010)
Tier3 RIS		
Shanghai	Shanghai plays a key role in heavy industry and financial services, but is still not internationally competitive in the high tech industry, so the institutions and quality of innovation systems for the ICT industry in this region are still marginal with respect to other parts of the country. Due to the recent rapid development, Shanghai has a series of urban problems (inequality of resources, social problems, lack of adequate infrastructure) compared to other regions where an ICT specialization is present	Abelson (1999) Yang (2002)
Trivandrum	Trivandrum's export of ICT is less than 1 billion US$	Malik and Ilavarasan (2011)
Nord-Norge	This is considered a potential region in terms of ICT, but the innovation activities and innovation output of firms in this region are still at a fairly low level	RIS (2009) Transform (2006)

Table A2. Main statistics related to the variables and correlation between the variables

Variable	Obs	Mean	SD	Min	Max
TIER	707	1.60396	0.6465302	1	3
Networks	646	0.062797	1.085694	−1.323656	2.792436
Inno_Perform	678	0.1590432	1.01533	−1.040586	2.674453
Small	647	0.4034003	0.4909593	0	1
Medium	647	0.3183926	0.4662131	0	1
Large	647	0.2782071	0.4484627	0	1
Headquarter	660	0.1742424	0.3796055	0	1
Standalone	660	0.569697	0.495494	0	1
Subsidiary	660	0.2560606	0.4367867	0	1

Variable	TIER	Networks	Inno_Perform	Small	Medium	Large	Headquarter	Standalone	Subsidiary
TIER	–								
Networks	0.0826*	–							
Inno_Perform	−0.0811*	0.2824*	–						
Small	−0.1351*	−0.2832*	−0.3212*	–					
Medium	0.006	0.0344	0.0846*	−0.5620*	–				
Large	0.1416*	0.2738*	0.2629*	−0.5105*	−0.4243*	–			
Headquarter	−0.1011*	0.1422*	0.2741*	−0.2310*	0.0871*	0.1648*	–		
Standalone	−0.1207*	−0.2507*	−0.3014*	0.3384*	−0.0863*	−0.2845*	−0.5285*	–	
Subsidiary	0.2248*	0.1602*	0.1045*	−0.1799*	0.0209	0.1774*	−0.2695*	−0.6751*	–

Note: $^{*}p < .05$.