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PREFACE

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In the recent past, many firms have started developing innovation networks whose reach are no longer limited to advanced economies, but extend to selected developing countries. These global innovation networks (GINs) are perhaps changing the geography of knowledge-intensive activities in the world economy. They seem to differ from previous forms of globalisation where networks involved developing country firms only in global production networks (GPN). Now, many firms increasingly also offshore or even outsource R&D and innovation to firms in the South. In turn, firms from the South increasingly seek knowledge in advanced economies as well. Thus, the production of knowledge is becoming more decentralised across space, albeit unevenly. The objective of this comprehensive research report is to bring forward the major results of the INGINEUS project, and on that basis, to identify some of the most relevant policy implications.

The internationalisation of R&D and innovation is still a relatively marginal phenomenon, but it is growing rapidly (Archibugi and Iammarino 2002; Wooldridge 2010). It is strongly linked to the strategies of multinational firms (Narula and Zanfei 2005) (OECD 2007) on the one hand and the emerging capabilities of regions and countries to absorb and produce knowledge on the other. How exactly it manifests itself differs across sectors (Filippaios, Papanastassiou et al. 2009) and national innovation systems (NIS) (Carlsson 2006) but there seems to be a general understanding that the more internationalised NISs are associated with higher innovation performance (Taylor 2009).

However, this leaves many questions unanswered. They include, among others, the functional configuration of global innovation networks in space (how global?), the nature of their activities (how much innovation?), and the processes by which they are pursued (how networked?). Getting clarity on these questions is in part a matter of clarifying an emerging taxonomy. But more importantly, they help establish the relevance of GINs for development, growth, and innovation.

Global innovation networks (GINs) evolve out of and in interaction with national and regional innovation systems. As a result, such systems may themselves change, depending among others on how successfully they participate in the globalisation of knowledge-intensive activities. Within these systems, firms pursue strategies to position themselves in GINs that are either helped or hindered by the relevant institutional framework under which they operate. This includes not only explicit innovation policies but also the education and training infrastructure, the relationships between firms and universities and other knowledge producers, the migration regime that influences where globally scarce knowledge workers settle, and relevant intellectual property regimes. In short, a regional or national system can support the exploitation of technological opportunities within GINs, but it can also lock firms into trajectories where emerging GINs bypass them in favour of other locations whose capabilities are more suited to the networked production of knowledge in an increasingly global context. Conversely, GINs can strengthen or weaken regional or national innovation systems.

The goals of this comprehensive report based on the WP10 of the INGINEUS project are to:

- Summarize and reflect upon the most relevant dynamics of GINs, on the basis of the most relevant research findings of the INGINEUS project. This will be undertaken by chapters 2-9 of this comprehensive report.
- Reflect upon GINs opportunities and challenges for the EU and other economies; as well as discuss the implications of GINs or the next 10-15 years. This will be undertaken by chapter 14, which summarizes the results of the 2-days foresight exercise conducted by SPRU at Brighton in September 2011, where top civil-servants and other stakeholders discussed these matters.
- Analyze the policy-related institutional aspects that affect the features and development of GINs between Europe and the latecomer economies studied, and derive specific innovation policy options for the EU, its member states and for latecomer countries. This will be undertaken in chapter 15 on the overall policy implications of the INGINEUS project.

During the course of the INGINEUS project we faced an especially sad circumstance when Jo Lorentzen (Jochen Peter Lorentzen) passed away in February 2011 while jogging in Pisa (Italy). He was only 48 years old. His friends and colleagues at INGINEUS remain shocked and deeply saddened by this terrible loss. Jo was a lively and highly engaged person with a deep commitment to making this world a better place.

Jo was a Chief Research Specialist in the Education Science and Skills Development programme at the Human Sciences Research Council (HSRC) in Cape Town, South Africa. He obtained his master's degree at the American University in Washington, US and his PhD at the European University Institute in Florence, Italy. In the early 1990s he helped set up the Central European University in Prague and Budapest. Before moving to South Africa in 2003, Jo was Associate Professor of International Business at Copenhagen Business School in Denmark (CBS). He spent the 2003/04 academic year on sabbatical at the School of Development Studies at the University of Kwazulu-Natal, where he became an honorary research fellow. At HSRC, Jo built a team of passionate researchers studying the impact of innovation on development in latecomer and poor countries and regions.

Jo was mainly interested in microeconomic perspectives on technological learning and their implications for innovation and industrial policy in latecomer countries. At the time of his sudden departure, he was running a study of the determinants of innovative activities in the Western Cape, focusing on the wine industry, boatbuilding, medical devices, and IT. He also worked closely with the Western Cape provincial government, and taught on competition policy, intellectual property rights, and science and technology in developing countries at the University of Cape Town.

Jo was a driving force in the creation and the life of INGINEUS project. This is the reason why, on behalf of the entire research team, we would like to dedicate this comprehensive research report to him.

In loving memory of Jo Lorentzen

(21st April 1962 – 15th February 2011)

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1 GLOBAL INNOVATION NETWORKS: PATTERNS AND RELATIONS TO INSTITUTIONAL FRAMEWORKS

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Abstract: The growing reach of global innovation networks (GINs) during the past decade is a hallmark of a new geography of knowledge in the world economy, and of the rising innovative capacity of the more advanced developing countries, such as Brazil, China, India and South Africa. This paper conceptualises global innovation networks by raising questions about their emerging patterns and dynamics, and about their effects on and interaction with local and national institutional frameworks. We will address these questions by drawing on organisational theories of innovation networks and processes, as well as on institutional theories of innovation systems. On this basis, we will formulate four overall propositions that will lead to the questions formulated in the papers of this special issue. These propositions are that global innovation networks involving emerging economies are increasingly becoming "knowledge-exploring", rather than merely "knowledge-exploiting"; that there are important differences across global innovation networks according to the knowledge bases of different industrial sectors; that global innovation networks are changing the geography of locational attractiveness for knowledge-intensive activities; and that global innovation networks might potentially exercise a significant impact on national and regional innovation systems by mobilizing local networks differently, and by supporting catching-up processes in developing countries through the upgrading of human capital and the strengthening of local organisational linkages. All this has important implications for the comparative performance of institutions in national and regional systems of innovation, not least their degree of openness and internationalization.

Keywords: Globalization, Innovation Systems, Innovation Networks, R&D Offshoring

1.1 Introduction

In February 2009 Novozymes, a Danish world leader in enzyme production for biofuels, announced an agreement with two state-owned Chinese companies, Sinopec (petroleum) and COFCO (foodstuffs), to develop commercial-scale cellulosic ethanol production from agricultural waste in China. The initiative positioned these companies strongly in the Chinese market for second-generation ethanol, which is generated from waste materials, rather than crops. Novozymes' research and development (R&D) centre in the Zhongguancun Science Park in Beijing, established in 1995, has been a central element in this strategy, which involves important research, as well as production activities. In 2010 the competition for cellulosic enzymes in the US market for ethanol led to the launch of new enzymes, resulting in considerable price reduction. Novozymes' strategy is to team up with leading local players, and, just as in China, arrange collaborations with, among others, Poet LLC in the US; Petrobras and CMC in Brazil; and Praj in India. Novozymes' research centres in China, India, Brazil, Denmark and the US are crucial to this strategy, and secure close co-operation with other firms, universities and research centres across the globe. Yet, with the rapid development of technological solutions for this new generation of ethanol, the fall in prices, and the large-scale demonstration plants scheduled to be built in the near future in virtually all the large world markets, the barriers this product might be facing will soon be mainly institutional. In spite of some national and regional governmental support for collaborative R&D in this field, important barriers to commercial success are, among others, the lack of an ethanol fuelling infrastructure, the regulatory limits to the amount of ethanol that can go in car engines, and the lack of distinction between crop- and waste-based ethanol. Likewise, the introduction of this product is likely to be different in the various regions, depending on levels of consumer confidence and engagement of lead users. For that reason, the success of this product will depend on the ability of Novozymes and its network partners to mobilise local organisations to address problems that might emerge in the introduction phase.

This example illustrates the fact that, during the past decade, many firms have been engaging in innovation networks whose reach is no longer limited to developed economies, but extends increasingly to advanced developing countries, notably the so-called BRICS countries (Brazil, Russia, India, China, and South Africa). The internationalisation of R&D and innovation has been growing rapidly during the past decades (Archibugi and Iammarino, 2002); (Wooldridge, 2010), driven, among other factors, by the organisational changes in science and new forms of knowledge production (Drori et al., 2003), by the extensive use of sophisticated information and communication systems that allow for managing complex cross-border innovation projects and processes, by the decentralizing strategies of multinational firms (Narula and Zanfei, 2005), and by inventors' willingness to access new markets (Guellec and van Pottelsberghe de la Potterie, 2001). Some factors usually associated with the globalisation of innovation are the gradual liberalisation of international trade and investment regulations; the rapid shortening of product lifecycles; the rapid pace of new knowledge-creation; and the considerable improvement and cost reduction in transport and communication across the globe over the past decades (Lundvall and Borrás, 1998).

Admittedly, innovation networks are not a new phenomenon. Innovation is essentially a social process, and therefore intrinsically relational. Yet the most remarkable novelties in the organisation of innovation are the intensity of the networks and their geographical spread. Firstly, network intensity results from the increasing reliance by firms on external knowledge sources for generating innovation (Hagedoorn and Duysters, 2002); (Chesbrough, 2003), mostly as a response to the rapid market and technical changes mentioned above (Frost, 2001). The use of external sources of knowledge registers positively in the innovative performance of firms, albeit only up to a certain point (Laursen and Salter, 2006). Firms establish collaboration with external organisations in order better to exploit their own knowledge, and to tap into complementary knowledge. With the rise in the intensity of global competition, the engagement in networks has become a central tenet of competitive strategy. Secondly, the growing geographical footprint of innovation has resulted from a general increase in firms' R&D investments during the past decade. Although the greatest share of global R&D continues to be in the developed world, there has been a remarkable increase in foreign direct investment (FDI) directed towards R&D in emerging knowledge economies (Bruche, 2009). This is mirrored by the rapid growth of domestic investment in R&D in these countries, and their improvement in terms of knowledge capabilities more generally (Pilat et al., 2009).

The Novozymes case also exemplifies the importance of institutional frameworks in which GINs are embedded. GINs evolve out of interaction with national and regional innovation systems. As a result, such systems may themselves change, depending on how successfully they engage with the globalisation of knowledge-intensive activities. How exactly this manifests itself differs across sectors (Filippaios et al., 2009), national innovation systems (NIS) (Carlsson, 2006), and regional innovation systems (Asheim et al., 2010). What seems to be uncontested, however, is that the more internationalised firms and innovation systems are, the higher their innovative performance (Belussi et al., 2010); (Taylor, 2009). Within these systems, firms pursue global innovation network strategies that are either helped or hindered by the institutional framework under which they operate. This includes not only explicit regulatory or innovation policy, but also the education and training infrastructure, the relationships between firms and universities and other knowledge producers, the migration regime that influences where globally scarce knowledge workers settle, and relevant intellectual property regimes. In short, much as a regional or national system can support the exploitation of technological opportunities within GINs, it can also lock firms into trajectories where emerging GINs bypass them in favour of other locations, whose capabilities are more suited to the networked production of knowledge in an increasingly global context. Conversely, GINs can strengthen regional or national innovation systems.

Despite the anecdotal evidence and conjecture mentioned above, the truth is that we still know very little about global innovation networks. Above all, there is a need to generate conceptual and theoretical clarification, which can organize and give coherence to the empirical analysis presented in the papers that form this special issue. Therefore, the objective of this introductory paper is to outline a conceptual and theoretical framework that will cast some light onto this rapidly evolving phenomenon. With this purpose in mind, the paper is structured around two main research questions. The first question refers to the nature of global innovation networks and their characterization: What are global innovation networks, their patterns and dynamics? The second main research question deals with the institutional framework within which these global innovation networks operate: How do global innovation networks affect the institutional frameworks in which they are embedded? And vice versa, how do institutional frameworks shape and impact the dynamics and patterns of global innovation networks?

This paper addresses these questions by drawing on organisational theories of innovation networks and processes, as well as on institutional theories of innovation systems. On this basis, we will formulate a set of propositions arguing that FDI in global innovation networks involving emerging economies is increasingly becoming "knowledge-exploring", rather than merely "knowledge-exploiting"; that there are important differences across global innovation networks and their locations according to the knowledge bases of different industrial sectors; that global innovation networks might potentially exercise important impacts on national and regional innovation systems by mobilizing local networks differently, and by supporting catching-up processes in developing countries through the upgrading of human capital and the strengthening of local organisational linkages. All this has important implications for the comparative performance of institutions in national and regional systems of innovation, not least their degree of openness and internationalization.

1.2 Global innovation networks: conceptualising new patterns & dynamics

On the basis of the discussions detailed above, we can conceptualize global innovation networks (GINs) as follows: A globally organized web of complex interactions between firms and non-firm organizations engaged in the production of knowledge and the development of innovation. This definition closely follows the one proposed by Chaminade (Chaminade, 2009), but differs slightly in that the new definition puts emphasis on the aspect of knowledge-production related to innovation (rather than on innovation alone). Interactions and collaborations within innovation networks might assume many forms, forming a complex web of inter-organisational relations. Among these forms are: multiple-actor forms of joint venture; strategic alliances; research consortia; outsourcing of knowledge activities to suppliers; decentralisation of R&D location by multinational corporations (MNCs); and research projects with public research organisations and universities, co-financed PhD programs and research training. These types of collaborations within networks are not mutually exclusive, as several types of collaborations might take place inside the same network, and the same firm or organisation might participate simultaneously in several networks.

The study of global innovation networks falls in between two different and extensive sets of scholarly literature: namely, the literature devoted generically to innovation networks, and the international business literature devoted to multi-nationals' (MNCs) internationalization of R&D strategies. The former provides very useful accounts of what innovation networks are, why firms have tended to engage in external sources of knowledge-production and utilization, and the consequences that this might generate. However, this literature does not take into account the increasing international and even global dimension of innovation networks, and so misses the complex set of issues that this international dimension raises, particularly when considering the growing involvement of advanced developing countries. For its part, the literature devoted to multi-national companies' dynamics is more aware of the global dimension. However, the overwhelming attention of this international business literature on MNCs' tendency to decentralize and internationalize their R&D activities has tended to disregard the broad perspective of these networks. Global innovation networks are not only shaped within the vertical organization of R&D activities in MNCs, but to a large extent by stand-alone firms and other non-firm organizations engaged in complex webs of contractual and non-contractual collaborations. We will examine the contributions, as well as the limitations, of both these literatures, before turning to our own conceptualization of the patterns of global innovation networks and their dynamics during recent years.

The generic literature on innovation networks has provided a series of suggestive taxonomies of innovation networks, some of which are partly overlapping. The broadest taxonomies include formal and informal types of interactions with or without contractually formalised interactions (Powell and Grodal, 2005) or distinguish between closed and open forms of interaction, mainly in terms of proprietary-based and tight relations as opposed to loosely coupled interactions based on more community-related interactions (Dittrich et al., 2007). These taxonomies are broad in that they include ubiquitous and very loosely articulated social communities (for example, scientific colleges, open software movements) and their practices. Such informal networks are very important in understanding the dynamics of innovation, but, given their highly dispersed nature, they are difficult to study. There is, however, a wide acknowledgement that formalised interactions also rely on some elements of informality, as trust and tacit knowledge are not inseparable from contractual transactions (Freeman, 1991), and that apparently weak ties in a network give comparative advantage (Granovetter, 1983). From a narrower perspective, the taxonomy of innovation networks is seen mostly from the formalised side of inter-organisational interactions.

From the transaction costs approach, networks are explicitly created as mechanisms to reduce the risks associated with opportunistic behaviour in the market, or associated with the risk of technological uncertainties in technical configurations and interfaces (DeBresson and Amesse, 1991). From the knowledge-based tradition, the motivations for the creation of external linkages in the forms of networks are not based on controlling risk or behaviour, but rather on the mutual diffusion of information, the access to new knowledge resources, and the organisational learning among its members (Pyka, 2002). Still on the formalised side, some innovation networks have assumed the form of multiple strategic alliances and joint ventures (Mowery et al., 1996). The ample interest in these types of network interactions in the knowledge-based approach literature is probably owing to the fact that they are typically formed by resource-strong partners, showing a high level of economic engagement, in mid-to-long-term interactions (Das and Teng, 2000). Formalised R&D consortia have also received considerable attention, not only because they too depend on firms' own R&D capabilities (Sakakibara, 2002), but because they also serve to evaluate the success of governmental programmes to enhance knowledge capacities (Sakakibara, 1997).

Although this literature provides a useful starting point for a discussion of innovation networks, it still lacks a specific analytical perspective to address the issues related to the global dimension of those networks. As innovation seems to have become more globalised, and firms now conduct important innovation and R&D activities externally in collaboration with suppliers, customers, subsidiaries, universities and others on a world-wide basis, the extent to which these dynamics are transforming previous patterns of innovation networks is still unclear. This is particularly important given the current context, in which firms from advanced developing countries (emerging markets) are becoming more involved in these networks. There is ample evidence that, traditionally, most external innovation activities were conducted among the Triad (US, Europe and Japan). This "Triadisation" was the case in the 1980s and 1990s (Freeman 1991; (Patel and Pavitt, 2000), and continues to be the case in the 2000s (Edler et al., 2002); (OECD, 2007). Yet, the gradual inclusion of firms and organisations from emerging economies in innovation networks (UNCTAD, 2005) represents a singular and important new dimension of global innovation processes.

The international business literature offers interesting insights regarding the global approach of firms. However, as mentioned above, it has tended to develop such an approach from the very specific perspective of MNCs. This literature has examined the dynamics of knowledge flows inside MNCs, the decisions by MNCs regarding the location of R&D activities close to or distant from headquarters, and the specific issues of knowledge-management within their value chains and production networks. Perhaps the most relevant topic for us here is the distinction between the motivations for the internationalisation of innovation activities. MNCs invest in R&D sites abroad and in international knowledge more broadly for two clearly discernible reasons: either for expanding the firm's existing knowledge with complementary knowledge from external sources (exploring or home-augmenting), or for exploiting its own internal knowledge (exploiting)

(Dunning and Narula, 1995); (Kuemmerle, 1999). The first type of knowledge, exploring new and cutting-edge knowledge through accessing new sources of technical knowledge through networks, typically entails collaborations with organizations with knowledge competences in other disciplines and technological areas. That is to say, networks based on knowledge-exploiting tend to be of a cross-disciplinary, technology-driven nature. The second type of knowledge is more market-driven, as it includes the adaptation of existing products to new markets or innovation dissemination, both of which require other types and sources of knowledge, which are typically based on user interaction and locally based knowledge.

This dichotomy has also been conceptualized in terms of the international diversification of MNCs (exploring as MNCs' home-base augmenting) or international duplication (as MNCs' home-base exploiting) (Zander, 1999). Building up from this exploring-exploiting dichotomy, some authors have distinguished between the "research" and "development" sides, indicating that MNCs' R&D internationalization strategies might differ according to their decision to keep those two types of knowledge at headquarters, or to disperse them geographically (von Zedtwitz and Gassmann, 2002). A similar distinction between different types of knowledge base has been put forward in terms of radical innovation and incremental innovation (Pittaway et al., 2004). As the first one demands more advanced forms of knowledge, the networks require intense interaction with universities and other high-level technical knowledge providers; by contrast, knowledge-exploring is more dependent on locally based knowledge. This suggests that the type of knowledge MNCs search for has an impact on the type of innovation networks and on the MNCs' R&D internationalization strategy. Likewise, following more closely the traditional typology of dense and loosely tied networks mentioned above, (Narula and Molero, 2003), it is possible to distinguish between different types of MNC-driven innovation network by locating them along a continuum ranging from high levels of internalized relations (mainly the decentralization of MNCs' innovative activities to their subsidiaries), to high levels of externalized quasi-market relations, with a very specific and clearly delimited number of transactions

Global innovation networks are much more than mere extensions of MNCs' R&D internationalization strategies, as the former involve many stand-alone organizations, which are not necessarily integrated within the value chain of MNCs. Therefore, in spite of the interesting perspectives that these typologies of international business literature offer on MNC R&D strategies, the dynamics and features of global innovation networks are still not adequately grasped, as they miss the essential "networking" part of those complex interactions.

Global innovation networks are far from being a homogeneous phenomenon. Some networks might be small, based on *ad hoc* relations and with a wide global reach, while others might be large networks spanning through many organizations, based on a web of complex contractual arrangements, and based mainly on specific global regions. The diversity of GINs might be bewildering. For that reason, we need to develop a typology of GINs that helps us better understand their general features, but above all their dynamics and trends; and given the institutional perspective of this special issue, also their relation with the institutional frameworks (both in terms of location factors and in terms of GINs' impact on systems of innovation, to be discussed in the next section).

Drawing from and combining elements from the previous literatures, and largely inspired by the knowledge approach in the field, our typology focuses on two of the most crucial parameters characterizing global innovation networks; namely, the type of knowledge and motivation of the individual organizations taking part in them on the one hand, and the formality/informality of interactions on the other. The first dimension takes the point of departure to be the international business literature in distinguishing between knowledge-exploitation and knowledge-exploration as a crucial dimension defining different patterns of global innovation networks. The second dimension takes the point of departure as the generic literature on innovation networks, emphasizing the importance of looking at the degrees of formality in network interactions. It is very important to keep in mind that the rationales behind global innovation networks' assumption of those specific forms can be highly varied. Informality, for example, might be owing to very different reasons. Table 1, below, illustrates these two dimensions in a matrix that aims to locate empirical cases of the different patterns that global innovation networks might assume.

Table 1: Patterns of global innovation networks

	Knowledge-exploitation	**Knowledge-exploration**
Formal network relations	*Type A*	*Type C*
Informal network relations	*Type B*	*Type D*

Starting from the networks that are based on knowledge-exploitation, these might be of formal or informal character. Networks that are Type-A in the table are global knowledge-use-oriented innovation networks, and are based on a web of contractual-based interactions that exploits the respective organizations' pre-existing knowledge. Global innovation networks of this type are mostly associated with interactions based on contractual agreements across borders that aim, for example, at developing specific products for entering new global markets, at the dissemination of innovations in concrete contexts, or at the acquisition and adaptation of specific technologies in the context of process-innovation. Sometimes they are associated with the upgrading of the knowledge dimension involved in pre-existing global production networks, and/or to opening up knowledge collaborations well beyond the traditional vertical integration of (knowledge-) production of MNCs.

Looking now at the informal dimension, Type-B networks are global local-context knowledge innovation networks, and are based on a web of informal types of collaborations and interactions that seek to exchange knowledge in a way that allows the organizations in the network to exploit their pre-existing knowledge—typically knowledge that has a local-dimension—in a complementary way. Global innovation networks of this type are based on organizations that seek complementary knowledge to exploit their own existing knowledge well beyond their national borders. The logic behind this globalization is that organizations aim at gaining access to local sources of knowledge. The informality of interactions is related to the fact that there are loose or few contractual relations in the collaboration. This might be owing to very different reasons; for instance, collaborations that are a "first approach" to a more formalized interaction (Type-A network); to collaboration in areas of knowledge that are perceived not to be "sensitive" for the respective organizations; or simply owing to the lack of organizational resources to manage the legal aspects of more formalized types of collaboration.

Turning now to the type of global innovation networks based on knowledge-exploitation, Type-C networks are global breakthrough-knowledge innovation networks; that is, networks based on a web of contract-based collaborations that aims at producing cutting-edge knowledge that the individual organizations did not possess earlier. The rationale behind this type of network is that the combination of different organizations' knowledge competences provides the necessary synergetic capacity for achieving the ambitions of breakthrough knowledge production. This type of global innovation network has most probably developed from the partners' mutual perception of being "world class" in complementary competences, in a way that the expected synergetic efforts from collaboration are able to produce cutting-edge innovation outcomes. Partners seek each other across national boundaries because of the excellence of the specific (sometimes highly specialized) knowledge capabilities, rather than the specific geographical location of that partner. The formalization of such agreements is an indication of the strategic and sensitive nature of the knowledge that is co-created through those networks, which might be particularly important in situations where the outcomes of this collaboration has the potential to generate new products with global market impact.

Last, but not least, are Type-D, or global invisible college innovation networks; these are networks based on an informal web of collaborations and interactions among organizations across national-borders that seek to keep ahead of cutting-edge knowledge of an exploratory nature. These networks can assume many forms, according to the types of organizations involved and the sensitivity of the knowledge created. Global innovation networks of this type are likely to be anchored in the dynamics of knowledge-production at universities and public research organizations (PROs). The informality of these collaborations might be associated with the understanding of science and technology as a public good on the part of public organizations, or to the traditional non-proprietary nature of scientific-technological knowledge-production at universities and PROs. This context, however, is changing very rapidly, with the increasing commoditisation of research results from academic institutions. Relations can also be informal, and not necessarily focused on the joint production of new knowledge, but rather on the informal exchange of information about publicly available codified knowledge (that is, scientific publications or patents). The global networking activity here serves as an information exchange in order to "keep ahead" of globally cutting-edge knowledge results that are otherwise difficult to find in an overwhelming amount of dissemination channels.

The global nature of the networks poses two sets of crucial questions regarding their rapid dynamics during the past decade. These questions are related, firstly, to the changes in the innovative interactions between firms and organizations in developing and developed countries; and secondly, to the differentiated patterns that GINs might assume according to the industrial sectors.

Regarding the first issue, much of the international business literature on R&D strategies of MNCs posits that innovation interactions taking place between organizations from developed and developing countries are solely knowledge-exploiting. It emphasizes that the geographical decentralization of R&D activities is premised on adapting existing knowledge to develop products for the idiosyncrasies of large emerging markets, like China, India and Brazil. The understanding is that such R&D activities in developing countries are essentially to exploit home-based knowledge assets and focus on applied development (von Zedtwitz and Gassmann, 2002). According to our typology, above, this would correspond to the premise that developing countries are only involved in global innovation networks of Types A and B, not of Types C and D. However, a significant amount of anecdotal evidence raises doubts about the accuracy of that interpretation. The dynamism of the emerging economies is not only related to market size and growth, but importantly also related to new business models, significant organizational innovation and growing levels of technological capabilities (Wooldridge, 2010). In fact, recent decisions by MNCs to locate R&D in emerging economies during the past years were not so much owing to the lower costs of R&D personnel, but to its high quality (OECD, 2008); (Thursby and Thursby, 2006). These remarks lead us to the formulation of the first overall proposition of this special issue, namely, that the growing FDI in global innovation networks involving emerging economies is increasingly becoming knowledge-exploring, rather than merely knowledge-exploiting. This proposition suggests that the nature of knowledge in those global networks is changing, as the firms located in developing countries are upgrading their knowledge basis. Many questions around this general proposition remain open, not least whether this is an extended phenomenon, and what the factors behind this might be.

The second issue has to do with the differences across industrial sectors. Evidence about the diversity of innovation processes across industrial sectors abounds (Pavitt, 1984). The different forms of knowledge shape different modes of innovation processes (Jensen et al., 2007), and this is reflected in the diversity of innovation networks (Freeman, 1991); (Powell et al., 1996). Yet, it is still unclear the extent to which the changing patterns of global innovation networks mentioned above also shows sectoral patterns. This is not a trivial question. The globalization of production has differed across industrial sectors, and on that basis, differences in the patterns of global innovation networks could result from the extent to which (and how) knowledge flows have been upgraded. Innovation processes are also getting more complex, combining knowledge sources outside the traditional technological domains of industries (that is, agro-food firms engaging in engineering and robotics for the interactive development of innovative solutions for packaging). Hence, we might assume that the different sectoral patterns of global innovation networks may result from the needs of different industries to search for new knowledge in distant locations, but also knowledge outside their traditional areas.

1.3 Institutional frameworks as location factors

Institutional frameworks matter for the evolution of global innovation networks in a number of ways. They influence where firms decide to direct R&D activities, and which entry mode they use. They also influence local absorptive capacities and the capability of the host economy to learn from foreign technology. Likewise, GINs might have an overall impact on the productivity levels of an economy and/or its aggregated innovative performance. And finally, they matter for the interaction between foreign knowledge and domestic capabilities over time. This section focuses on the first aspect, whereas the next section will be devoted to the other three. Before moving on, however, it is important to clarify the notion of an "institutional framework" and the way it is used in the present analytical context in relation to GINs.

Institutional and evolutionary economists share the general understanding that institutions are important factors for innovators and for the innovation process in general, and that there tends to be a process of co-evolution between technologies and institutions (Nelson, 1994). However, when it comes to the precise nature and performance of institutions in relation to innovation, the literature offers a wide diversity of perspectives. Three major issues are relevant in this regard. The first issue is the distinction (or lack thereof) between "organizations" and "institutions". This is an important conceptual matter. One stream of the literature distinguishes between institutions as rules of the game and organizations as actors (North, 1990); organizational sociologists for their part do not tend to distinguish between these, because they see institutions as expressions of actors' interactions (Powell et al., 1996). This is important because, for the latter stream in the literature, networks can be seen as institutions; whereas this is not possible for the former stream.

A second crucial issue is the identification of institutions. The general starting point in the literature is the distinction between endogenous institutions (implicit and actor-generated rules of the game) and exogenous institutions (externally given to/imposed on the actors) (Coriat and Weinstein, 2002). In some more sophisticated theoretical models, the typology can include up to five different sets of institutions co-existing at nested levels (Hollingsworth, 2000). In empirical studies there is, however, a more pragmatic approach to this, focusing on the institutions of areas like education (especially higher education), labour market, finance, intellectual property, competition regulations, etc. All of these areas are believed to be decisive in shaping the opportunities and constraints that innovative firms face when interacting with each other and in the market. This leads to the next aspect of the literature: the expectations regarding the performance of institutions.

The third crucial aspect of the literature on institutions and innovation has to do with the "innovation system" approach. The focus has been on the interactions between institutions and organizations in shaping a specific innovation system. Here, the focus has been on the performance of institutions in national systems (Lundvall, 1992); (Edquist and Holmen, 2008); regional systems (Cooke, 1996); and industrial sector-defined systems (Malerba, 2005).

Assumptions about institutional performance have been based on the individual functions of those institutions (Bergek et al., 2008), or on expected reinforcing complementarities of the institutions according to the overall type of capitalist economy (that is, the contested assumption that liberal market economies tend to produce more "radical innovations" than co-ordinated market economies) (Akkermans et al., 2009).

From the above, it follows that we should define an "institutional framework" as the set of exogenous and endogenous rules that affect the behaviour of innovative actors in a given national or regional economy in important areas like education; research; finance; intellectual property; employment; competition regulation; and migration regulations.

Institutional frameworks influence firms' decisions on where to invest, and are therefore important locational factors. Evidence from the developed world shows that OECD countries with a good business climate and a high quality of tertiary education benefit more, both from domestic R&D and from international R&D spillovers (Sachwald, 2009). The returns on domestic R&D and the size of international R&D spillovers are larger in economies with stronger patent protection. Investor protection afforded by the legal regime also influences how much a country benefits from knowledge-intensive activities (Coe et al., 2008); (Belderbos et al., 2009). A survey of more than 200 MNCs revealed that, next to market growth potential, what mattered most for the choice of R&D location was the quality of R&D personnel, opportunities for collaboration with universities, and the intellectual property rights regime (Thursby and Thursby, 2006).

Similar results exist for emerging-market economies. In a broad sense, their innovation systems influence whether they attract knowledge-intensive activities (OECD, 2008); (Klinger and Lederman, 2006). Factors that matter for whether or not they become locations that attract offshored R&D include their knowledge infrastructure, such as the quality and quantity of R&D and design expertise and the level of education of the workforce (Demirbag and Glaister, 2010). Moreover, governance in developing countries (as a composite indicator, including voice and accountability; political stability; government effectiveness; regulatory quality; rule of law; and control of corruption) is a good predictor of cross-border mergers and acquisitions, an MNC entry mode that presupposes a relatively high level of local absorptive capacities and reflects a stronger commitment to the host economy than other forms of FDI. Hence, the process and the quality of integration into global networks are conditioned by local embeddedness, which in turn depends on the institutional framework and influences how attractive a location a country is (Álvarez and Marín, 2010); (Chen, 2007).

To date, the relevant literature has focused on technology from developed (North) to developing (South) countries, or global to local, and hence of the attractiveness of developing-country locations for Northern investments. This reflects the historical technological pre-eminence of advanced economies. But increasingly firms of Southern origin have become active in the global economy. Initially, their outward FDI went to economies at similar or lower levels of development, and only later explored market-seeking and asset-augmenting investments in more developed countries. This process was caused by globalization in the sense that liberalization opened up more and larger markets, including their home markets, while at the same time accelerated technological change raised the costs of innovation, design, and production. Their presence in these markets is therefore necessary to deal with heightened competition and realize positive returns (Narula, 2010).

From an National Innovation System (NIS) perspective, what matters is which location-specific advantages can be harnessed to augment the opportunities resulting from an insertion in global innovation networks led by MNCs and other actors that co-ordinate the relevant knowledge flows between geographically distant innovation systems (Zanfei, 2007). For example, academic research capabilities have a direct influence on the attractiveness of host locations for offshored R&D, more so than market size and GDP per capita, including in advanced developing countries. In fact, market factors seem to weaken over time, whereas technology and cost factors have become more important. What matters are not these capabilities per se, but the opportunities they offer foreign firms to collaborate with research teams in universities and to hire science and engineering talent. This means that national policies and institutional frameworks in support of academic capabilities can enhance the location-specific advantages of a region (Liefner and Schiller, 2008).

This leads to our third overall proposition in this paper and in this special issue, namely that the different quality and nature of knowledge flows between national innovation systems and global innovation networks—occasioned by technological change and the dispersion of technological capabilities—is changing the geography of locational attractiveness for knowledge-intensive activities. For firms and other actors, such as universities, this underlines the importance of linkages with relevant partners *wherever* they happen to be. For governments, it implies that they must be aware that their institutional framework is a very important factor of their locational attractiveness for innovation activities.

1.4 Impact of global innovation networks on national and regional innovation systems

In spite of the attention paid to the growing internationalization of innovation at the firm level, there has been very little empirical endeavour dedicated to the study of the internationalization of innovation *systems* (Niosi and Bellon, 1996); (Carlsson, 2006). (Taylor, 2009) argues that the overwhelming domestic institutional focus of the literature on innovation systems has tended to disregard the importance of internationalisation as a factor when accounting for different levels of innovative performance. Yet, in spite of this general view on globalization of innovation, the impact of global innovation networks on national/regional innovation systems continues to be a sensitive topic. Generally speaking, the effects of global innovation networks has to do with how the bidirectional relations inward and outward from innovation systems affect pre-existing patterns of a national system of innovation, particularly how these networks are transforming some actor-interactions and institutional frameworks within the national/regional territory. This is indeed a politically sensitive issue, as it touches upon the question of whether global innovation networks are having negative or positive effects on economic growth in the short and medium term.

In developed countries, the debate has revolved around the economic consequences of the firms' rapid international outsourcing and offshoring of knowledge-intensive functions for the competitiveness of the economy and the knowledge capacities in the home system. In a sense, this political debate has tended to focus mostly on the outward dimension of the internationalisation of innovation, disregarding the bidirectional dimension of global innovation networks (which includes inward investment as well). Studying the bi-directionality of innovation networks would provide a more holistic approach to this matter. Likewise, in developing countries there are mixed opinions on the consequences of inward R&D FDI and technology transfer for economic catching-up dynamics. Technological dependencies, exogenous-driven patterns of specialization, and weak local ties with the rest of the innovation system, are some of the problems for developing countries. Global innovation networks might offer some potential for upgrading human capital and for the creation of new linkages within the local innovation systems.

We propose to focus now on two interrelated issues that deserve further scholarly attention: the impact of GINs on innovation systems' knowledge dynamics in terms of their impact on national networks of innovators and the specific effects of GINs on the competence-building processes in innovation systems of developing countries. We examine these two themes in continuation, formulating the fourth overall proposition of this paper.

The first main topic of our attention is the impact of GINs on innovation systems' knowledge dynamics. Naturally, this question takes the innovation system as the dependent variable, examining the development of GINs as a factor underpinning changes in the innovation system. In order to address this question, we might revert to the institutional economics literature on innovation systems, and to the literature at firm level. One of the premises of this literature is that innovation systems exhibit strong intra-systemic linkages that generate positive knowledge spillovers in the territory. These intra-systemic linkages express different forms of knowledge interaction within the borders of the system, while some firms/organizations operate as well at higher levels (national or international). The literature considers the "systemness" of innovation systems to be based on the fact that interactions within the territory generate agglomeration economies with positive network externalities (knowledge spillovers). For that reason, one of the most relevant questions is the impact of GINs on national/local innovation systems. When discussing this impact, we need to revert to the distinction between different types of knowledge dynamics. On that basis, it is a general proposition of this paper that global innovation networks might potentially exercise significant impacts on national and regional systems of innovation by mobilizing national networks differently according to the knowledge sources. This relates to the set of questions on whether, and how, the different quality and nature of knowledge flows between national innovation systems and global innovation networks—as opposed to traditional production networks—condition the evolution of those networks and affect the interactions between actors in the NIS, as well as the institutional framework within which they are embedded. There is no doubt that the quality and nature of the knowledge flows has been changing, and that the rate of change is increasing. For that reason, we assume a differentiated impact.

This brings us to the second focus of attention. When studying the specific effects of GINs on the competence-building processes in innovation systems of developing countries, it is of paramount importance to take into consideration the issue of knowledge flows in human capital upgrading and university-industry linkages. Although the bulk of global R&D is still undertaken in developed countries, a global shortage of qualified knowledge workers, together with a rise in science and engineering graduates in advanced developing countries, leads to more advanced knowledge flows between innovation systems in the North and in the South (Howells 2008). The global knowledge architecture therefore changes, and the more the resulting networks are invested in high capabilities in different locations around the world and are managed efficiently, the less it will become possible and relevant to distinguish between “home” and “foreign”, especially if key personnel circulates between the relevant sites (Lewin et al., 2009); (Saxenian, 2007).

Baldwin (2006) terms the change from global competition primarily between firms and sectors in different nations to one between individual workers doing similar things in different countries, “the great unbundling(s)”. No longer are all high-skilled jobs “safe” in developed economies, because some may well be suitable for offshoring, although it is also true that offshoring can increase the scale and scope of resources invested in innovation, with no consequent job losses at home. It therefore becomes more complicated for public policy to try to hold on to the “good” jobs, because in the absence of stickiness only a flexible workforce and strategies of “smart specialisation”, based on a particularisation of the future knowledge base with co-specialised assets, can help local competitiveness (Pontikakis et al., 2009). The impact of immigrant entrepreneurs and the phenomenon of reverse brain-drain in developing countries have been documented (for example, Saxenian 2006). But effective knowledge diffusion from returnee scientists and engineers to local firms is not a straightforward process. Firms have to make efforts to internalise the knowledge across different working cultures and skills sets. Social infrastructure also matters in providing incentives to expatriate knowledge workers to return to their countries of origin, underlining the role of government in providing attractive conditions (Kale, 2009). New interactions include those between local universities or research institutes and foreign firms, for the purpose of collaborative or contract research, or customized training. Although this does not necessarily mean that university-industry linkages in the North weaken while strengthening in the South, it adds to the complexity of actor interfaces within each innovation system. MNCs must therefore learn to co-ordinate networks in which often highly specific capabilities exist in multiple nodes.

From the above, we formulate our fourth overall proposition of this paper: that global innovation networks might potentially exercise important impacts on national and regional innovation systems by mobilizing local networks differently, and by supporting catching-up processes in developing countries through the upgrading of human capital and the strengthening of local organizational linkages. Still, for innovation systems in developed and developing countries, the question is whether knowledge-intensive activities give rise to knowledge spillovers. This is so because the empirical evidence on the impact of spillovers is still inconclusive (for a recent literature review see (Gachino, 2010) and (Görg and Greenaway, 2004).

1.5 Concluding remarks and this special issue

During the past two decades, the literature has paid significant attention to issues related to the globalization of innovation processes. Yet, in spite of this scholarly attention, the study of global innovation networks has tended to be disregarded. This paper addresses this matter, focusing on the dynamics and patterns of these global innovation networks, as well as their interactions with national and regional innovation systems. This is of particular importance in view of the processes of reorganizing the global geography of innovation, mainly because firms in developed, as well as developing countries are reorganizing their innovation-related collaborative activities with partners outside national boundaries. The bi-directionality of global innovation networks (that is, the two-directions of cross-border inflows and outflows of knowledge) poses challenges for scholars studying this phenomenon. The difficulty is not only owing to the complexity of the phenomenon, but to the lack of existing data suitable to examine it (that is, statistical material is mostly on inflows of R&D FDI, and extremely scarce and incomplete on outflows). Global innovation networks are more than a mere relocation and decentralization of MNCs' R&D activities in subsidiaries, or processes of off-shoring R&D activities. Global innovation networks include partnerships with other organizations like universities, public research laboratories, stand-alone firms, etc., as well as MNCs subsidiaries or suppliers. Likewise, the inward dimension of innovation activities and knowledge flows into innovation systems (not just outflows) is a crucial aspect of understanding the fluid bidirectional dynamics of knowledge-production and innovation processes in a globalized context. For that reason, the study of global innovation networks requires a new approach that goes beyond MNCs' decentralization, offshoring and analysis of outflows of knowledge, into one that looks into the dynamics of these bidirectional networks, examines the patterns, considers the relevant locational attractiveness factors, and studies the impact of these global dynamics on the national systems. Regarding the latter, this paper takes the stand-point that the institutional context in which these global innovation networks take place does matter. "Global" does not mean that the geographical dimension of institutional and organizational configurations is irrelevant. On the contrary, it becomes most fundamental, as those innovation networks are formed by firms and other organisations that seek precisely to benefit from local knowledge competences as specific locational advantages.

From this basis, this paper has formulated four general propositions that will serve as guidance to the papers that form this special issue. The first proposition is that global innovation networks involving emerging economies are increasingly becoming knowledge-exploring, rather than merely knowledge-exploiting. This means that we expect to find clear evidence that there has been a significant upgrading of the nature of the knowledge involved in these global networks, as firms are no longer establishing cross-border collaborations in order to exploit their respective existing knowledge in new ways, but increasingly are collaborating across borders in order to expand the knowledge frontier creating innovative products/services that are based on cutting-edge knowledge. The second proposition is that the dynamics and patterns of global innovation networks differ according to the knowledge bases of different industrial sectors. Here, we expect to see remarkable differences in the three sectors collectively studied (agro-food; automotive; and information and communication technologies, ICT).

This proposition is a natural continuation of commonly accepted understandings in the field. Thirdly, this paper suggests that global innovation networks are changing the geography of locational attractiveness for knowledge-intensive activities. This proposition expects to find evidence that the location patterns of collaborative activities are not rootless, but determined by local factors that are geographically defined by the institutional context in which innovation takes place on those localities. We expect as well to find that the locational attractiveness of the developing countries studied (India, Brazil, South Africa and China) have increased significantly during the past few years. Lastly, our fourth proposition is that GINs are exercising a significant impact on national and regional innovation systems. This is not because they are "draining" or "crowding out" knowledge resources in given localities. Such a view would imply that there is a zero-sum game on knowledge, namely, that what one locality gains in knowledge another loses.

The problem with this zero-sum view is that it contravenes the common understandings that knowledge is a non-rival public good. Instead, our proposition is that the impact of GINs on national/regional systems is generally positive, as those global networks are mobilizing pre-existing local innovation networks differently, and are supporting catching-up processes in developing countries through the upgrading of human capital and the strengthening of local organisational linkages.

The contributions to this special issue are organised following these general propositions. The first set of papers looks at the taxonomies of GINS, in order to bring clarity to the idea of these types of networks, both conceptually and empirically. A second set of contributions studies the dynamics and patterns of GINs in relation to specific sets of countries, regions, and industrial sectors. Finally, a third set of papers focuses on the relationship between firm strategies and institutional frameworks, and discuss the implications of GINs for (national) development and growth in the context of the global economy. In short, this special issue offers a critical and groundbreaking analysis of global innovation networks, casting light on a remarkable trend in innovation processes worldwide, which that has remained understudied during many years.

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2 GLOBAL INNOVATION NETWORKS: WHAT ARE THEY AND WHERE CAN WE FIND THEM? (CONCEPTUAL AND EMPIRICAL ISSUES)

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Abstract: The rapid move of China and India from low-cost producers to innovators has triggered an increasing interest in the globalization of innovation activities and more specifically, on the surge of global innovation networks (GINs). However, hitherto most of the literature is rather theoretical or based on a handful of cases. We do not know what are the different forms of GINs in which firms participate attending at the various degrees of globalness, innovativeness and neworkedness as well as what are their main characteristics. In this paper, we propose a taxonomy of global innovation networks that takes into account these three dimensions. This paper provides empirical evidence about the characteristics of the different variants of global innovation networks, observed in seven European countries as well as Brazil, China, India and South Africa. It relies on firm-level data collected through a survey in 2010 and provides for the first time a theoretical and empirical overview of the different forms of global innovation networks**.**

Keywords: Globalization, innovation networks, taxonomy, Europe, South Africa, Brazil, China, India

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2.1 Introduction

In 2005 the UNCTAD published a report on R&D Foreign Direct Investment which pointed out, almost for the first time, to the changing role of developing countries in the global flows of innovation-related investments (UNCTAD, 2005). It showed how R&D investments to and from developing countries had increased dramatically in a few years. Since then, a growing number of studies have been trying to understand the drivers, consequences and dynamics of the new global **configuration** of innovation activities. This paper belongs to this new stream of literature.

The main conceptual issue raised by the emergence of GINs is whether they represent a deepening of a long-standing phenomenon, or whether the phenomenon represents the emergence of a new way of organising. On the one hand, the constituent elements of GINs (globalness, innovativeness and networkedness) have been long documented. On the other hand, GINs may represent an organisational form that is emerging from a changing techno-social-economic paradigm. The era is characterized by the ascent of developing countries as important economic players on the global arena (Gammeltoft, Barnard & Madhok, 2010; Ramamurti & Singh, 2009).

Although there is a general consensus on the international nature of innovation (Archibugi and Iammarino, 2002; Cantwell, 2000a; Cantwell, 2000b; Narula and Zanfei, 2004) as well as its networked character (Coe N.M. et al., 2004; De Bresson and Amesse, 1991; Ernst, 2002; Freeman, 1991; N.M. and Dicken, 2004; Nooteboom, 2003; Powell and Grodal, 2004; Saxenian, 2002), there is little empirical work on the nature and functioning of global innovation networks (GINs).

Hitherto, most empirical evidence is based either on a few number of qualitative case studies (Ernst and Kim 2002; Ernst 2005; Ernst 2007; Yeung 2007; Altenburg et al. 2008), on the analysis of patent data of US-based multinationals (Cantwell, 2004; Cantwell and Piscitello, 2002; Cantwell and Piscitello, 2007; Cantwell, 2000b; Federica and Zanfei, 2009; Gerybadze and Reger, 1997) or strategic alliances (Hagedoorn, 1993; Narula and Hagedoorn, 1998; Narula and Zanfei, 2003). These studies have contributed to our understanding on why multinationals from developed countries locate R&D activities abroad (Cantwell and Piscitello, 2005b), on the rapid accumulation of innovation capabilities in certain regions in India and China (Altenburg et al., 2008; Basant and Chandra, 2007; Chaminade and Vang, 2008; Partharasarathy and Aoyama, 2006) and on the networked character of innovation at a global scale (Gertler and Levitte, 2005; Oecd, 2008; The Economist Intelligence Unit, 2007). However, they have not been able to provide any conclusive evidence on the types of global innovation networks, the role of different actors (MNCs and non-MNCs) in global innovation networks or the role of developed and developing countries in global innovation networks.

This paper contributes to this research gap by proposing a taxonomy of global innovation networks based on the degree of globalness, innovativeness and networkdness. The main research question addressed by this paper is what are the different forms of global innovation networks and what are their main characteristics in terms of the type of firm (multinational and non-multinational) and location of the unit (developed or developing countries).

This paper provides empirical evidence about the characteristics of the different variants of global innovation networks, observed in seven European countries as well as Brazil, China, India and South Africa. It relies on firm-level data collected through a survey in 2010 and provides for the first time a theoretical and empirical overview of the different forms of global innovation networks.

We find evidence that levels of globalness, innovativeness and networkedness tend to co-occur, although it is possible to have an emphasis on one of the dimensions. Furthermore, there seems to be a trade-off between being innovative and being global. The most innovative companies are those that keep their innovation networks at regional or national level. High-level balanced GINs are almost exclusively found in developing countries, sometimes as subsidiaries of MNCs, both from the developed and the developing world, but often also in stand-alone firms. This complicates the view that the MNCs of the developed world are spearheading the emergence of GINs, and suggests that those MNCs may be struggling to overcome path-dependent patterns.

2.2 Theoretical framework

2.2.1 Global innovation networks

Innovation has long been considered a networked phenomenon. Innovation is the result of the continued interactions between firms and other organizations (Freeman, 1987, Lundvall, 1992, Nelson, 1993) and it is through interactions that tacit and explicit knowledge is transferred and new knowledge is created.

Archibugi and Michie have proposed a taxonomy of globalization of technology which distinguished between the global exploitation of innovations, the global research collaboration and global generation of innovation (Archibugi and Michie, 1995). While their taxonomy was rather theoretical in nature, over the last decade, scholars have collected evidence on the increasing global character of the exploitation of innovation and the collaboration of innovation (Chesnais, 1988; Gugler and Dunning, 1993; Hagerdoorn, 1990; Luukkonen et al., 1993) while the global generation of technology was still in the early 2000s a marginal phenomenon, consisting almost exclusively of MNCs from developed countries locating R&D departments in another developed region in the world.

On the other hand, the global nature of knowledge intensive activities caught the interest of scholars in the international business literature also in the last decade (Cantwell and Piscitello, 2005a; Cantwell and Piscitello, 2007; Dunning and Lundan, 2009; Le Bas and Sierra, 2002; Zanfei, 2000). Firms internationalize their research and innovation activities in order to exploit existing knowledge competences (knowledge exploiting strategy) or, more increasingly, in order to access competences needed for innovation (asset seeking) (Castellani and Zanfei, 2006). The international business literature has, by and large, focused on the analysis of internalized networks, that is, the networks of subsidiaries belonging to the same multinational firm, that might be located in different countries and that are performing different functions (Lam, 2004; Tsai, 2001). This MNC-centred literature has had a strong influence on the conceptualization of global innovation networks as networks around MNCs. While this may be true for some forms of globalization – like the global generation of innovation through R&D FDI- it doesn’t necessarily apply to global research collaboration, global sourcing or global exploitation of innovation. We may expect to find both MNCs and stand-alone firms participating in different forms of GINs.

Economic geographers, on the other hand, are more interested in the geography of externalized networks, which can be composed only by firms – inter-firm networks – (De Bresson and Amesse, 1991) or by a variety of organizations – inter-organisational networks – (Freeman, 1991). Studies on user-producer networks (Lundvall, 1992), inter-industrial networks and clusters (Malmberg and Power, 2005; Porter, 1998) would fall in the first category while, for example, a system of innovation is usually understood as composed by inter-organizations networks. For the economic geographers, innovation networks are geographically bounded and proximity with other members of the network facilitates the exchange of codified but more importantly non-codified or tacit knowledge (Asheim and Gertler, 2005; Becattini, 1990; Camagni, 1991; Cooke et al., 1997; Cooke and Morgan, 1998; Marshall, 1930; Piore and Sabel, 1984; Storper, 1997). It is only recently, that economic geographers have started also to pay attention to the importance of global "pipelines" for local networks and the interaction between global and local networks of innovators (Bathelt et al., 2004; Giuliani et al., 2005; Malberg A. and Maskell P., 2006; Moodysson, 2008). They argue that due to the different nature of their knowledge bases, industries will likely differ in the degree of globalization of their innovation networks. Following this stream of literature, we may expect different industries to engage in different forms of GINs. While these streams of literature have highlighted the growing international character of innovation networks, with only few exceptions (Martin and Moodysson, 2010; Moodysson, 2008; Moodysson et al., 2008); (Sotarauta and Kosonen, Forthcoming 2011); (Tödtling et al., Forthcoming 2011), they haven't done so in comparison with the importance of regional or domestic networks. In other words, we know very little about under which conditions networks of innovators are global instead of regional or domestic (degree of globalness) or when and for which actors are internal networks more important than external actors (degree of networkedness).

Furthermore, with few exceptions (Barnard, 2006, 2008; Goldstein and Corporation, 2007) most of the evidence on the globalization of innovation is based on data-bases or cases from developed countries; e.g., looking at the motivation of firms from Europe, Japan or the US to locate innovation activities in other regions in the world. Yet the new global technological paradigm is characterised by the rise of countries like India and China, and it is important to consider the role of less developed (but often fast-growing) regions in the knowledge-related activities of firms.

2.2.2 Global innovation networks and developing countries

It has been generally argued that the proportion of firms introducing innovations that are new to the firm versus new to the world varies significantly between developed and developing countries (Plechero and Chaminade, 2010). Whilst most of the new to the world innovations are being implemented by firms headquartered in the North, product innovations in developing countries is often behind the technological frontier: it is mainly imitative innovation, therefore more related to the acquisition of technology developed somewhere else and its adaptation to the local needs that to the development of new products (Bell and Pavitt, 1993, 1995; Fagerberg et al., 2007; Hobday, 2001).

Following the logic expressed in this literature, we might expect that most of the global networks in which firms from developing countries are part of will involve incremental innovations. That is, we may expect that new to the world innovation will take place in networks dominated by multinationals from the developed world while firms in developing countries will use their innovation networks to acquire existing technology that will be further introduced to the firm.

In terms of globalness and networkedness, we may expect firms from developing countries to rely much more on global networks than firms from developed countries as the local institutional context is often underdeveloped and inadequate for the knowledge needs of a global player. One of the commonly-mentioned characteristics of how developing countries engage in business is their use of business groups and networks. Such networks are often argued to be a strategy they use to compensate for an underdeveloped institutional context (Chang & Hong, 2000, 2002; Khanna & Yafeh, 2007; Tan & Meyer, 2010). Because of their previous use of business groups, developing country firms may be particularly experienced at accessing knowledge and capabilities through networks, which could put them at an advantage in terms of the ability to access global networks.

There is evidence that developing country MNCs are able to transform the disadvantages of their location into a competitive advantage (Cuervo-Cazurra & Genc, 2008), and even some anecdotal evidence that developing countries can leverage their locational "disadvantages" to generate new to the world innovations, for example in Prahalad's (2006) work on the base of the pyramid. The bulk of the evidence suggests that most developing country MNCs are found in rather mature industries, and that innovations have tended to be incremental (Ramamurti & Singh, 2009). It is relevant that many of the examples offered by Prahalad were generated outside of developing countries' MNCs, and instead originated from smaller firms or in quite a few cases, partnerships between both firm and non-firm partners.

It is therefore possible that the phenomenon of GINs may not be limited purely to the advanced MNCs of the developed world, as most of the literature suggests. Although the advanced MNCs can benefit from their well-developed capabilities and extensive networks (Andersson, Forsgren & Holm, 2002; Zhao, Anand & Mitchell, 2005), they are also at risk of lock-in into their current practices. As long ago as 2003, Cantwell and Kosmopoulou pointed out that the creation of linkages does not reflect an optimal choice, but is constrained by previous practice, and that it is especially the stronger firms in *small* countries who internationalize in the search for new technology. It is quite possible that the same logic applies to institutionally weaker (rather than small) countries.

2.3 Methodological design

Using unique firm-level data collected in 2009-2010, this paper tries to identify global innovation networks in three industries: automotive, IT equipment and software, and agro-processing. Because GINs are an emerging phenomenon, we may not expect to find many strong-form GINs; that is, truly global, truly networked and engaged in the creation of new to the world innovations. This research will identify and discuss such strong-form GINs.

But it is equally important to understand the permutations of GINs, for example, a network of organizations engaged in the development of new to the world products or processes, with a supra-national but only regional character (gIN). Similarly, there may be a network of organizations engaged in the diffusion of essentially incremental innovations, but with a truly global reach (GiN)[1]. Two research questions relate to those permutations: First is the issue of whether elements co-occur. If a firm is innovative, is it also more like to be global and networked? Understanding this would make it possible to develop a taxonomy and by mapping the most common forms of innovation networks, we hope to provide not only an empirical but also a theoretical foundation for considering global innovation networks.

[1] We us capital letters to identify firms that are truly global (G), innovative (I) or networked (N), lower caps to refer to firms that are supra-national but regional rather than truly global (g), incrementally innovative (i) and with some but limited networks (n), and finally asterisks (*) to identify firms that are only domestic, not at all innovative and not at all networked, This yields 27 possible permutations, such as Gin, g*N, G** and so on.

2.3.1 Ingineus survey and data base

The EU-funded INGINEUS project aims to capture the dimensions of GINs (global, innovative and networked enterprises) through a variety of methodological approaches, including a survey. The survey was conducted across nine countries: Brazil, India, China, South Africa, Norway, Sweden, Germany, Estonia and Denmark. Each country had a dedicated sector of focus in either ICT, automotive or agro-processing[2], a sector which was of economic importance in that country. Where possible, a sample frame was established by using existing databases, e.g. Statistics Sweden or the German commercial database Hoppenstedt. This was not always possible, especially for the less developed countries. There the strategy was to combine existing (but often out-of-date or inadequate) databases, e.g. in Brazil the database of the automotive union SINDIPECAS, the official Annual Registry of Social Information (RAIS) and information from large automotive firms about their suppliers was used to compile a sample frame. All databases were filtered to ensure that only firms with five or more employees were contacted.

The information gathering also took place in a variety of different ways. In countries with a culture of participating in surveys, e.g. the Scandinavian countries, firms were sent a link to an online tool. In the developing countries, data gathering was done either telephonically or through face-to-face interviews. In all sectors and across all countries 1215 responses were collected.

The combined INGINEUS sample was dominated by ICT responses. This was in part due to the size of India and China, but also due to the more established and thus concentrated nature of the agro-processing and auto industries[3]. Table 1 offers a summary of the results received from each sector and each country, the number of responses and response rates.

Table 1: Survey results by country and industry (number of responses and response rates in brackets)

Countries	ICT	Auto	Agro	TOTAL
Brazil		69 (25.9%)		
China	243 (2.7%)			
India	324 (25.2%)			
South Africa			84 (16.9%)	
TOTAL emerging markets	**567**	**69**	**84**	**720**
Denmark			49 (23.3%)	
Estonia	17 (14%)			
Germany		53 (4.7%)		
Norway	181 (11.9%)			
Sweden	171 (10.3%)	24 (14.3%)		
TOTAL developed countries	**369**	**77**	**49**	**495**
Total	**936**	**146**	**133**	**1215**

[2] Sweden had both auto and ICT surveys.

[3] Although China had the second-highest number of responses, it also had the lowest response rate (2.7%). This is because the Chinese team had opted to choose a broader sample and use a less labour-intensive strategy for targeting respondents. The low German response rate is most likely due to the fact that the questionnaire was sent out during a period when the German automotive industry was struggling with the aftermath of the economic crisis.

2.3.2 Analysis of global innovation networks

For each of the three concepts (Global, Innovative and Networked), relevant questions in the survey were chosen and then weighted according to their importance. A scoring system was devised, and a formula specified which gave each instance in the dataset a continuous value greater than or equal to 0. This value was divided by the maximum value in the dataset, so that each instance had a continuous score between 0 and 1, with the instance with score 1 being that which most epitomised the concept in question. This resulted in each instance being scored relative to the other instances in the dataset.

These scores were displayed on a scatter plot, and a combination of cluster analysis and inspection of the scatter plot used to identify the cut-off point between categories, e.g. highly global, somewhat global and not at all global. Alternative scoring systems were explored to test the robustness of the original scoring. Once the scoring was determined, each instance in the dataset was classified as one of the types of GINs.

Globalness

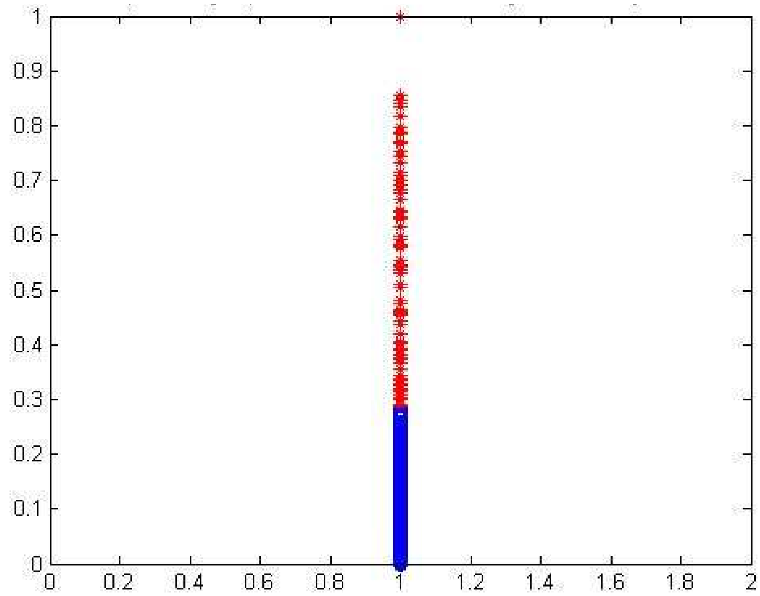
The purpose of this measure is to establish the degree of globalness (rather than innovativeness or networkedness), and it was therefore deemed important to not give greater weight to more "complex" activities (like innovation) than to "simpler" tasks like exports – what matters is global reach. We therefore considered all questions that asked respondents about the locational spread of their activities, regardless of what those activities were.

For indications of **Globalness**, we used several indicators like the percentage of total sales derived from export and the largest markets, the geographical location of partners with whom firms they collaborate for innovation; the location of the different functions of the firm (by the unit in location, by geographically dispersed subsidiaries or outsourced) and the location of firms' outsourced or offshored production or innovation activities (if they do use outsourcing). The precise wording of each question is included as an Annex to this paper.

After transforming each value so that they all had a score between 0 and 1, all five categories listed in the table were used to calculate an average. For the robustness test an average was calculated where questions 4.2 (regarding sales) and 7 (regarding innovation) were given greater weight. Those questions are more fine-grained and force the respondent to state precisely which regions are involved.

We use k-means cluster analysis with two groups and the squared Euclidean distance as the distance measure between points. The silhouette plot for the analysis where greater geographical distance has greater value is shown below. The diamond markers indicate Cluster 1 and the circle markers indicate Cluster 2. The mean of Cluster 1 is 0.5178 and the mean of Cluster 2 is 0.0552. Looking at the scatter plot, the value 0.283 is a natural break point and we classify all instances >0.283 as G, all instances greater than 0 and up to 0.283 as g, and all instances of zero as *, with G denoting truly global, and g denoting somewhat global.

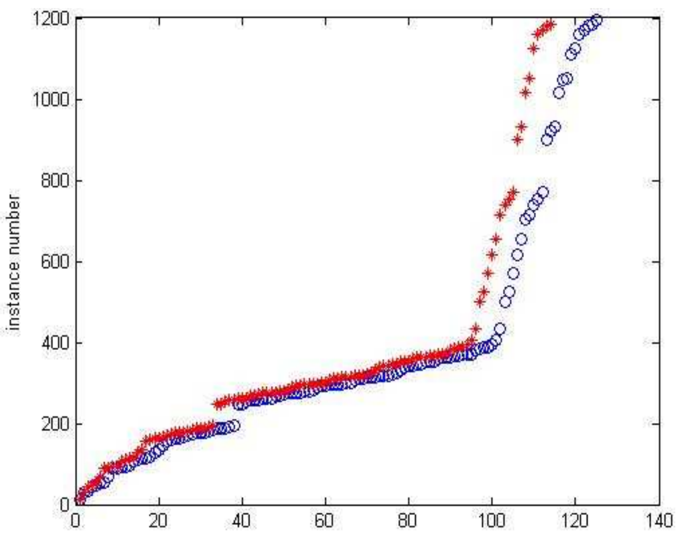
Figure 1: Distribution of values for globalness



A similar process for the model where all instances of globalness are given equal values results in a cut-off point for >0.27 as G, and for all instances greater than 0 and up to 0.27 as g.

Comparing the two models, we observe that these two formulae (based on different questions) give similar groupings. Numerically, 99.09% of all 1215 instances in the dataset have the same value under each of the models. This implies that the scoring system for globalness is robust.

Figure 2: Robustness check of two models for globalness

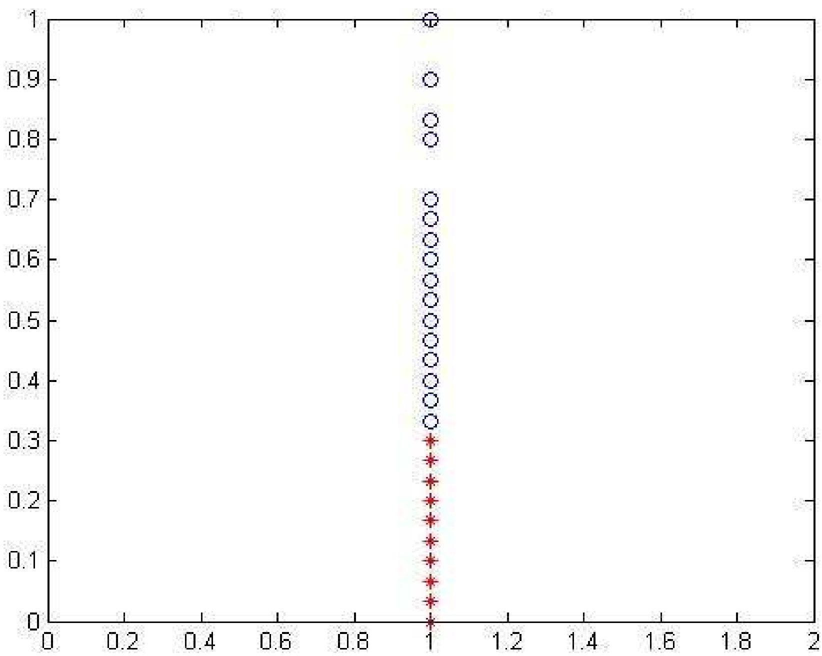


Innovativeness

With regards to innovation, respondents were asked to indicate if they have innovated in 2006 to 2008 in any of five categories: New products, new services, new or significantly improved methods of manufacturing or producing, new or significantly improved logistics, distribution or delivery methods for your inputs, goods and services and new or significantly improved supporting activities for your processes (e.g. purchasing, accounting, maintenance systems, etc.). For each of the options selected, the respondent was asked to indicate if the innovation was new to the world (which was given a value of 3), new to the industry (with a value of 2) or new to the firm (with a value of 1). This yielded a maximum score of 15. However, that scoring system implies that there is a linear progression from new-to-the-firm to new-to-the-industry to new-to-the-world innovations, whereas it may be significantly more complex to generate more novel innovations. To test for robustness, all scores for “new to the world” are multipled by 3 (to a maximum of 9), and all scores for “new to the industry” by 2 (to a maximum of 4). This approach provides greater weighting by degree of innovativeness.

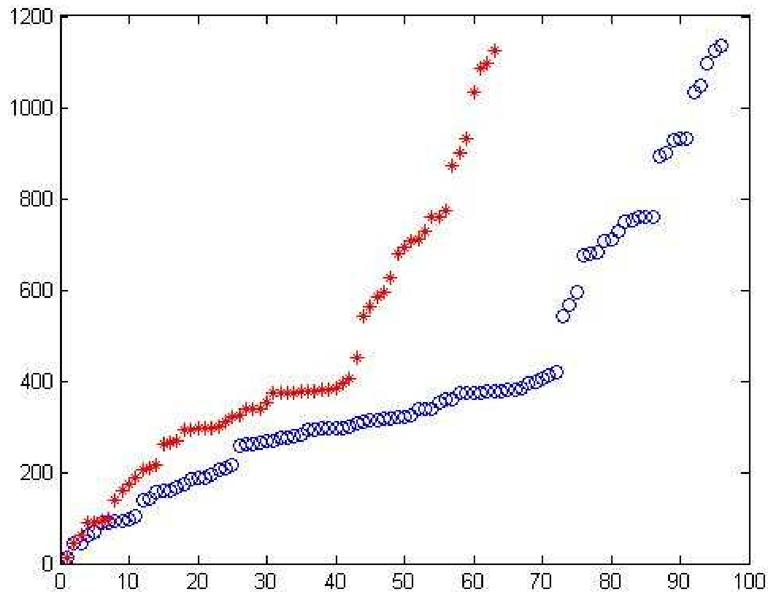
We first do a cluster analysis using the linear scale. The diamond markers indicate in Figure 3 indicate Cluster 1 and the circle markers indicate Cluster 2. There seems to be a break at around 0.7. However, this is a very strict cut-off point, as less than 2% of the values fall above this point. Therefore, we choose the next most obvious cut-off point (by inspection), which is just below 0.6. The values get much denser below this point, and increasingly sparser above this point. We classify all instances >=0.6 as I, all instances between 0 and 0.6 as i, and zero as *, with I denoting “Innovative” and i denoting “somewhat innovative”.

Figure 3: Distribution of values for innovativeness



To test the robustness of the cluster analysis, we do a similar analysis, but one where innovations are given much greater weightings for greater novelty. The graphical representation of the comparison indicates that although the two sets of markers are not one on top of the other, they follow the same general trends. Since the y-axis denotes the instance number, it is clear that many of the same instances occur for the two formulae, although the ordering may be slightly different (as each formula has a slightly different number of instances classified as “I”). In other words, since the markers for both scores appear on the same *horizontal gridlines*, the two scoring systems must classify most of the instances in the same way. Doing a logical check, we find that 95.72% of the values for the two scores are identical. This suggests that the scoring system for innovativeness is robust.

Figure 4: Robustness check of two models of innovativeness



Networkedness

In operationalizing the concept of networkedness, we considered debates about the indicators of a “strong” network. Formal linkages may be seen as especially strong, as they provide the benefit of legal protection (Zhou & Poppo, 2010). However, there is also an argument that trust may be reduced by formal control mechanisms (Das & Teng, 1998; Malhotra & Murnighan, 2002) and that informal linkages may signal especially strong relationships. Similarly, although it is plausible that the strongest network would be within the firm – where people share an organisational culture and goal – it is also possible that a firm may be less inclined to take for granted and therefore take more care to nurture important external networks.

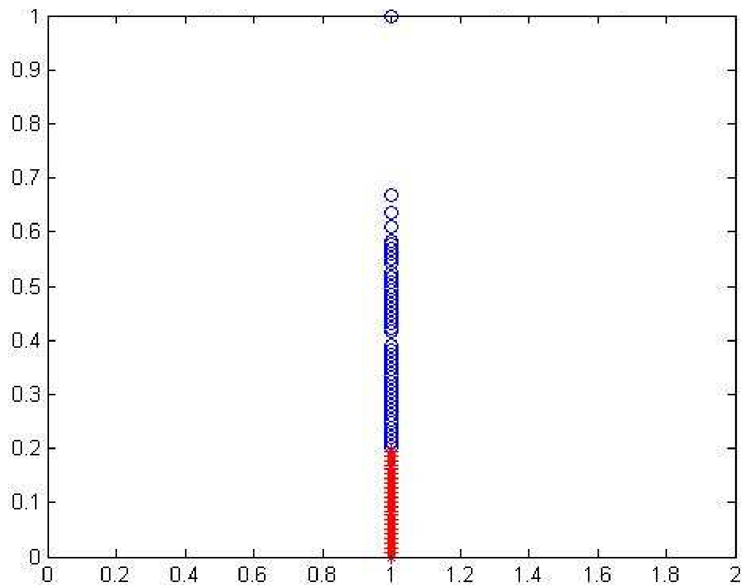
We therefore incorporate two measures of connectedness, span and depth. An enterprise is highly networked firstly if it has connections or relationships with many other people, enterprises or institutions. The more connections which an enterprise has with people or bodies outside of the enterprise itself (e.g. clients, suppliers, competitors, universities, etc.), the larger is the span of the network. Secondly, an enterprise is highly networked if those connections or relationships are deep. A deep connection is one which is meaningful or even crucial to the running, development or success of the enterprise.

In developing the measures, we considered both internal/external (to capture span) and formal/informal linkages (to capture depth). We calculate three scores for networkedness, one where all scores are given equal weighting, one where external linkages are given greater weight than internal linkages, and one where formal linkages are given greater weight than informal linkages.

Networkedness was based on the following questions: How different functions of the firm are performed (by the unit in location, by subsidiaries or outsourced); With whom outside the firm it has been collaborating for the development of its most important recent innovation and whether a firm has developed formal/informal linkages (e.g. research relationships) with a variety of external organizations, e.g. universities, research institutes, government etc. The precise wording of each question is included in the Annex

Figure 5 maps values for networkedness with an equal weight for all indicators. The red markers represent Cluster 1 and the blue markers represent Cluster 2. Although the figure indicates that the two clusters are separated around 0.2, the data points at the break for clusters 1 and 2 are very close together – almost on top of each other. At the same time, the above plot shows a slight gap in data values around 0.4. Looking at the scatter plot, this seems to be closer to where the natural break occurs. Therefore we reject this cluster analysis, and rely instead on inspection of the scatter plot in order to decide on a natural break in the data values. Taking into account that the percentage of values greater than 0.2 = 15.3909%, greater than 0.28 = 8.9712%, greater than 0.32 = 6.6667% and greater than 0.4 = 3.7860%, we consider a natural break at 0.32 (by inspection). Following this model, we classify all instances >0.32 as N, all instances with a value greater than 0 and as high as 0.32 as n, and all instances of zero as *, with N denoting "truly networked" and n denoting "somewhat networked".

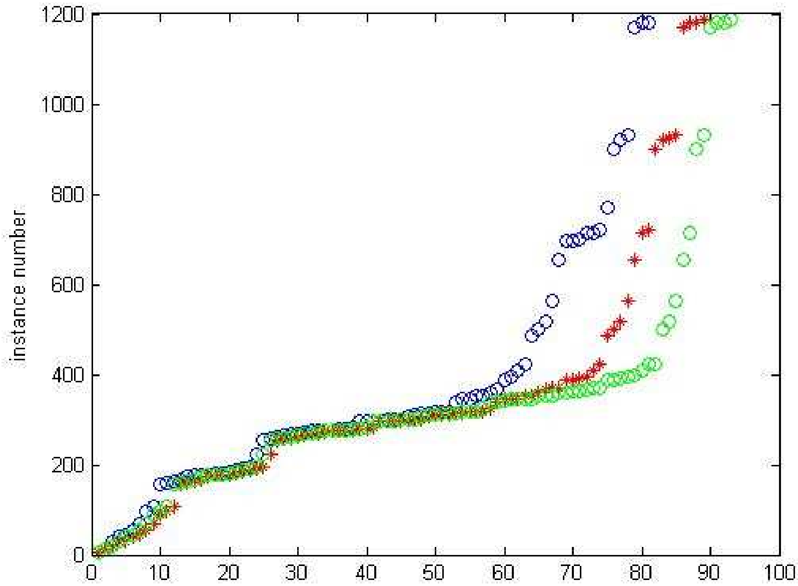
Figure 5: Networkedness using equal weights



The second and third models emphasize the relative formality of linkages, and external scope of linkages respectively. Each time, using the same process described before, it is calculated which respondents can be considered truly networked, somewhat networked, and not at all networked.

Figure 6 compares the three models. In most instances, the same value is obtained regardless of which model us used. Numerically, 97.2% of all 1215 instances in the dataset have the same scoring for networkedness. This implies that the scoring system is robust.

Figure 6: Robustness of scoring for networkedness



2.4 Results

2.4.1 Towards a taxonomy of GINs

The fact that the indicators for globalness, innovativeness and networkedness proved to be robust to different operationalisations of each construct suggests that they tap into robust constructs.

Using the calculated scores, we classify each firm within one of the types of global innovation networks. We use a capital letter to indicate that the firm is highly global (G), highly innovative (I) or highly networked (N), and small letters if the firm has been classified as somewhat global (g), somewhat innovative (i) or somewhat networked (n). Finally, we use an asterisk (*) in cases where a firm is not at all global, innovative or networked. Mathematically, twenty-seven (3x3x3) permutations are possible, but to the extent that firms are engaging in some form of GIN not on a random basis, but because of an underlying logic, we expect that only some combinations will be seen.

The results indicate that there is an underlying logic for firms' behaviour. Certain combinations are not found – it is extremely rare to find a firm scoring highly on one dimension, and not at all on another dimension.[4] In fact, only twelve of the possible 27 categories account for more than 97% of the dataset, and it is possible to combine those twelve categories into six main types. The types are presented in Table 2.

In addition, there are indeed some strong-form GINs. They represent only 15 firms (just more than 1%) in the sample, but given the emergent nature of the phenomenon, this is to be expected. The strong-form GINs are discussed in more detail later.

Table 2: Types of GINs

Type of GIN	Description	Values
Balanced GINs	All the elements are in alignment	GIN (1.23% of sample) gin (40.41%) *** (12.18%)
Global asset exploiters	Global reach is greater than the extent of innovation or networkedness	Gin (2.96%) g** (1.65%)
Innovators	Firms are relatively more innovative than their global reach or the extent of their networks would suggest	gIn (2.63%) *i* (1.89%)
Networkers	Strength of networks is greater than global reach or innovativeness	giN (1.48%) **n (5.76%)
Global networkers	Innovation is not as high as both the globalness and the innnovativeness. This is the only common combination of two stronger dimensions	GiN (4.36%) g*n (3.79%)
Domestics	Firms that have no supra-national footprint at all, but are innovative and networked enough to (presumably) survive domestically or locally – this category accounts for the second largest group of firms.	*in (18.93%)

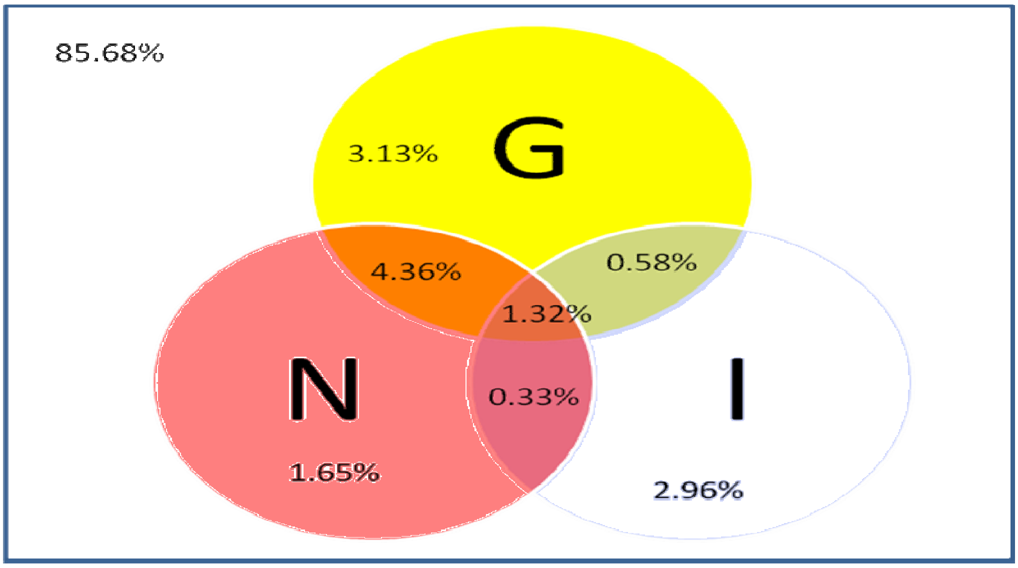
The greatest proportion of firms, 40% of the sample, consists of firms that are somewhat global, somewhat innovative and somewhat networked, and the third most commonly found category (12% of the sample) of firms that are not at all global, innovative or networked. These firms are all "balanced", in that their globalness, innovativeness and networkedness are at an equal level of development. The prevalence of cases where the three elements are at a similar level of development suggests that there is indeed an element of co-evolution in their development.

Almost a fifth of the dataset (the second-largest category overall) consists of firms that have no supra-national connection at all, but are still somewhat innovative and networked. These firms are clearly focused on a local or domestic market. But for the categories of global asset exploiters, innovators and global networkers, the firms that are *somewhat* global, innovative and globally networked are outnumbered by those with *high* scores on those dimensions. It seems that there

[4] In terms of how we designate types, it virtually never happens that a firm would be described with both an asterisk and a capital letter.

could be some kind of momentum or logic by which it is easier for firms to have intensive than somewhat global, innovative and/or networked behaviour when they participate in a global innovation network, even when it is not yet a stronger form GIN.

Figure 7: Global Innovation Networks



Mapping the entire dataset is useful in order to quantify the relative importance of GINs, and it provides evidence that about 15% of the firms in the dataset are truly global, innovative and/or networked. These firms belong to various stronger forms of GINs, and it is worth investigating the characteristics of the stronger forms GINs.

2.4.2 Characteristics of the stronger forms of GINs

Table 3 below provides evidence of some core characteristics of the stronger forms of GINs, that is, those that have a higher degree of globalness, networkedness or innovativeness.

The **Global asset exploiters** and global networkers have a similar distribution in terms of both size (large firms) and firm type – mainly the subsidiaries and headquarters of MNCs. Among the global asset exploiters, the European locations are relatively well represented. These firms seem to follow a fairly traditional model of market-seeking expansion.

In contrast, the **Global networkers** is the single category where developing country firms are most prevalent – with almost 7% of all developing country firms in the dataset represented in this category. Networkers are also large firms, also predominantly subsidiaries and headquarters of MNCs, but firms from developing countries are not as readily found as among the global networker category.

The comparison between **Networkers** and global networkers is useful because the main dimension of difference is the scope of the network. It is telling that the developing country firms are so much more global, and that high levels of globalness and networkedness co-occur, but not innovativeness. This pattern is consistent with previous evidence about the relatively lower innovativeness of developing country firms. We suggest that the less munificent institional context of entities in less developed countries is an important explanatory factor in their strong drive for global networking.

In contrast, **Innovators** are more often from Europe than any other category, more often small (less than 50 employees) standalone firms, and more likely to generate new to the world product and/or service innovations than any other category. It seems that these players are most able to draw on an appropriate regional institutional infrastructure. Innovators are relatively small firms that offer new-to-the-world goods and services. Previous research has suggested that new-to-the-world innovations are especially critical to an economy, and therefore these firms have the potential to play a particularly important role in an economy. However, Innovators have a very low proportion of exports and few international clients. This raises the question of whether firms are capturing adequate economic value from their innovations - it seems likely that more markets could be found for their innovations.

It is worth to look in detail at those firms that are highly global, highly innovative and highly networked (GINs with block capitals) within the **Balanced GINs** – we call these the **High-level Balanced GINs** . Of the fifteen firms that fall in this category two are in the agro-processing industry, and the other thirteen all in ICT. This to some effect reflects the dominance of ICT in the dataset, although this result is also quite coherent with the literature that has long argued that globalization is more likely to occur in some industries than in others, due to the different nature of their knowledge bases (Pavitt, K. 1984; Asheim, B. and Gertler, M. 2005). The fact that no automotive firms are part of High-level Balanced GINs is also consistent with that evidence.

As regards the size distribution of the High-level Balanced GINs, one very small firm is found, and the others range in size from 50 to more than 1000 employees. This is smaller than would be the case for most traditional industries (e.g. much of manufacturing), and suggests that there may be a current optimal point in terms of number of employees as regards the complexity of managing a GIN. Those firms with a global footprint (global asset exploiters and global networkers) that are only somewhat innovative are generally large firms with 1000 plus employees, and those firms that are innovative but with a limited global footprint tend to be very small (around 50 employees). In contrast, the High-level Balanced GINs have a considerable footprint, although they have clearly not internalised all activities. This could also be related to the fact that the majority of firms are in ICT, which has a stronger skills than labour component and often fewer in-house employees.

The location of the High-level Balanced GINs is somewhat surprising in relation to what we might expect from the existing literature. One High-level Balanced GIN is found in China, two in South Africa, and eleven in India. Five of them are the subsidiaries of advanced (and in fact, US) MNCs in India, as is the single Chinese High-level Balanced form GIN. But an additional five of the High-level Balanced GINs are subsidiaries or headquarters of emerging MNCs, and four more are stand-alone firms. Apart from the Norwegian firm, the only European participation in this list is the fact that two of the emerging MNCs whose subsidiaries are represented have dual headquarters, both in their country of origin and in a European country.

Table 3. Main characteristics of stronger forms of GINs

	Industry % of all firms in that industry (number)	Country % of all firms in that country (number)	Size % of all firms of that size (number)	Firm type % of all firms of that firm type (number)	Location responding unit % of all firms of that type in that location
Global asset exploiters	Auto 2.05% (3)	China 0.82% (2)	<10 1.53% (2)	Standalone 2.31% (16)	Developing 2.98% (10)
	Agro 1.50% (2)	India 8.02% (26)	<50 1.94% (7)		Europe 1.83% (6)
	ICT 3.53% (33)	South Africa 1.19% (1)	<250 4.39% (13)	Subsidiary 6.50% (16)	Developing 7.61% (15)
38 cases, 3.13% of dataset		**Developing 4.03% (29)**	<1000 4.71% (8)		Europe 1.79% (1)
		Denmark 2.04% (1)	>1000 6.80% (7)	MNC HQ 4.44% (6)	Developing 3.39% (4)
		Germany 3.77% (2)	No info 0.65% (1)		Europe 11.11% (2)
		Norway 1.66% (3)			
		Sweden 1.54% (3)			
		Europe 1.82% (9)			
Innovators	Auto 0.53% (5)	Brazil 5.80% (4)	<10 0.76% (1)	Standalone 2.89% (20)	Developing 3.57% (12)
	Agro 1.50% (2)	China 1.23% (3)	<50 3.60% (13)		Europe 2.44% (8)
36 cases, 2.96% of dataset	ICT 3.10% (29)	India 5.25% (17)	<250 4.39% (13)	Subsidiary 4.07% (10)	Developing 4.06% (8)
		South Africa 1.19% (1)	<1000 2.94% (5)		Europe 3.57% (2)
		Developing 3.47% (25)	>1000 3.88% (4)	MNC HQ 3.70% (5)	Developing 3.39% (4)
		Denmark 2.04% (1)			Europe 5.56% (1)
		Norway 2.76% (5)		No info 1	
		Sweden 2.56% (5)			
		Europe 2.22% (11)			
Networkers	Auto 1.37% (2)	India 3.09% (10)	<10 0.76% (1)	Standalone 1.01% (7)	Developing 0.60% (2)
	Agro 2.26% (3)	South Africa 3.57% (3)	<50 1.11% (4)		Europe 1.52% (5)
20 cases, 1.65% of dataset	ICT 1.60% (15)	Developing 2.29% (13)	<250 1.69% (5)	Subsidiary 3.25% (8)	Developing 3.55% (7)
		Germany 3.77% (2)	<1000 1.76% (3)		Europe 1.79% (1)
		Sweden 2.56% (5)	>1000 4.85% (5)	MNC HQ 2.96% (4)	Developing 3.39% (4)
		Europe 1.41% (7)	No info 1.30% (2)		Europe 0.00% (0)
				No info 1	
Global networkers	Auto 2.05% (3)	Brazil 2.90% (2)	<10 0.76% (1)	Standalone 1.59% (11)	Developing 2.68% (9)
	Agro 3.01% (4)	India 13.89% (45)	<50 0.83% (3)		Europe 0.61% (2)
53 cases, 4.36% of dataset	ICT 4.91% (46)	South Africa 3.57% (3)	<250 4.73% (14)	Subsidiary 9.76% (24)	Developing 12.18% (24)
		Developing 6.94% (50)	<1000 10.59% (18)		Europe 0.00% (0)
		Germany 3.77% (2)	>1000 16.50% (17)	MNC HQ 13.33% (18)	Developing 14.41% (17)
		Sweden 0.51% (1)			Europe 5.56% (1)
		Europe 0.61% (3)			
High-level balanced GINs	Auto 0 % (0)	China 0.41% (1)	<10 0.76% (1)	Standalone 0.58% (4)	Developing 0.89% (3)
	Agro 1.50% (2)	India 3.40% (11)	<50 0.00% (0)		Europe 0.30% (1)
15 cases, 1.23% of dataset	ICT 1.39% (13)	South Africa 2.38% (2)	<250 1.35% (4)	Subsidiary 4.07% (10)	Developing 10.71% (10)
		Developing 1.94% (14)	<1000 4.12% (7)		Europe 0 (0)
		Norway 0.55% (1)	>1000 2.91% (3)	MNC HQ 0.74% (1)	Developing 0.84% (1)
		Europe 0.20% (1)			Europe 0 (0)

The evidence suggests that it would be wrong to regard High-level Balanced GINs as the domain primarily of the most advanced MNCs of the developed world. High-level Balanced forms of GINs seem to have two origins: Some are advanced MNCs evolving into GINs, who are able to manage the complexity of a global network and achieve substantial innovation. The other strand is of developing country firms that have long had the global networks, but are also achieving true innovation.

In terms of industry, the auto industry has a strong showing in two categories – innovators and global networkers, but it does not have any High-level Balanced GIN. The fact that firms are either capable of strong innovation, or of global networking, suggests that there may be some trade-off between managing advanced innovation, and managing extensive global networks. In addition, it seems that there are “assembler firms” in the industry that are tasked with global sourcing and integration of innovations that come from specialist innovative suppliers, and this most likely links to different positions in the value chain**.** It is also interesting to see that the agro-processing industry does not show up as dominant in any of the categories but they are present in the High-level balanced GINs.

As can be seen from Table 4, GINs also seem to a certain extent to be an “India” phenomenon with a third of the Indian dataset showing up as a strong form G, I and/or N. Part of the reason may be that the India survey was conducted in the ICT sector with its emphasis on connectedness, and the virtual (and therefore easily globalised) nature of many of its offering. However, countries like China and Norway also conducted the survey in ICT, and do not seem to have so many GINs. This indicates that firm strategy matters: India is English-speaking, it is a popular outsourcing destination for established MNCs, and domestic Indian firms often target the global market first. In contrast, China and Norway experience not only language barriers, but there is also a stronger domestic focus among IT firms.

Table 4: Participation in some stronger-form GIN

Respondents participating in a stronger form GIN	#	% of all respondents from that country
Brazil	6	8.70%
China	6	2.47%
India	109	33.64%
South Africa	5	5.95%
Total developing countries	**126**	**22.22%**
Denmark	2	4.08%
Estonia	0	0.00%
Germany	6	11.32%
Norway	9	4.97%
Sweden	14	7.18%
Total Europe	**31**	**6.26%**
Total	**157**	**12.92%**

2.4.3 Methodological limitations

It is important to note that although the paper theorises global innovation networks, what is polled is not the network, but a single node of the network. The evidence can at best be described as an “ego network”, and it suffers from the typical shortcomings of ego networks. The evidence is self-reported, and respondents are likely to provide more accurate information on local matters (e.g. the number of people employed at that unit) than on more distant matters (e.g. the size of the organisation overall). Another issue of concern is ownership and control. First, although the data provides the location of the unit, which is adequate for standalone firms, it provides inadequate information about the location of the parent of subsidiaries. Although some post-hoc information gathering was conducted, this oversight is regrettable.

Specifically related to the strong representation of firms from developing countries, the evidence does not allow us to adequately distinguish between a subsidiary which is part of a strong-form GIN because it is part of the complex network of an advanced MNC and a subsidiary that uses a strong-form GIN to compensate for not only a weaker institutional context, but also the absence of the advanced MNC's rich network. Stated differently, if participation in a stronger form GIN can be regarded as a form of created asset seeking, it is not possible to establish whether the motive lies with the unit in the responding location or with the parent.

Although the considerations related to ego networks affect respondents from Europe and the developing countries equally, it may also be the case that the two groups have a different reference point on certain matters. For example, when assessing the novelty of a given innovation, an entity in the developing world may judge it relative to other innovations in its less developed context, and judge it as more innovative than an entity in Europe would, since new-to-the-world innovations are more common there.

This shortcoming relates to the substantial challenges of conducting and interpreting a standardised survey across very different countries and industries. In spite of considerable efforts to ensure concordance between different countries and different industries, there are considerable differences in the types of databases used and response rates between countries. At a conceptual level, it must be asked to what extent even "objective" measures like the number of people working in a firm in two contexts as different as, for example, Denmark and India, can be regarded as comparable.

This is especially consequential because the analysis relies on *relative* measures for the construction of groups. The highly globalised, innovative and/or networked respondents are so relative to the other responses in the dataset, not according to some objective external measure. A relative measure is useful in the case of an emerging phenomenon such as GINs, as it allows us to capture the patterns that already exist. However, it also makes the conclusions vulnerable to the specifics of a dataset. The size and the breadth of the dataset may mitigate that limitation in this case.

Finally, it is important to remember that especially the final list of strong-form GINs is a short one, and that the limited data allow only tentative conclusions. For example, a more balanced dataset may or may not reveal fewer GINs in the ICT sector. The current era is dominated by the emergence of ICT, and advances in ICT have been described as a "carrier branch" in the overall economy (Cantwell, 2001). It may be that ICT firms lend themselves to operating in a global innovation network. However the relatively strong showing of agro-processing firms (2 out of a total of 133 agro-processing responses compared to the 13 out of 936 ICT responses) suggests that GINs may actually function across a range of industries. Further research is needed to clarify the link between the nature of the industry and GIN participation.

2.5 Conclusions

The taxonomy of GINs proposed in this paper opens up several venues for research and challenges some of the assumptions in the literature.

First, while the bulk of stronger forms of GINs are in MNCs, and there is a considerable body of work to support the importance of the MNC as a vehicle for cross-border networks, there is also an unexpectedly strong showing of stand-alone firms. The first important issue is whether the pattern will persist in a larger dataset, and only then will it be possible to examine how stand-alone firms use global networks to potentially compensate for limited in-house capabilities. Previous work has argued that SMEs can benefit from outsourcing (Di Gregorio, Musteen and Thomas, 2009), but participation in GINs may even signal that non-MNCs are rethinking the boundaries of the firm. This is an important venue for future research, particularly complementing the hitherto MNC-centered literature on internationalization of innovation.

The number of emerging MNCs operating within a high-level balanced global innovation network and the dominance of developing countries in this form of GINs is another robust result of this analysis. This evidence suggests that firms who are institutionally somewhat disadvantaged, or even only geographically at some distance from the leading economic actors, have started to exploit the potential of leveraging dense and globally dispersed networks. In the same way that Japan was able to upgrade rapidly in the post-war years because it exploited the opportunities of a new technological paradigm (Cantwell, 1992; Kodama, 1992) and Korea managed to upgrade on the basis of its early embrace of semiconductors, these "marginal" actors are not constrained by path-dependent practices. At the moment it seems that especially Indian ICT entities are exploiting the opportunities of a global innovation network, and it remains to be seen to what extent firms from other less and more developed contexts will follow suit.

It is important to consider the much larger list of different types of GINs. By far the greatest proportion of the dataset (54%) consists of firms where globalness, innovativeness and networkedness are in balance. But it is interesting to see that those excelling in Innovation are not scoring so high in neworkedness or globalness. This may be pointing out to the fact that engaging in global networks is a costly option, and only those firms that are not able to find the resources needed for innovation close by, will engage in the search at a global scale. Furthermore, what our results seem to suggest is that a larger geographical spread of the network may have a negative impact on the technological advantage of the firm.

The relationship between innovation, global networks and size is also very interesting. Most Innovators are European standalone and small firms that rely often on a limited network of partners for innovation, and that mostly interact at regional or domestic level. On the other hand, the networkers and global networkers are firms with more than 1000 employees. Those firms that balance to be highly innovative and, at the same time participate in global networks (high-level balanced GINs) are somehow in the middle. They are mostly firms with 250-1000 employees. This suggests that may be that number of employees is a current optimal point into the complexity of managing a GIN and the value that can be gained from it.

This suggests that operating within a GIN is not a preference, but rather (and perhaps increasingly) a key mode of organising activities. GINs take the cross-border organisation of activities (to use the classic definition of globalisation) a step further. However, they do challenge existing ways of organising, for example by changing the boundaries of the firm, or by requiring identification, sourcing and collaborating with (the most) appropriate partners. We speculate that locational "disadvantages" may have driven the emergence of many of the true GINs – perhaps by having to outsource as much as possible because skills are relatively scarce, by having to be willing to source partners from distant locations because of geographic distance, or because of previous experience in business groups.

For policymakers, it is important to identify the triggers that challenge firms to engage in global innovation networks. The European firms seem to have a regional (rather than global) focus, and (perhaps as a consequence) limited span of networks. Because of the co-occurrence of innovation with globalness and networkedness, this trend can limit their longer-term innovativeness. The research also suggests that the focus on MNCs as the sole drivers of GINs is too limited. Although MNCs play a very important role in many GINs, stand-alone firms can increasingly access capabilities through external rather than internal networks.

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3 DO REGIONS MAKE A DIFFERENCE? EXPLORING THE ROLE OF REGIONAL INNOVATION SYSTEMS AND INSTITUTIONS IN GLOBAL INNOVATION NETWORKS

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Abstract: The access to global innovation networks (GINs) has been extremely unequal across regions around the globe. While certain regions are considered knowledge hubs in global value chains, able to attract knowledge-intensive activities, other still remain marginalized, pointing out to the role of regional innovation systems and sub-national institutional frameworks in the emergence and development of GINs. Using firm-level data collected through a survey and case studies in 2009-2010, this article systematically compares the patterns of globalization of innovation in regions with different institutional thickness in a selection of European (Norway, Sweden, Denmark, Germany and Estonia) and non-European countries (India, Brazil, China and South Africa). Contrary to what we expected, the results show that GINs may emerge in regions which are neither institutionally too thick (like Tier 1) or too thin (like Tier 3).

Keywords: globalization; innovation networks; regions; Europe; India; Brazil; China; South Africa

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3.1 Introduction

The access to global innovation networks (GINs) has been extremely unequal across regions around the globe. In certain countries, while the country as a whole may not be playing a role in GINs certain sub-national regions do, pointing out to the role of regional innovation systems and sub-national institutional frameworks in the emergence and development of GINs.

This paper explores the role of the region in the emergence and development of GINs in a selection of European (Norway, Sweden, Denmark, Germany and Estonia) and non-European countries (India, Brazil, China and South Africa).

The starting point of the paper is the literature on economic geography in general and regional innovation systems in particular (Asheim and Isaksen, 1997; Cooke, 1992, 1999, 2001) which argue that despite economies have become much more globalized, most innovation activity is still concentrated in certain regions around the globe. Agglomeration economies can be explained, among other factors by the tacit nature of knowledge and its sticky character (Asheim and Isaksen, 2002). Tacit knowledge is more likely to be spread among firms and organizations that are located in the same geographical area. This, in turn may facilitate innovation as the success of regions like Third Italy, Baden-Wuttenberg in Germany or the Sillicon Valley has shown (Piore and Sabel, 1984; Saxenian, 1994; Staber, 1996).

While some authors predicted that the increased globalization of economic activities will put a threat to the regions, the reality has shown that globalization has come hand in hand with an increased role played by certain regions in the global economy (Amin and Thrift, 1994, 1996; Chaminade and Vang, 2008). Despite the opportunities opened by information and communication technologies for the transfer of (codified) knowledge and the role that relational proximity may play in link together actors that are geographically distant enabling the transfer of knowledge, some regions remain power houses or knowledge hubs in global value chains and networks(Chaminade and Vang, 2008). In other words, global processes are still “pinned down” in certain regions around the globe (Amin and Thrift, 1994) and the observed differences between sub-national regions around the globe could be explained by the different configurations of their innovation systems.

Regional innovation systems (RIS) can be defined as the “institutional infrastructure supporting innovation within the production structure of a region” (Asheim and Gertler, 2005). While institutions have been at the core of the definition of RIS, there are a very limited number of studies analyzing the role of institutions in RIS (Doloreux and Parto, 2005), and even fewer attempting to uncover how regions influence the way in which firms participate in global innovation networks and how different regional institutional frameworks may facilitate or hamper the access to global networks of innovation (Tödtling et al., Forthcoming 2011).

This paper deals with these questions. More specifically, the paper addresses the following questions: 1) Do we observe different patterns of globalization of innovation activities in different regions? and 2) What is the role of the institutional frameworks explaining the observed differences?

Using firm-level data collected through a survey and case studies in 2009-2010, this article systematically compares the patterns of globalization of innovation in regions with different institutional thickness. The paper shows that these patterns differ substantially across regions and discusses relationship between regions, institutional frameworks and different forms of globalization of innovation.

The paper is structured as follows. Section 2 introduces the concept of globalization of innovation, the different modes of globalizing innovation and the relationship between regions and the globalization of innovation, paying particular attention to the role of the institutional thickness. Section 3 describes the data sources used for the analysis and the method. Section 4 summarizes the main results, which is followed by conclusions.

3.2 Main theoretical framework

3.2.1 Globalization of innovation

The internationalization of production activities is not a new phenomenon. Multinational firms have long been locating different functions of the organization in geographically distant places to exploit ownership, location or internationalization advantages (Dunning, 2001). But it is only recently, that scholars in the international business literature as well as innovation studies have started to pay attention to the *globalization* of innovation activities (Cantwell and Piscitello, 2002, 2005a; Cantwell and Piscitello, 2005b, 2007; Dunning and Lundan, 2009; Le Bas and Sierra, 2002; Zanfei, 2000). The globalization of innovation is a different phenomenon from the internationalization of production for two reasons: on the one hand because globalization is more than internationalization. Globalization implies not only the geographical spread of economic activities across the globe but also a high degree of functional (des)integration (Dickens, 2007). It also highlights the *global* spread of the activities, that is, beyond the existing technology clubs (Castellacci and Archibugi, 2008). On the other hand as the motivations, determinants and consequences of the globalization of knowledge intensive activities differ from the globalization of production (Castellani and Zanfei, 2006).

It follows that there are different degrees in the internationalization or globalization of innovation, from the mere commercialization of new products and services in international markets (asset exploiting strategy) to the global generation of innovation activities (asset seeking strategy). Already back in the mid-nineties, Archibugi and Michie (1995) proposed to distinguish between three forms of globalization of innovation: the global exploitation of innovation, the global research collaboration and global generation of innovation. The **global exploitation of innovations** refers to the international commercialization of new products or services and has its economic equivalent in the export of new products or services or in the international licensing of patents. The **global research collaboration** alludes to the joint development of know-how or innovations with the participation of partners from more than one country. This collaboration can take a variety of forms, including R&D joint-ventures, R&D alliances, contractual R&D, etc. and can involve a variety of actors, including firms, research centers, universities or the government, among others. Finally, the **global generation of innovations** refers mainly to the location of R&D activities in a different country and it is associated with R&D related foreign direct investment.

In the context of developing countries, there is a forth category of globalization of innovation worth considering (Plechero and Chaminade, 2010): **the global sourcing of technology (and innovation)**. More often than not, firms in developing countries depend on technology acquired from the developed world (Bell and Pavitt, 1995; Lall, 1992; Lundvall et al., 2009). Their innovation capacity is often limited and they rely more on the acquisition of technology and its adaptation to the local context than on the development of new technology.

As recent evidence shows, different regions are specialized in different forms of globalization of innovation. For example, firms located in the Pune region in India are more specialized in the three types of globalization of innovation and in particular in the exploitation of innovation more than firms located in Beijing (Plechero and Chaminade, 2010). However, the existing evidence is limited in terms of the number of regions considered in the analysis as well as in providing some useful explanation of why this is so. A deeper look into the innovation systems of those particular regions may provide some insights to why different regions get involved in different forms of globalization of innovation.

3.3 Regional innovation systems and institutional thickness

It is generally accepted that innovation is socially embedded and that it is the result of continuous interactions and exchange of knowledge between organizations (Freeman, 1987; Kline and Rosenberg, 1986; Lundvall, 1992). For long, economic geographers have argued that due to the tacit nature of knowledge those interactions often take place at local level, that is, between organizations that are geographically close (Asheim and Gertler, 2005; Boschma, 2005; Cooke, 1995; Storper and Venables, 2004). Thus, geographical proximity may facilitate interactive learning and innovation through the exchange of both tacit and explicit knowledge among the individuals and organizations located in that particular region. Innovation in general, and knowledge sharing in particular, is a social process that is shaped by soft and hard institutions like culture, habits, convention and routines but also by laws and regulations (Hollingsworth, 2000). Most of the institutions have a very strong regional character and this is particularly the case for soft institutions. The same industry, operating in the same national institutional framework may behave very differently in two sub-national regions, due to the different regional institutional frameworks in the two regions (Gertler, 2010).

Institutions, both formal and informal, may facilitate or hamper the exchange of knowledge (Asheim and Isaksen, 2002; Cooke et al., 1997; Gertler, 2010; Morgan, 2007), shape the geography of the knowledge flows of a particular region (Amin and Thrift, 1994, 1996; Tödtling et al., Forthcoming 2011) and are the main engine of change within the regional innovation system (Boschma and Frenken, 2009; Boschma and Frenken, 2006). Despite the fact that institutions are at the heart of the very definition of regional innovation systems (Rafiqui, 2009), there are very few authors that have dealt explicitly with the role of institutions in regional innovation systems (Doloreux and Parto, 2005).

The institutional "thickness" of a particular region is defined as a combination of different elements (Amin and Thrift, 1994): a strong organizational infrastructure, high levels of interaction, a culture of collective representation and shared norms and values which serve to constitute the social identity of a particular locality. Strong organizational infrastructure refers to the number and diversity of organizations in that particular RIS, from firms to universities, research centers, financial institutions, chambers of commerce, government agencies, etc. But a strong organizational infrastructure would have limited impact if there were not high level of interactions. The third and fourth factor are more difficult to grasp and to measure, and refer to the existence of an effort to work for the interests of the collectivity and not only of the individuals (collective representation) as well as a commonly held industrial agenda and shared norms and values. Empirical studies on the institutional thickness of a particular region are scarce, largely due to the difficulties measuring most of the elements that define institutional thickness and thus are based on qualitative information collected on a particular region like Birmingham (Coulson and Ferrario, 2007), Vienna and Salzburg (Tödtling and Trippl, 2005) or several European regions (Cooke et al., 1997).

According to Cooke et al (2000) institutionally thick RIS are often located in metropolitan areas. Firms in this RIS benefit from a dense network of support institutions, interactions take place often and in general, these regions show high levels of innovation. Institutionally thick regional innovation systems tend to play a more significant role globally than institutionally thin RIS (Amin and Thrift, 1996) as they host a larger amount of multinationals headquarters and subsidiaries (Cooke et al., 2000; Tödtling and Trippl, 2005). We may, therefore, expect that firms located in institutionally thick regions will engage more in different modes of globalization of innovation than firms located in less favored regions.

Institutionally thin RIS are usually to be found in less urbanized regions and are characterized by the strong presence of SMEs with limited innovative capacity, lack of support organizations and low level of agglomeration as compared to thick regions. Some recent evidence suggests that the institutional thickness of a particular region influences the geography of the knowledge linkages, or in other words, how different regions engage in global, domestic or regional networks. In a study of ICT firms in Austria, Tödtling et al (Forthcoming, 2011) show that institutionally thin RIS, firms will tend to establish more international linkages while institutionally thick RIS will tend to establish more domestic. We may therefore expect firms in institutionally thin regions to engage more in GINs to overcome the limitations of the innovation system in which they are embedded.

The extent to which this observed relationship between institutional thickness and internationalization of innovation holds for a variety of regions across the globe will be investigated in this paper.

3.4 Method

3.4.1 Sample

This paper is based on a firm-based survey conducted in 2009 across 9 countries: Brazil, India, China, South Africa, Norway, Sweden, Germany, Estonia and Denmark, as well as case studies conducted in Beijing and Cape Town.

For the survey, each country focused on just one industry: ICT, Automotive or Agroprocessing. In all industries there was always at least one European and one non-European country to be able to perform North-South comparisons. Each institute conducting the survey across the nine countries chose a sector which was of economic importance within their national or regional context. In all sectors and across all countries 1215 responses were collected. The combined INGINEUS sample was dominated by ICT responses. This was in part due to the size of the Indian and Chinese market but also due to the nature of the agro processing and Auto industries which tend to be more concentrated (Barnard and Ismail 2010a). Table 1 below offers a summary of the results and number of responses received from each sector and each country.

Table 1: Survey results by country and industry

Countries	ICT	Auto	Agro
Brazil		69	
China	243		
Estonia	17		
Denmark			49
India	324		
Germany		53	
Norway	181		
South Africa			84
Sweden	171	24	
Total sector	936	146	133

Source: INGINEUS survey

More than half of the sample are standalone companies (681), about 250 are subsidiaries of a multinational company and only 133 are the headquarters of a Multinational. About 46 % of the firms have less than 50 employees, 30 % have between 50 and 250, and the rest are large companies with more than 250 employees. Only 100 companies have more than 1000 employees.

Data on the cases was collected through semi-structured interviews. Interviews were conducted during 2009-2010 in site with the R&D manager, president and/or vice president of the company either directly by the author or by one of the partners in the project (in the case of Cape Town).

3.4.2 Survey and questions selected for analysis

The survey questionnaire consisted of 14 questions covering some background information on the main production activities of the firm, 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, government etc., the offshoring of production and innovation and the role of the institutional framework (mainly at national and international level) supporting or hampering the access to GINs.

This paper is based on the analysis of the four questions capturing the four forms of globalization of innovation:

- Global exploitation of innovation: As a proxy we use the question in which we asked the firm about their largest market, being the options internal to the enterprise, regional, domestic or export.
- Global collaboration for innovation: we use the question on the geographical spread of innovation networks which asked the firm "regarding the development of the most important innovation of your firm in the last 3 years, who did you actively collaborate with and in which geographical location?". The question provided different options as partners: clients,

suppliers, competitors, consultancy companies, government and universities. Firms where asked to indicate if the partners with whom they collaborated where located in the region (subnational), country or a list of other international locations (North and South America, Western and Central&Eastern Europe, Africa, Japan and Australasia and Rest of Asia). In this paper I have collapsed all international interactions under one category called "International".

- Global sourcing: we use question 5 which asked the firm to indicate which is the most important source of technology for the enterprise. The firms were given 5 options: "we produce most technological inputs in house"; "we buy inputs from other branches of our own MNC", "we buy from MNCs not formally connected" ; "we buy from non MNC firms" or "we buy from universities and other public organizations". Although this question does not provide precise information on the geography of the linkages, it does give an indication on the balance between intra-mural and extra-mural sourcing and the importance of sourcing from MNCs.
- Global generation: as a proxy, we use questions number 9.1 in which firms were ask to indicate if they were off shoring production or innovation activities.

In order to assess the relationship between different forms of globalization of innovation (and thus innovation networks) and regions, all the cases in the sample were codified as belonging to a region considered as Tier 1, Tier 2 or Tier 3. To define the three Tiers, quantitative information was used to capture the strength of organizational infrastructure and qualitative for the other 3 elements of institutional thickness (levels of interaction, culture of collective representation and shared norms and values). In the project, each country collected data about one particular industry. Statistics broken down at the level of industry and region are scarce or even not available at all for developing countries. Information on the number of firms for the specific industry in a particular region, number of employees and, in some cases[1], the volume of exports was collected if that information was available in the country[2]. The available information is included as Annex 1. Information on the availability of specialized universities, research centres and intermediate organizations in the region was also collected, when available[3]. This information was used as a proxy for organizational infrastructure and it is the only pseudo-quantifiable indicator. Consultation with country experts in the project as well as review of the literature on clusters in those specific industries for each country was used to acquire information on levels of interaction, culture of collective representation and shared norms and values (qualitative).

Basically, regions with the highest concentration of firms and employment in that particular industry in that country, with frequent interactions and a strong identity in that particular industry were considered as Tier 1. Regions with an average or above the average number of firms and employment in the industry and some specialized supporting institutions and with less strong interactions, culture and shared norms were classified as Tier 2. Those regions that have no specialization in that particular industry were classified as Tier 3. The final classification of the regions in Tiers was checked once again with industry experts in the country. Table 2 below summarizes what is considered to be Tier 1, 2 or 3 in each industry and country.

[1] For example in India, as most of the ICT firms.
[2] Most of the countries did not have information broken down to both region and industry. Information on the number of employees and number of firms per region was available for Brazil, Germany, Norway and Sweden. Information on the volume of exports on ICT per state was available for India.
[3] In most cases, when information is available it does not refer to a particular industry.

On the other side of the spectrum, Tier 3 regions are usually institutionally thin regional innovation systems for the particular industry considered. The number of firms specialized in that particular industry is low and there are not so many specialized support organizations. Kwa-Zulu Natal in South Africa or Hasrstad in Norway are examples of Tier 3 regions.

In the middle, we are considering another category, Tier 2 regions. These are usually secondary regions in the country, in which there is a significant number of firms specialized in that industry, there is also presence of support institutions but that are yet not so well networked, not attracting so many multinationals and in general, do not show the same institutional thickness than those regions considered Tier 1. One example could be the Malmö ICT cluster, which employs around 23000 people, but that is still far away from the more than 100.000 people employed in ICT in the area of Stockholm (Tier 1), which is considered as the hub for the ICT industry in Sweden.

As a result 419 firms were classified as Tier 1, 430 as Tier 2 and 198 as Tier 3. The sample is also quite well distributed by industries. ICT has 308 firms located in Tier 1, 377 in Tier 2 and 156 in Tier 3; Agroprocessing has 32 firms in Tier 1, 64 in Tier 2 and 20 in Tier 3; finally automotive has 44 in Tier 1, 72 in Tier 2 and 31 in Tier 3.

Table 2. Distribution of cases by tiers

Country	Industry	Tier 1	Tier 2 (example)	Tier 3
Brazil	Automotive	Sao Paulo	Minas Gerais	Porto Alegre[4]
China	ICT	Beijing	Shenzhen	Shanghai
Denmark	Agro-process	Århus, Glostrup, Græsted, Greve, Ishøj København,	Ansager, Bjerringbro, Gråsten, Kjellerup, Kolding, Ejby, Faxe, Lynge, Ringsted, Slagelse, Sorø and Viby Sj	No*
Estonia	ICT	Tallin	Tartu	No*
Germany	Automotive	Baden-Württemberg, Bayern	NRW,Rheinland Pfalz, Thüringen,	Hessen, Saarland
India	ICT	Bangalore	New Delhi (incl. Noida, Gurgaon), Mumbai, Chennai, Hyderabad Pune	Cochin, Trivandrum Chandigarh
Norway	ICT	Oslo, Trollåsen Lisaker, Bergen, Stavanger, Fornebu	Moi, Trondheim, Brumunddal, Sunndalsøra,	Hasrstad

[4] Only one firm

South Africa	Agro-process	Gauteng	Western Cape	Eastern Cape, Free State, Kwa-Zulu Natal Limpopo, Mpumalanga, North West, Northern Cape
Sweden	ICT, Auto	Stockholm, Kista and Solna (ICT) Gothenborg (Auto)	Malmö, Gothenborg (ICT) Trollhättan, Södertälje (Auto)	Jönkoping, Helsinborg (ICT) Rest (Auto)

* Due to size of the country, it was estimated that there was not such as Tier 3 regions.Tier 1 regions can be considered as thick regional innovation systems, usually located in metropolitan areas, that show a strong specialization in that particular industry. For example, Stockholm in Sweden and Bangalore in India are considered to be the most important clusters in the ICT industry, while Baden- Württemberg (Germany) or Sao Paulo (Brazil) are the equivalent for the automotive industry. They are not only considered to be the strongest hub in the country but they are also strong regions globally, for that particular industry.

Table 3 next summarizes the distribution by type of firm and size of firm. As can be observed, Tier 1 has more headquarters of multinationals but it is also a region that is dominated by SMEs. Tier 2, in comparison, has the highest proportion of largest companies as well as the higher number of subsidiaries of MNCs. Tier 3, finally, is dominated by standalone companies and also SMEs.

Table 3. Type of firm and size by Tier. Percentages over total in Tier (total category)[5]

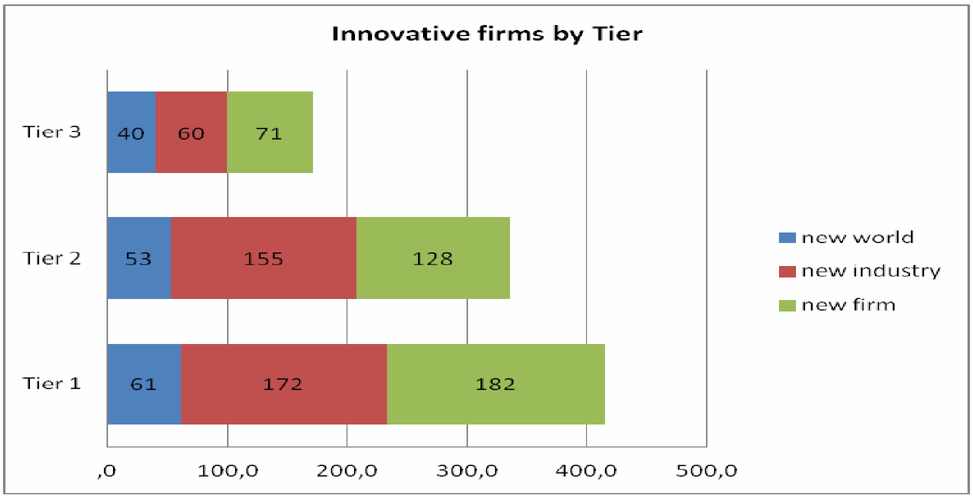
	Region Cluster Tier			
	First Tier	Second Tier	Third Tier	Total
A standalone company	64,20 (39,50)	62,79 (39,65)	71,71 (20,85)	39,26 (100)
A subsidiary of a MNC	17,66 (30,45)	28,37 (50,21)	23,73 (19,34)	22,98 (100)
The headquar-ters of a MNC	15,51 (48,51)	14,18 (45,52)	4,04 (5,97)	12,58 (100)
Fewer than 10 FTE employees	11,69 (38,28)	8,60 (28,91)	21,21 (32,81)	12,10 (100)
10 to 49 employees	38,18 (44,69)	26,51 (31,84)	42,42 (23,46)	33,86 (100)
50 to 249 employees	26,96 (38,44)	32,09 (46,94)	21,71 (14,63)	27,81 (100)

[5] There is a strong correlation between Tiers and the type of firms. Tier 1 is correlated with the firm being a headquarter (HQ) with a 5% confidence interval and with subsidiaries at 1%. Tier 2 is not correlated with HQ but is correlated with subsidiaries at 1%. Finally Tier 3 is correlated with HQ at 1% and not correlated with subsidiaries.

250 to 999 employees	15,03 (37,72)	20 (51,50)	9,09 (10,78)	15,79 (100)
1000 or more employees	8,11 (34)	12,79 (55)	5,55 (11)	9,46 (100)

As expected, the proportion of firms that are innovative is much higher in Tier 1 firms than Tier 2 and Tier 3, as Graph 1 shows.

Graph 1: Distribution of innovative firms by tier



Source: INGINEUS survey

Tier 1 regions, like Stockholm, Beijing or Bangalore could be considered *Globalized regional innovation systems* (Cooke et al, 2007). They are characterized by a large presence of multinationals and in general large corporations, surrounded by a network of SMEs. They host a large number of research institutes, providing qualified human capital and research to the productive system.

Tier 2 regions, like Shenzhen, Western Cape or Malmö could resemble what Cooke et al call *Interactive regional innovation systems*. The productive structure is a mix between large and small firms. Tier 2 regions are also characterized by larger number of subsidiaries of MNCs rather than headquarters.

Finally, Tier 3 regions, like Pune, Easter Cape or Jönkoping could resemble a *Localist innovation system*, dominated by small firms and with limited research capabilities. Interactions take place within the value chain, with suppliers and clients for example.

3.5 The role of regions in global innovation networks

From the literature review we may expect that firms located in institutionally thick regions will innovate more and engage more in GINs, while also showing high levels of interaction with local actors than those located in more marginal regions. For example, we would expect ICT firms located in Kista (a knowledge hub for the ICT industry in Sweden) to collaborate more with other actors in Kista than, for example, an ICT firm located in Umeå (a remote region in North of Sweden). We would also expect firms in Kista to display international linkages due to the higher number of MNCs located there. Similarly, we would expect firms located in Bangalore to interact more at regional and domestic level than firms located in Maharashtra, just simply because there are more knowledge-intensive firms located in that specific region.

3.5.1 Regions and the Global exploitation of innovations

The first analysis is to look at the relationship between different regions and the exploitation of innovations. We use the information on the most important market as a proxy, as the question was not asking specifically about market for new products or services. Table 4 below shows the proportion of firms targeting the different markets per type of region. The results are significant at 1%.

The largest proportions of firms that target international markets are to be found in Tier 2 regions (52,3 per cent of all the firms that export) followed by Tier 1. Firms in Tier 1 tend to commercialize their products mainly in the domestic market. Being the strongest regions, we would have expected Tier 1 regions to play a more dominant role in international markets, particularly taking into account the large amount of headquarters of MNCs located in Tier 1.

Table 4: Regions and global exploitation of innovations

4.1 In geographical terms, is your enterprise’s largest market?			Internal to your enterprise	A regional market (local region in your country)	Domestic market (rest of your country)	An export market	Total
Region Cluster Tier	First Tier	Count	4	72	247	89	412
		% within Region Cluster Tier	1,0%	17,5%	60,0%	21,6%	100,0%
		% total in that market	22,2%	34,8%	48,0%	27,5%	38,7%
	Second Tier	Count	11	85	182	176	454
		% within Region Cluster Tier	2,4%	18,7%	40,1%	38,8%	100,0%
		% total in that market	61,1%	41,1%	35,3%	54,3%	42,7%
	Third Tier	Count	3	50	86	59	198
		% within Region Cluster Tier	1,5%	25,3%	43,4%	29,8%	100,0%
		% total in that market	16,7%	24,2%	16,7%	18,2%	18,6%
Total		Count	18	207	515	324	1064

	% within Region Cluster Tier	1,7%	19,5%	48,4%	30,5%	100,0%
	% total in that market	100,0%	100,0%	100,0%	100,0%	100,0%

Chi2: 46,891, significant at a 1%.

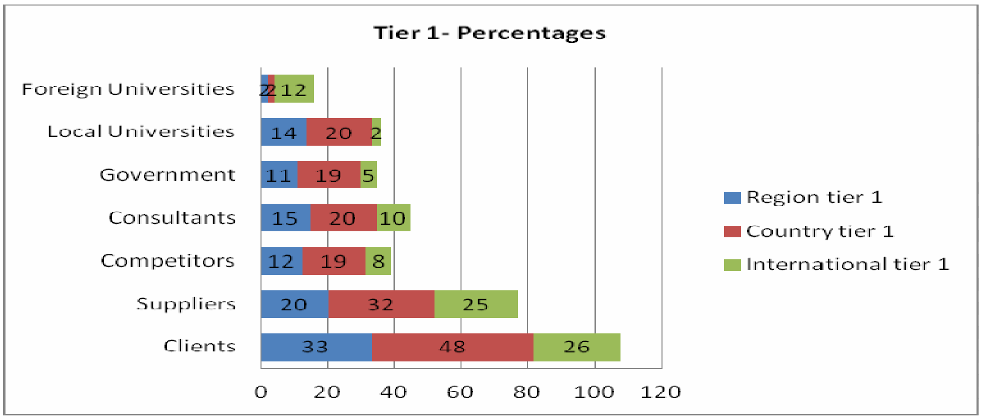
3.5.2 Regions and the Global collaboration for innovation

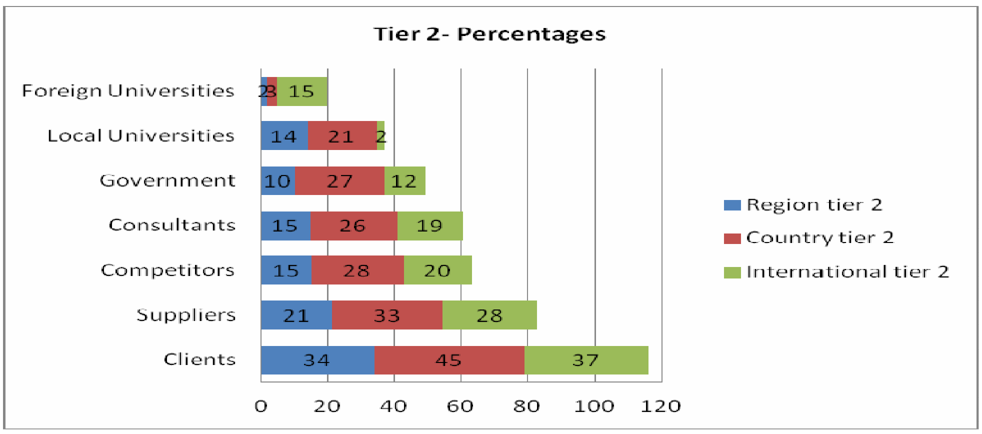
To investigate if firms in stronger regions collaborate more at regional level, we calculate the percentage of firms, in that particular region, that collaborate with each of the potential partners for innovation. The results are plotted next, one graph per region.

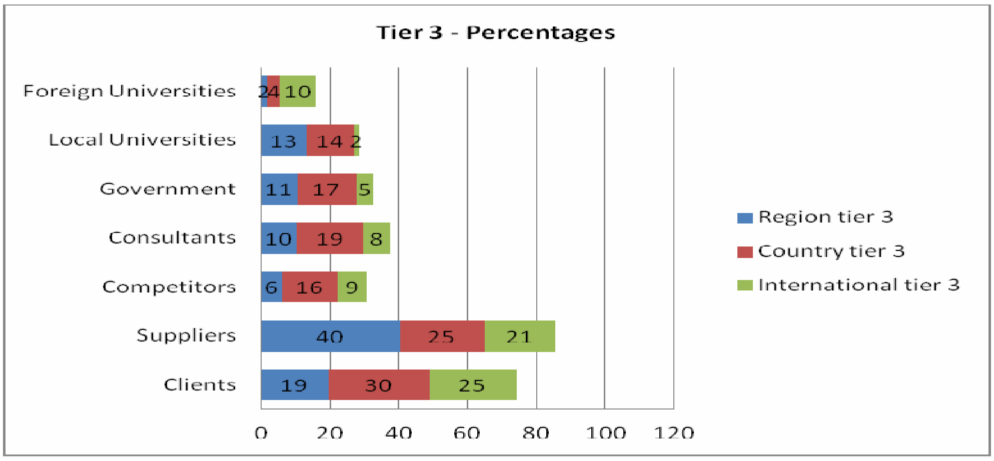
Contrary to what we would have expected, it is again firms located in Tier 2 regions that tend, in general to collaborate more with partners not only at regional level, but also at international levels. They are more networked than firms in Tier 1. The only exception is the collaboration with regional suppliers in Tier 3 regions, which is higher than in Tier 1 and 2.

So, while Tier 1 regions tend to concentrate a larger number of innovative firms, they are less prone to participate in international networks. It is firms in Tier 2 that collaborate with a larger variety of international networks.

Graph 2: Collaboration for innovation







Source: INGINEUS survey

It is interesting to analyze the differences also in terms of the partners for the collaboration. Table 1 compares the distribution of responses of the firms located in Tier 1, 2 and 3, independently of the industry (inter-regional differences) using Chi-square test. As can be observed in the table, the proportion of firms that collaborate at domestic level is always the highest for all sources (excluding international universities), all industries and Tier 1 and 2. Having said that, there are significant differences across regions with regards to the breadth of the network and the geographical spread of the different sources

The comparison between firms located in regions Tier 1, 2 and 3 shows that there are significant differences when it comes to the collaboration with clients, competitors, consultants and government. In fact, Tier 3 firms rely much more on international clients than firms in the other two tiers, in relative terms. This would be expected in one thinks that Tier 3 regions are regions with no strong productive structure in a particular industry and often no specialized knowledge suppliers for that industry. In other words, Tier 3 regions are often weak regional innovation systems, which may force the firms to look for the partners in innovation outside the region, either domestically or internationally.

Table 5: Inter-regional differences in the importance of different partners for collaboration (Chi-Square test)

	total in number			**Test**		
	regional	domestic	international	regional	domestic	internat
Clients	336	511	362	4,870*	9,014**	11,790**
Suppliers	242	364	303	2,588	2,797	1,094
Competitors	144	336	156	5,737*	8,510**	24,744***
Consultants	165	269	160	2,027	7,730**	12,731**
Government	128	257	94	1,038	9,376**	10,431**
Local Universities	164	228	26	0,350	1,955	0,464
Foreign Universities	23	35	153	0,300	4,535	1,617

Comparison of distribution across Tiers. Chi2 (test of disjoint distribution). P-value: Significant level: 1% ***; 5% **; 10%*)

3.5.3 Regions and the global sourcing of technology

There is a significant relationship between the type of region and the global sourcing of technology. In terms of sourcing of technology, the majority of firms in all three tiers produce their own technological inputs in house. However, in Tier 1 we find the higher concentration of firms that acquire their inputs from other branches of their own MNC. This is coherent with the fact that it is in this Tier 1 that we find more headquarters of MNCs.

In Tier 2 we find the higher proportion of firms that acquire the inputs from non-multinational firms or from MNCs that are not formally connected to the firm. This reflects the external character of the networks of firms in Tier 2, as compared to the more internal character of the networks in Tier 1.

Table 6: Regions and global sourcing of technology

5. Which is the most important source of technology for your enterprise (including hardware, software and knowledge)?			We produce most technological inputs in-house	We buy most of our inputs from other branches of our own MNC	We buy most of our technological inputs from non-MNC firms	We buy most of our inputs from MNCs with which we are not formally connected	We buy most of our inputs from public-sector organizations, e.g. research institutes, universities etc	Total
Region Cluster Tier	First Tier	Count	258	48	30	60	8	404
		% within Region Cluster Tier	63,90%	11,90%	7,40%	14,90%	2,00%	100,00%
		% over total number in that source	42,20%	44,90%	24,60%	39,00%	34,80%	39,70%
	Second Tier	Count	241	34	69	80	11	435
		% within Region Cluster Tier	55,40%	7,80%	15,90%	18,40%	2,50%	100,00%
		% over total number in that source	39,40%	31,80%	56,60%	51,90%	47,80%	42,80%
	Third Tier	Count	112	25	23	14	4	178
		% within Region Cluster Tier	62,90%	14,00%	12,90%	7,90%	2,20%	100,00%
		% over total number in that source	18,30%	23,40%	18,90%	9,10%	17,40%	17,50%
Total		Count	611	107	122	154	23	1017
		% within Region Cluster Tier	60,10%	10,50%	12,00%	15,10%	2,30%	100,00%
		% over total number in that source	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Chi2: 30,761 significant at 1%

3.5.4 Regions and the global generation

We take as a proxy for the global generation of technology the question on whether the firms has offshored production or innovation. As can be observed in Table 7, Tier 2 hosts a higher proportion of firms offshoring production and innovation than Tier 1 and 3. The Chi2 tests are, however, not significant, pointing out to a weak relationship between different tiers and the globalization of production and innovation.

Table 7

9.1 Regarding internationalisation, does your firm offshore (or has your firm offshored) production or any R&D activities?			No	Yes	Total
Region Cluster Tier	First Tier	Count	283	114	397
		% within Region Cluster Tier	71,3%	28,7%	100,0%
		% within firms offshoring	39,4%	37,6%	38,8%
	Second Tier	Count	290	141	431
		% within Region Cluster Tier	67,3%	32,7%	100,0%
		% within firms offshoring	40,3%	46,5%	42,2%
	Third Tier	Count	146	48	194
		% within Region Cluster Tier	75,3%	24,7%	100,0%
		% within firms offshoring	20,3%	15,8%	19,0%
Total		Count	719	303	1022
		% within Region Cluster Tier	70,4%	29,6%	100,0%
		% within firms offshoring	100,0%	100,0%	100,0%

Chi2: 4,347, not significant

In sum, regions with different institutional thickness show different patterns of globalization of innovation, at least with regards to the global exploitation of innovations, the global research collaboration and global sourcing. It is firms in Tier 2 regions which engage more in global innovation networks than firms in Tier 1 or 3. Table 8 summarizes the main results

Table 8: Summary of results

	Characteristics of firms in the Tier	**Insertion in Global Innovation Networks**
Tier 1 – Institutionally thick RIS	The higher proportion of MNCs is located in this Tier, although the majority of the firms are standalone companies. Tier 1 firms are the most innovative.	Firms tend to commercialize their products in the domestic market. Collaboration for innovation is either local or domestic and, when they engage in networks is mainly internal networks (part of MNCs)
Tier 2 – Neither institutionally too thick or too thin	Higher proportion of subsidiaries is in Tier 2 and the largest proportion of firms with more than 250 employees, including those with more than 1000.	Largest proportion of firms targeting international markets. Although this Tier is the one with the highest proportion of subsidiaries, they tend to rely more on external networks than internal (for sourcing). Firms located in Tier 2 show the higher propensity to engage in GINs in its diverse forms: global exploitation, sourcing and collaboration.

Tier 3 – Institutionally thin RIS	Mostly standalone companies, of small size. Lower proportion of innovative firms.	Tier 3 firms rely on international clients for their operations, and on local suppliers. The breadth of their network for collaboration is narrower. It is more a value chain (links with suppliers and competitors than a network)

3.5.5 Some illustrative cases

Why and how firms in Tier 1 and 2 engage differently in GINs can be better illustrated by some firm cases. Two in Beijing (Tier 1) and one in Cape Town.

Beijing is considered to be a Tier 1 region in China for the ICT industry, as Shanghai would be for automotive. It is also one of the most important S&T centers in China, independently of the industry. Beijing regional innovation system is composed both by a large number of multinational companies as well as a dense network of small and medium size enterprises (90% of the firms in Beijing are small). At the end of 2007, there were approximately 280 R&D labs of MNCs located in Beijing (Lv and Liu, 2011). In 2010, Beijing hosted around 20000 high tech enterprises. There are around 39 Universities located in Beijing, including some of the best in China and worldwide like Tsinghua University, Peking University or the Graduate University of the Chinese Academy of Management (CAS). There are several high-tech parks in Beijing, concentrating a large amount of firms, being one of the most important ones the Zhongguancun Science Park. IBM China research laboratory, Microsoft R&D Center, Intel China Research Center, Motorola China R&D institute or Bell Labs research China are located in Zhongguancun Science Park (Lv and Liu, 2011). The Zhongguancun science Park collectively represents the firms located in the Park, which is another issue contributing to the thickness of the RIS. There are a number of Government promoted initiatives to increase the number of alliances between firms located in Beijing. Hitherto, initiatives like the software alliance, the IGRS (Intelligent Grouping and Resource Sharing) Industrial Alliance or the Zhongguancun Cloud Computing Industry Alliance have supported the establishment of more than 100 industrial alliances involving more than 5000 members (Lv and Liu, 2011). In terms of networks, the analysis of the INGINEUS survey for Beijing shows that although local interactions are important, most collaboration for innovation take place at domestic level and with clients.

Two cases can help illustrate the interactions of the firms with the regional innovation systems, one of a Chinese-based firm and another from a MNC located in Beijing. VOICE[6] is a high-tech company spin-off of a research institute of the Chinese Academy of Sciences. VOICE develops speech recognition engines and Audio Signal Processing Modules, which are sold in three ICT markets: telecom services; embedded services (MP3; MP4; learning machines); and speak control systems (e.g. interface to control telematic system in the cars). - The company is global leader for speech recognition technologies but it is mainly targeting the domestic market. The main partners for innovation are their customers- for example a Chinese mobile company that is a leader in the market as well as the Government. As a spin-off of the Chinese Academy of Sciences, they still

[6] The names of the two firms are fictional. The real name is kept confidential.

keep very strong linkages with CAS. This partnership, provides them with access to a large pool of researchers as well as R&D funds. The sourcing of technology is internal to the company and the exploitation of innovation as well as the collaboration takes place at national level. One significant local interaction is with CAS, which supplies all the R&D resources needed to develop the innovation.

SOFTSERV, on the other hand, is a MNC company established in Beijing. They provide R&D services (where they develop, test and localize the product) and IT services (e.g. enterprise solutions that require more business domain knowledge than technical expertise). Although they started as an internationally oriented company, developing products for international clients (mainly US), currently they are shifting their focus to the domestic market. When the interview took place (2009) their objective was to increase the revenues from the Chinese Market to 50% (when it was 30%). In terms of collaboration for innovation, the company develops its open standard processes to share and to use as a base to construct later the services in collaboration with their customers. Therefore the 'innovation' is done also in cooperation with their clients, which are international, domestic and also local. Sourcing of technology is also done domestically, tapping on the expertise of the different branches around the country.

As the two examples illustrate, both firms are located in Beijing to serve the domestic market (SOFTSERV also the international market). They benefit from the pool of qualified human capital in Beijing, as well as some clients, but the bulk of their technological sourcing, exploitation of innovation and collaboration for innovation takes place at domestic level. The strong institutional framework supports innovation in the sense of providing human capital and proximity to competitors and some clients, but when the objective is the domestic market and the client is the main source of innovation (together with the internal employees), interactions take place domestically.

The Western Cape, is considered to be a Tier 2 region. The RIS is dominated by small and medium size enterprises (Kaplan et al, 2010) which are not specialized in high-added value activities. There are four universities in the Cape Town region, accounting for about 2200 research staff. One of them, the University of Cape Town is considered among the top 200 Universities in the world and the highest ranked in Africa (Lorentzen and Muller, 2010). Although the Cape Town has some specialization in agro-processing, it is not so strong in ICT. There is a considerable amount of ICT firms and the desire of the government to make this industry a landmark in the region, but it has not crystallized yet. There are also a number of sector associations and initiatives, like the Cape IT Initiative, the Bandwidth Barn and the Silicon Cape. In terms of networks, there is a certain degree of collaboration between university, industry and the government, but firms report that interactions with local knowledge producers are marginal. The RIS in Cape Town can be considered as neither too strong institutionally nor too weak. It is clearly a Tier 2 region. There is some organizational infrastructure both in terms of firms as well as strong universities (especially Cape Town University), some initiatives and support from the government. There is some interaction taking place between firms, government and universities, but collaborations work sub-optimally and they seem to be only marginal to innovation. There is an emerging culture of collective representation in the form of initiatives to create an ICT hub in the Cape Town region and there seem to be a strong Cape Town identity, reported in the cases. Yet, the technological capabilities of the local firm are not strong enough and firms tend to source technology internationally and sell their products to domestic or international clients.

How this RIS affects the insertion of firms in Global Value Chains can be illustrated with a case. DCM[7] is a Cape Town based firm specialized in high speed digital signal processing technologies for radar and sonar applications. DCMs principal customer is a South African engineering company based in Gauteng (domestic link) that, in turn, sells both domestically (second domestic link) and internationally (insertion in global innovation networks –global exploitation of innovations- through the node of the client) and has two large European defense companies as shareholders. DCM sources from international sources, as the quality of the domestic and local sources is considered low (global sourcing of technology). So, DCM has not very strong linkages in the Cape Town region. Its clients are domestic (with further international linkages) and its suppliers are international. The only strong linkages with the regional innovation systems are for the recruitment of staff, which is done locally (Lorentzen and Muller, 2010).

3.6 Conclusions

Our data shows that there are significant differences across regions with regards to three out of four forms of globalization of innovation: global exploitation of innovation, global research collaboration and global sourcing. Our initial assumptions were that GINs were happening either in institutionally thick regions or institutionally too thin RIS.

Instead, the analysis shows that, contrary to what we expected, GINs may emerge in regions which are neither institutionally too thick (like Tier 1) or too thin (like Tier 3). Firms that are located in institutional thick regions, tend to network with other firms and organizations that are in close proximity or with domestic actors. Intra-firm networks are also more common than extra-firm. Transactions take place more often between different units of the same organization rather than with external firms or knowledge providers, also pointing out to the transaction costs associated with engaging in networks with other organizations, independently of their geography.

What the results seem to suggest in line with Barnard and Chaminade (in this same special issue) is that engaging in global innovation networks is costly and hard to maintain and only when the firm cannot find the resources they need to innovate in their close proximity or when they need larger markets, they will engage in different forms of GINs. But even when the need exists (like in Tier 3) firms may not have the capabilities to engage in GINs. Tier 2 firms are in general medium or large firms, with a high proportion of subsidiaries. They have the need but also the possibility to engage in global innovation networks. Firms located in Tier 1, may have the possibility, in terms of capabilities, but they may not have the need as they are able to source technology from within their internal network or externally network for innovation at local or domestic level. Firms located in Tier 3 regions, may have the need, but not the possibility. Most of the firms are of smaller size and stand-alone firms.

This paper is a first attempt to assess the role of regional innovation systems and institutions in Global innovation networks. Our data suggests that regions really matter for GINs and more precisely, that the institutional thickness of the region has an impact on GINs.

The extent of the analysis is limited in several respects. First, the lack of available quantitative data on the institutional thickness limits the possibilities for a more elaborated econometric analysis to disentangle, for example, the impact of the Tier from other factors like, the firms being mainly

[7] DCM stands for Defense Components Manufacturer. The real name of the firm is confidential (Lorentzen and Muller, 2010)

subsidiaries or MNCs. Second, there is an overrepresentation in the sample of ICT companies and companies from India, which may be influencing the results of the analysis.

Due to these limitations, the paper is exploratory in nature. Further research is needed in order to explore the differences between Tiers and level of development, i.e. to investigate if Tier 1, Tier 2 and Tier 3 regions in developed countries differ from Tier 1, 2 and 3 in developing countries. It is also interesting to assess the interplay between inter-industry and inter-regional differences, i.e. to investigate if the observed differences in Tiers are consistent across industries.

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Annex 1. Organizational infrastructure by region

Country/ Industry	Tier 1	Tier 2	Tier 3	Sources
Brazil / Auto	The greater Sao Paulo (including the ABC) is responsible for 67% of employment; 76% of the firms are located there (Large Sao Paulo Area)	14 % of employment in industry	Aprox 4,5 % of employment	Sindipecas. www.sindipecas.org.br (accessed 17 June 2011)
China / ICT	Data on number of firms or employment in ICT not available at the level of the region. Classification in Tiers based on information of local experts.			--
Denmark / Agro-process	Data on number of firms or employment in agroprocessing not available at the level of the region. Classification in Tiers based on information of local experts.			--
Estonia / ICT	Between 60-70% of the employment in the ICT industry is in Tallin.	About 30-40 % of employment.		Kalvet (2004) "The Estonian ICT manufacturing and software industry: Current State and Future Outlook". IPTS report.
Germany / Auto	Baden-Wûrttemberg responds to 25% employment in Auto in germany	Thûringen employs 5% of auto in Germany		Germany Trade Invest www.gtai.com (Accessed 17 June 2011)
India / ICT	Employment in Karnataka state is 554000 in software industry (2009) Software exports above 17 billion US$ (34% of total in India in 2008/9)	Exports between 3 to 1 billion US$	Less than 1 billion US$ in exports	Malik and Ilavarasan (2011) "Trends in the ICT industry and ICT R&D in India" . http://is.jrc.ec.europa.eu/pages/ISG/PREDICT/documents/2PayalMalikfinal.pdf.(Accessed 17 June 2011)**ndia**
Norway / ICT	Aound Oslo there are 3 ICT clusters. About 60% of the ICT companies are located here. Aprox. 45000 Employees in the ICT.	Aprox. 10000 employees in Trondheim.		Rekene project report .- http://www.nordregio.se/rekene/maps.htm (accessed 17 June 2011) and Hansen & Serin (2010) "The European ICT clusters" http://rucforsk.ruc.dk/site/files/32956338/the_european_ict_clusters_web_0.pdf (Accessed 18 June 2011)
South Africa /	Gauteng – Aprox 50000 employees	Data on number of firms or employment in agroprocessing not available at the level of		http://www.gautengcompanies.co.za/pls/cms/ti_secout.secout_prov

Country/ Industry	Tier 1	Tier 2	Tier 3	Sources
Agro	(2007), 50% of the firms (about 4000 companies)	these other regions. Classification in Tiers based on information of local experts.		?p_sid=13&p_site_id=128
Sweden / Auto	Regions with more than 15000 employees in the auto industry	Regions with 5000-15000 employees in auto	Regions with less than 2000 employees in auto	Invest Sweden Agency (2009) "Automotive". Stockhom: ISA
Sweden / ICT	The Stockholm area employs around 100.000 people in the ICT industry.	The Skåne region, employs around 23000 people in the ICT industry.		Hansen & Serin (2010) "The European ICT clusters" http://rucforsk.ruc.dk/site/files/32956338/the_european_ict_clusters_web_0.pdf (Accessed 18 June 2011)

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