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Who are the world leaders in innovation? The changing role of firms from emerging economies

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Abstract

The technology clubs of the world have remained more or less unchanged in the last 50 years (Castellacci and Archibugi 2008). However, recent evidence suggests that this may be changing, as increasingly firms from China and India are playing a more important role in global innovation (Altenburg, Schmitz et al. 2008; Demirbag and Glaister 2010). Despite the importance of this last line of research, most of the evidence is still based on a handful of cases. Based on firm-level data collected in 9 countries worldwide and 3 industries, this paper identifies who are the world leaders, followers and laggards in terms of innovation worldwide, what are their micro characteristics and where are they located. The evidence suggests that the micro-characteristics of the firms as well as the region in which they are located (rather than the particular country) seem to explain the differences between world leaders and laggards in innovation worldwide and that firms from emerging economies are also to be found among the exclusive group of world innovators.

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Abstract

The technology clubs of the world have remained more or less unchanged in the last 50 years (Castellacci and Archibugi 2008). However, recent evidence suggests that this may be changing, as increasingly firms from China and India are playing a more important role in global innovation (Altenburg, Schmitz et al. 2008; Demirbag and Glaister 2010). Despite the importance of this last line of research, most of the evidence is still based on a handful of cases. Based on firm-level data collected in 9 countries worldwide and 3 industries, this paper identifies who are the world leaders, followers and laggards in terms of innovation worldwide, what are their micro characteristics and where are they located. The evidence suggests that the micro-characteristics of the firms as well as the region in which they are located (rather than the particular country) seem to explain the differences between world leaders and laggards in innovation worldwide and that firms from emerging economies are also to be found among the exclusive group of world innovators.

1. Introduction

In the last years there has been an increasing number of industry and firm based cases suggesting that some emerging regions are starting to move up the value chain, from competing in costs to competing in knowledge and innovation (Altenburg, Schmitz et al. 2008; Pietrobelli and Rabellotti 2009). A prime example is the embedded software cluster in Bangalore, India (Chaminade and Vang 2008). The new role of emerging countries has an important impact in changing the dynamics of production and innovation at a global scale. However, there has not yet been any systematic analysis of the general extensiveness of this phenomenon and on the different roles that regions and countries play in innovation on a global scale. Hitherto, almost all evidence is based on analysis on one particular region or industry, while few analysis have been made at a global scale (Barnard and Chaminade 2011).

This paper builds on the literature of globalization of innovation to explore a taxonomy of patterns of globalization of innovation in developed countries and emerging economies along three different industries, ICT, automotive and agro-processing. The three industries respond to different dynamics regarding their knowledge bases (Cantwell 1995), but they also follow different dynamics in terms of the characteristics of the firm and the specificities of the system of innovation where they are located (Chaminade 2011). The main aim of his paper is to explore a taxonomy of patterns for globalization of innovation based on firm's characteristics, context and the mode of globalization that ranges from knowledge seeking – collaboration and sourcing – to knowledge exploiting strategies. Based on firm-level data collected in during 2009-2010 in nine countries worldwide in the auto parts, software and agro-processing industries, this paper aims to address the following research questions:

1. Who are the world leaders, followers and laggards in innovation worldwide?
2. Is there a taxonomy of globalization of innovation that help us identify what are the most important factors explaining different patterns of globalization of innovation.

The development of a taxonomy will set the groundwork to identify the main characteristics that impact the dynamics of globalization of innovation in developed countries and emerging economies. Our hypothesis is that firms located in developed countries belong to groups that present more radical innovation and more internal networks, particularly if they are MNC; while firms located in emerging economies belong to groups that present more incremental innovation and need to access external networks to compensate for lower capabilities. Using cluster analysis we build four main groups of firms to identify the importance of each dimension of innovation performance, region, and mode of globalization on the patterns of GIN.

The remaining of the paper is structured as follows. First we introduce the changing role of emerging economies in global innovation networks and discuss the role of micro and meso determinants to access to global innovation networks. We then follow by introducing the data set in which this paper is based as well as the main variables and method of analysis. Section 4 presents the main results, followed by discussion and conclusions.

2. Theoretical framework

2.1. The importance of globalization of innovation and the changing role of emerging economies

It is generally accepted that innovation is becoming more global, involving different players from developed and emerging economies (Unctad 2006; The Economist Intelligence Unit 2007). The increased complexity of innovation has fostered competition and collaboration both across and within national boundaries (Archibugi, Howells et al. 1999) and the de-localization of R&D (Borrás and Haakonsson 2011; Haakonsson and Ujjal 2011) supporting the emergence of innovation networks across geographical boundaries.

For many decades those networks have been mainly confined to developed countries – mainly the triad: United States, European Union and Japan and to the activities of large multinationals (MNCs). Despite the growing importance of the globalization of innovation, just few scholars have included the analysis of emerging economies, as they are relatively new players in innovation at a global scale. Empirical evidence suggest that particularly emerging economies such as China, India, Brazil and South Africa are playing an increasing role on global innovation networks worldwide (Narula 2000; Figueiredo 2005; Chaminade and Vang 2008; Aslesen, Ebersberger et al. 2011; Borrás and Lorentzen 2011; Lorentzen and Gastrow 2011).

Whilst a handful of firms have achieved ‘new to the world’ innovations (Chaminade and Plechero 2012), the majority of firms in new industrialized economies still experience some difficulties in moving from new to the firm to new to the world innovation, in particular for product innovation. Most innovation in developing countries is still on an incremental nature.

Global Innovation Networks (GINs) are defined in this paper as a “Globally organized web of complex interactions between firms and non-firm organizations engaged in knowledge production related to and resulting in innovation” (Borrás, Chaminade et al. 2009). GINs are thus defined in terms of its geographical spread (global rather than confined to the Triad), the extent of its networks (both internal and external) and their outcome (innovation). Firms might engage global innovation networks either to exploit markets or to source from more advanced technologies and knowledge available in other locations, or for both reasons. Both the exploitation of external markets and the sourcing of external knowledge have a positive impact in the innovative performance of a firm. Firms collaborate with external organizations to share and build new knowledge, thus we can argue that the engagement of global networks is central for firms’ competitive strategy.

Archibugi and Michie (1995; 1999) indicate that firms and other organizations may engage in innovation activities globally in different ways (modes), according to their main purpose and strategy. Firms may be willing simply to exploit internationally the technology produced on a national basis (global exploitation), develop a new innovation through global technological collaborations (global collaboration), or by locating R&D subsidiaries in other countries to take advantage of the host-country or host-region competences (global generation of innovations) or simply acquire technology from international sources (global sourcing). GINs are defined in this paper in very broad terms, that includes: a) the commercialization of innovations abroad, b) the sourcing of embedded and immaterial technology, but also c) the international research collaboration, and d) the offshoring of innovation activities (R&D investments abroad).

These four modes of globalization of innovation reflect two broader strategies, namely knowledge exploiting (international exploitation of technology) and knowledge seeking (global sourcing, global technological collaborations and global generation of innovations). Global exploitation of innovation refers to exports, technology transfer, licenses, patents, or the foreign production of innovative goods. MNC or stand-alone companies can engage in global exploitation of innovation. Global generation of innovations refers to R&D and innovative activities in a global environment, and the acquisition or investment of R&D laboratories in host countries. Global generation of innovation might apply only to MNC, which are in the position to develop global research networks, perform R&D in global networks, and generate global innovations. Global technological collaboration refers to joint scientific projects, human resources exchange, and productive agreements, and might involve different private and public agents, not only MNC. This last mode of globalization of innovation does not impose competition among countries, and each partner preserves its identity and ownership (Archibugi and Michie 1995; Archibugi and Iammarino 1999).

While most of the literature has traditionally highlighted the role of developing countries as buyers of technology or in general as receptors of technology via FDI (Pietrobelli and Rabellotti 2004) and as participants in global value chains (Zander 1999; Ernst and Kim 2002; Unido 2004; Gereffi, Humphrey et al. 2005; Giuliani, Pietrobelli et al. 2005), recent evidence suggests that they involve actively in the four modes of globalization of innovation (Chaminade and Plechero 2012). The increase level of competition in the domestic markets (Archibugi and Michie 1995; Archibugi and Iammarino 1999), and the accumulation of capabilities in certain regions in emerging economies (Arora 2006; Pilat, De Backer et al.

2009) and firm specific characteristics may explain this global shift as we will discuss in next section.

2.2. Determinants of globalization of innovation

The participation in GINs requires profound changes in the management of innovation processes inside the firm. The creation of global innovation networks is the outcome of a mix between strategies of knowledge exploitation, increasing demand for knowledge sources, and the rapid development of capabilities for innovation in emerging economies. The interaction of these three factors has to this date been understudied, mainly due to the fragmentation of the literature on global innovation networks. International business literature has been traditionally looking at the motivations of large multinationals to locate both production and innovation activities abroad as well as the role of size and competences in this process. They are thus basically concerned with firm-level motivations of offshoring of innovation and its impact in the host location (Cantwell and Janne 1999; Cantwell 2000; Cantwell and Piscitello 2002; Cantwell and Piscitello 2005; Cantwell and Piscitello 2005; Cantwell and Piscitello 2007). Innovation studies, on the other hand, have been concerned with innovation networks and collaboration for innovation (Carlsson 2006), as well as the role of institutions and regions on knowledge sourcing and collaboration. Of particular concern of economic geographers has been the impact of knowledge bases on the geography of knowledge linkages (Asheim, Coenen et al. 2007; Chaminade 2011a; Chaminade 2011b). We might therefore expect that globalization of innovation will be affected by internal characteristics of the firm, as well as their immediate environment, and the mode or modes of globalization that are engaged.

Firm's internal characteristics

The international business literature has long studied the importance of firm-specific characteristics such as ownership and size on the propensity of firms to internationalize their production, and more recently their innovation activities (Blanc and Sierra 1999; Dunning 2001).

Foreign-owned firms and national firms that are part of a multinational group have higher propensity to internationalize than the rest of the firms (Sousa, Martínez-López et al. 2008). Larger firms tend to export more than smaller firms (Bonaccorsi 1992; Calof 1994; Moen

1999; Dean and Mengüç 2000; Sousa, Martínez-López et al. 2008) as they have the human, technological and financial resources necessary to internationalize and exploit technologies in foreign markets. Size also seems to matter for global research collaboration, global sourcing, and global generation, although the evidence is less conclusive. Some authors (Vonortas 1997; Fritsch and Lukas 2001) find that size is related to the propensity to cooperate in research, others (Kleinknecht and Van Reijnen 1992) find positive evidence only in the relationship between private firms and research organizations but not with regards to research collaboration with other agents. Participating in international research activities requires an ability to coordinate geographically dispersed R&D capabilities (Zander 1999). Modularization of production activities has played a key role to enable the community to adopt standardized knowledge and technology, and facilitate the design and knowledge intensive activities along the value chain and to perform different activities in different locations that contribute to a particular product or service (Unido 2004), but the firm needs to have the ability to manage and integrate these geographically dispersed sources of knowledge, and sometimes this ability to coordinate is linked to firm's size.

Finally, the firm's technological competences –such as their engagement in R&D activities or the number of researchers in the firm – have a direct impact on firms' innovative performance (Alcácer and Chung 2003; Giuliani 2003; Ivarsson and C 2005; Vera-Cruz and Dutrénit 2005; Marin and Bell 2006; Chudnovsky, López et al. 2008; Escribano, Fosfuri et al. 2009), as well as the ability of firms to participate in innovation networks as it increases its absorptive capacity (Cohen and Levinthal 1990).

The industry

The analysis of globalization of innovation needs a sectoral perspective. Not only the sources of innovation are different (Pavitt 1984) but also the nature of their knowledge bases differ (Laestadius 1998; Asheim and Gertler 2005; Asheim, Coenen et al. 2007) and as a consequence the geography of their networks (Asheim, Coenen et al. 2007; Moodysson, Coenen et al. 2008).

Industries in which knowledge is fundamentally of a tacit nature will, in principle, display different patterns of knowledge sourcing within and across national borders, than industries in which a substantial part of the knowledge can be codified (Moodysson 2008; Moodysson,

Coenen et al. 2008). In industries characterized by analytical knowledge bases like life sciences, scientific knowledge is important. Knowledge is derived through R&D processes and it is mainly codified thus, more prone to geographical de-location. In industries characterized by synthetic knowledge bases (Asheim, Coenen et al. 2007), innovation is often the result of incremental change through the search of engineering solutions. Industries like shipbuilding or machine manufacturing rely more on learning by doing and tacit knowledge than on analytic knowledge bases. Finally, symbolic knowledge bases are characterized by cultural industries like film or video gaming. They are highly context specific and thus more difficult to transfer across geographical borders (Martin and Moodysson 2011).

However, as recent evidence has suggested (Chaminade 2011; Tödtling, Lengauer et al. 2011), the same industry may behave in a completely different way in two locations. According to the specific activities that are performed, pointing out at the role of the region shaping the patterns of globalization of innovation activities.

Region

Regions also play an important role for the innovation and internationalization strategy of firms. The structure and dynamism of a specific region influence the innovation possibilities of the firms located there at least in two ways. The institutional set-up and dynamics in terms of networks among agents and knowledge flows are important determinants for absorptive capacity and the innovative potential that exist in a region (Saxenian 1994; Cooke 2001; Malberg A. and Maskell P. 2006). Regions with strong systems of innovation may facilitate collaboration and generation of new knowledge, fostering innovation within that region both in developed (Asheim, Coenen et al. 2007) and emerging regions (Chaminade 2011). Furthermore, as regions differ in terms institutional endowment and innovation dynamics, some regions are more attractive for the location of R&D and other innovation related activities, acting as magnets for the location of firms in specific sectors, creating a virtual circle for innovation. Furthermore, recent evidence suggests that the institutional thickness of a region is directly related to the propensity of the firms to engage in global innovation networks (Chaminade 2011; Tödtling, Lengauer et al. 2011).

From the innovation systems literature, networks and knowledge flows between agents are important elements to build an innovative environment (Asheim and Isaksen 2002; Asheim and Gertler 2005). However, some regional systems of innovation have limitations to foster

incremental or radical innovations, particularly systems of innovation in developing countries, as there might be several system failures related to the agents, to the connection among them, or to the institutions (Chaminade, Lundvall et al. 2009). In this sense, for the specific case of emerging economies, global networks can play a more important role than local networks to achieve incremental or radical innovations (Chaminade and Plechero 2012) as firms located in emerging economies cannot find the resources they need to innovate in their immediate environment (Barnard 2008; Barnard 2010; Barnard and Chaminade 2011).

Modes of globalization

The different modes of globalization of innovation, sourcing, collaboration, exploitation and generation are not mutually exclusive, on the contrary, we can argue that firms with global exploitation strategies might engage in a more natural way into global collaboration networks, or generate innovations in a global context. The different modes of globalization of innovation provide a specific background for firms that facilitate the engagement into other different and more complex types of global innovation networks. Thus modes of interaction are also a determinant of globalization of innovation.

3. Methodology

3.1. The data

This paper is based on a survey that was conducted across nine countries – Brazil, India, China, South Africa, Norway, Sweden, Germany, Estonia and Denmark; and three sectors – automotive, ICT and agro-industry in the framework of the INGINEUS project. The survey for each country focused on either ICT, automotive or agro-processing.*

The selection of firms was based on existing datasets, i.e. Statistics Sweden or the German commercial database Hoppenstedt. In emerging economies there was the necessity to combine existing databases to have more complete and up-to-date information, i.e. 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 were used

*Sweden had both auto and ICT surveys.

to compile a sample frame.[†] All databases were filtered to ensure that firms with five or more employees were contacted.

The information gathering also took place in a variety of ways. In countries with a culture of participating in surveys – like the Scandinavian countries, firms were sent a link to an online survey. In the middle-income countries, data gathering was done by telephone, or face-to-face interviews. Table 1 indicates that 1,215 responses were collected in total, the response rate varied across countries.

Table 1 Distribution of countries and sectors (number of responses and response rates in brackets)

Countries	ICT	Auto	Agro	TOTAL
Brazil		69 (25.9%)		
China	243 (2.7%)			
Estonia	17 (14%)			
India	324 (20.2%)			
South Africa			84 (16.9%)	
TOTAL emerging economies	584 (5.34%)	69 (25.9%)	84 (16.9%)	737 (6.32%)
Denmark			49 (23.3%)	
Germany		53 (4.7%)		
Norway	181 (11.9%)			
Sweden	171 (10.3%)	24 (14.3%)		
TOTAL high-income countries	352 (11.05%)	77 (6.18%)	49 (23.2%)	478 (10.59%)
Total	936 (6.59%)	146 (10.64%)	133 (18.58%)	1215 (7.5%)

Source: Barnard and Chaminade (2011)[‡]

ICT firms dominated the sample. This was in part due to the size of the Indian and Chinese markets, but also due to the nature of the agro processing and auto industries, which tend to be more concentrated (Barnard and Ismail, 2011).

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

The survey captures information about the different dimensions of the globalization of innovation for each firm, such as global exploitation of technology (market strategy), global technological collaboration (off-shoring), and global generation of technology (R&D strategy,

[†] See [http://www.ingineus.eu/UserFiles/INGINEUS_D2.2_MethodologyReport\(1\).pdf](http://www.ingineus.eu/UserFiles/INGINEUS_D2.2_MethodologyReport(1).pdf) (accessed Dec 1, 2011) for more detail about the data gathering process.

[‡] Barnard and Chaminade (2011), and Barnard and Ismail (2011).

sources of technology, establishment of networks for sourcing/developing technologies or innovations). The survey also captures information about structural characteristics of the firm, such as size, industry, specific activities, and the main functions performed by the firm.

3.2. Analysis

To analyze the most important determinants of in global innovation networks, we grouped the firms that answered the survey based on their characteristics, mode of globalization and the characteristics of the region where they are located. We used the technique of cluster analysis by K-means, which groups each observation according to the most similar characteristics to other observations. Cluster analysis by K-means performs non-hierarchical k-means, grouping cases based on their proximity to a multidimensional centroid. Thus, this technique groups the firms with more similar characteristics according to their structural characteristics, innovation intensity, internal capabilities, world networks, strategies of world markets, strategies of offshoring, and the regional Tier where the firm is located. The following variables are considered:

- **Firms' structural characteristics** are represented by dummy variables related to the type of firm (MNC, subsidiary or standalone company); size is a categorical variable that goes from one to five, reflecting the number of employees.
- **Firms' innovation capabilities** is captured by a dummy variable that expresses if the firm has a significant R&D activity, a continuous variable for full time employees for R&D, and a series of variables capturing the type of innovation and the degree of novelty. For level of innovation we considered four forms of innovation: product, service, process and support. We considered three degrees of novelty: new to the world, new to the industry and new to the firm.
- **Sector** we used three dummy variables for ICT, automotive or agro-processing.
- The identification of the most important determinants of global innovation networks acknowledges the existence of different **modes of globalization of innovation**, such as global sourcing, global collaboration, global generation and global exploitation of innovation. We used variables that indicate the nature of global/local networks and external/internal networks. For global sourcing of innovation we use a dummy variable that equals 1 if the firm relies in external sources of technology to develop innovative activities. For global collaboration for innovation we used two dummy variables that indicate external and global collaboration for innovation, and formal or informal linkages

at a global level and external to the firm. For global generation of innovation we used a dummy variable that equals 1 when the firms off-shore innovation activities. For global exploitation of innovation we rely on two dummy variables, one for external exploitation of innovation, and the second for global exploitation of innovation.

- In terms of the **region**, we have categorized regions where the firms are located in Tier 1, Tier 2 and Tier 3, based on the industry dynamism, but also on the institutional thickness of the particular sector in the particular country. To define the three Tiers we combined quantitative (when available) and qualitative information about the innovation dynamics of the regional innovation system (RIS) and their institutional thickness. The European Regional Innovation Scoreboard 2009 (RIS Scoreboard, 2009), which classifies European regions according to different indicators of regional innovation performance, was used as a proxy for evaluating the degree of innovation dynamics of some of the regions. To capture the organizational structure of the RIS (linked to the institutional thickness) we used the number of firms in a particular sector and in a particular region, number of employees and, in some cases the volume of exports compared, for example, to the average of the country when that information was available. This latter information was used as a general proxy for assessing the organizational infrastructure of the region and together with the innovation dynamic indicators are the only pseudo-quantifiable measure we can consider. In general statistics broken down at the level of the industry are scarce or not available for the regions in emerging economies. Qualitative information was also collected through literature review, cluster reports and consultation with country experts involved directly in the project. Basically, regions with the highest regional innovation dynamics, highest concentration of educational facilities, firms and employment in the specific industry and country, with frequent interactions and a strong identity in that particular industry and country were considered as Tier 1. Regions with an average number of firms and employment in that industry respect to the country, with some specialized supporting institutions and with less strong interactions, culture and shared norms were classified as Tier 2. Those regions that have no or little specialization in that particular industry, and/or with a weaker institutional setting or weaker innovation dynamics compared to other regions in that country were classified as Tier 3. The final classification of the regions in tiers was checked once again with industry experts in each country.

- We also used a dummy variable for the development level of the country, that equals 1 when the country is developed.

From our sample, we have complete information to analyze 976 firms, 90.8% of the total.

Table 2 presents the descriptive statistics for the variables used for the cluster analysis.

Table 2 Variables included for the analysis

Indicator	Variable	Type	Mean	St. Dev.	
Type of firm	2 Type of firm	3 dummies:			
		Stand alone=1	0.645	0.478	
		Subsidiary=1	0.229	0.420	
		Headquarters=1	0.125	0.331	
Size	3.1 Full time employees	Categorical			
		1<10			
		2=10-49	2.767	1.153	
		3=50-249			
		4=250-999			
		5>1000			
Sector	1 Sector	3 dummies:			
		Agro=1	0.105	0.307	
		ICT=1	0.772	0.419	
		Auto=1	0.122	0.327	
Innovation intensity	3.3 R&D activity	Dummy: 1=yes	0.529	0.499	
	3.3.1 Full time equivalent employees for R&D	Continuous	10.426	14.687	
	InnovLevel	Categorical			
		1= Firm level	0.919	0.980	
		2=Industry level	0.725	0.901	
		3=World level	0.728	0.874	
Sourcing	SourceIntExt	Dummy: 1=External	0.293	0.455	
Collaboration	CollabExt (from 7)	Dummy: 1=external, global	0.425	0.493	
Links	LinkExt (from 8)	Dummy: 1=external, global	0.658	0.474	
Generation	offshoringInn	Dummy: 1=yes	0.129	0.335	
Exploitation	ExpExt (Exploitation External)	Dummy: 1=External	0.981	0.134	
	ExpGlo (Exploitation global)	Dummy: 1=Global	0.300	0.458	
Region Tier	RegionTier	Categorical:			
		1=First Tier	1.780	0.721	
		2=Second Tier			
		3=Third Tier			
Country	Developed or Developing	Dummy: 1=developed	0.393	0.489	

4. Cluster analysis. Towards a taxonomy

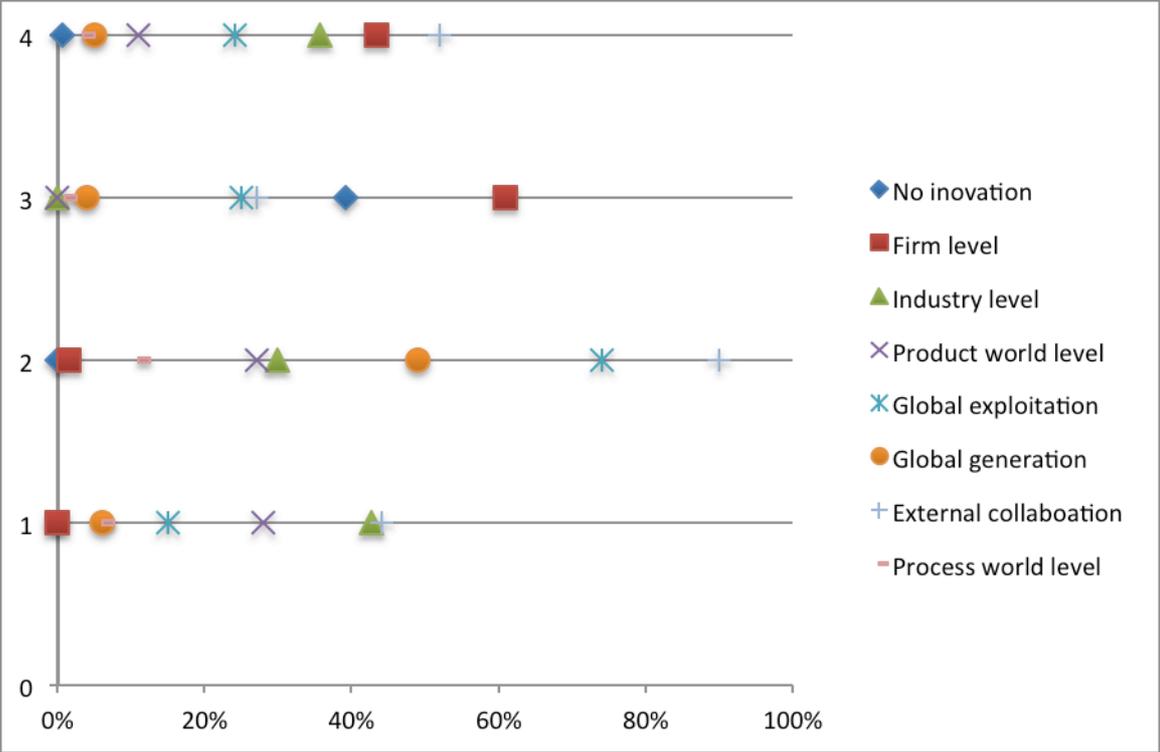
We found four main groups of firms in our sample with particular characteristics regarding firm's structural characteristics, firm's intensity, modes of globalization of innovation and regional characteristics where they are located. Cluster 1 has 286 firms, cluster 2 has 204 firms, cluster 3 has 343 firms and cluster 4 has 143 firms. **Error! Reference source not found.** presents the main characteristics for each cluster.

Table 3 Cluster characteristics

LABEL	Cluster Membership				Total
	1 World leaders	2 World followers	3 Moderate innovators	4 Laggards	
Standalone company	223 78%	36 18%	245 71%	120 84%	624 64%
Subsidiary of a MNC	17 6%	116 57%	72 21%	19 13%	224 23%
Headquarters of a MNC	46 16%	52 25%	26 8%	4 3%	128 13%
Agro-processing	20 7%	8 4%	37 11%	22 15%	87 9%
ICT	230 80%	184 90%	286 83%	92 64%	792 81%
Automotive	36 13%	12 6%	20 6%	29 20%	97 10%
Emerging economy	160 56%	190 93%	208 61%	41 29%	599 61%
Developed country	126 44%	14 7%	135 39%	102 71%	377 39%
Tier 1	193 67%	46 23%	139 41%	0 0%	378 39%
Tier 2	93 33%	134 66%	177 52%	19 13%	423 43%
Tier 3	0 0%	24 12%	27 8%	124 87%	175 18%
Product innovation new to the world (% over total firms in cluster)	78 27%	55 27%	0 0	16 11%	149 --
Process innovation new to the world (% over total firms in cluster)	18 6%	22 11%	2 1%	5 3%	47 --
Product innovation new to the firms (% over total firms in cluster)	29 10%	25 12%	145 42%	46 32%	245 --
Process innovation new to the firms (% over total firms in cluster)	77 27%	42 21%	106 31%	45 31%	270 --
External sourcing for innovation	78 27%	71 35%	107 31%	33 23%	289 30%
External/global collaboration for innovation	125 44%	184 90%	91 27%	75 52%	475 49%
Global exploitation	44 15%	151 74%	85 25%	34 24%	314 32%
Global generation	18 6%	100 49%	15 4%	7 5%	140 14%
Total	286 100%	204 100%	343 100%	143 100%	976 100%

The groups of firms range in terms of their innovation intensity, from firm level to world level innovation, thus we conceptualized the different groups in World leaders, world followers, Moderate innovators and Laggards. The four groups show significant differences in their patterns of globalization of innovation. Figure 1 Table 4 summarizes the main characteristics of the 4 clusters for innovation intensity and mode of innovation.

Figure 1 Innovation level and modes of globalization of innovation for the four groups of firms



From the cluster analysis we observe that most of the firms in Tier 1 were located in clusters one and three. Firms in those clusters are mainly standalone firms. On the other hand, firms in Tier 2 were located in clusters two and three. Firms in those clusters one are mainly standalone firms. Most of the firms in Tier 3 are in cluster 4, where firms are mainly standalone companies located in developed countries (See table 4).

World leaders (Cluster 1)

Firms in cluster 1 are world innovators in product and services. Cluster 1 has the largest number of firms (78) that have introduced new to the world products in the whole sample.

They are typically the world leaders in their respective industries and sub-industries. About 27% of all the firms in this cluster have introduced new to the world product innovation and close to 16% also new to the world services.

Even though, a large percentage of those firms establish global collaboration for innovation (44%), a smaller percentage exploits their products globally (15%), or generates innovation globally (6%). Geographically, they are located mainly in Tier 1 (67%) and Tier 2 (33%) regions, that is, the strongest regions in terms of the institutional set-up. Firms in these regions tend to establish relationships with other organizations co-located in the same region or in the country as other studies suggest (Chaminade and Plechero, 2012; Barnard and Chaminade, 2011). Furthermore, as suggested by other authors (Barnard and Chaminade, 2011) there seem to be a trade off between innovation and internationalization. The more innovative the firm is, the more local and domestic its networks are.

While we find a high proportion of firms from developed countries in this group – as expected – we also find a surprisingly high proportion of firms located in developing countries: 28% of the firms come from China, 16% from India and 5% from Brazil.

World close followers (Cluster 2)

Cluster two is a follower in terms of product and service innovation but is definitively a world leader in process innovation and support innovation. This group is also highly populated by firms from emerging economies: 67% of firms located in India, and 19% of firms located in China are grouped in cluster 2. Even though 57% of firms in this cluster are subsidiaries of MNC, 18% are standalone companies and 25% are headquarters of MNC.

The majority of firms are located in Tier 2 (66%) and Tier 1 (23%) regions, that is, the institutionally strongest regions in the country, with a high degree of specialization in the particular industry (for example, Bangalore in India for ICT). Tier 1 and Tier 2 are the most important regional innovation systems in the specific countries for the particular industries. Being located in an institutionally strong regional innovation system provides the firms with access to knowledge sources that are fundamental for innovation.

This cluster is far more visible internationally than the first one. About 35% of the firms seek external sources of innovation, 90% establish external collaboration to perform research with international actors. 74% of firms in this cluster exploit their technologies in global markets, and 49% have offshored innovation activities. Firms in this cluster are specialized on

international markets, which has a very similar service portfolio as the world leaders, but which is delivered in a very novel way, either in terms of the business models or the organization of the production or in both.

This is truly the most innovative group although there are not so many firms with new to the world product innovations in this cluster as in cluster 1, the proportion is quite similar and the number is much higher for process innovations and also the most globalized in the different modes of globalization of innovation.

Moderate innovators (Cluster 4)

Cluster 4 is mainly composed of standalone service firms with incremental innovations at firm and industry level, although there are few new to the world innovators in services. Firms in this cluster are mainly from the agro industry sector located in South Africa and the ICT sector located in Sweden, mainly in Tier 3 regions.

Most of these firms focus on domestic and regional markets and collaborate mainly with international actors to innovate, which probably reflect the lack of supporting knowledge institutions characterizing Tier 3 regions. 24% of these firms exploit their technologies globally, and 5% offshore innovation activities. In this respect, one could argue that this cluster is also highly internationalized, at least with respect to collaboration (higher than world followers), and global sourcing of innovation (second to the world followers), both of which are knowledge-seeking strategies.

Laggards (Cluster 3)

Finally, we find most of the non-innovative firms in cluster 3 – which we have labeled the Laggards – as they are clearly falling behind in terms of product, services, process, and support innovations. Typically a firm in this cluster will be a standalone company located in a Tier 2 region, in an emerging economy. Many firms from India, Brazil and Denmark fall in this cluster.

Most of the firms in this cluster have a clear regional or domestic orientation in terms of their markets. Only 27% collaborate globally for research, and 4% of them offshore innovation activities, both activities are the lowest compared to other clusters. Some firms from agro-processing, ICT and auto fall in this cluster.

Table 4 Main characteristics of clusters

	CLUSTER 1 World leaders	CLUSTER 2 World followers	CLUSTER 3 Laggards	CLUSTER 4 Moderate innovators
Number of firms	286	204	343	143
Type of firm	Standalone (78%)	Subsidiary (57%)	Standalone (71%)	Standalone (84%)
Firm size	Small (41%) Medium (36%)	Medium (59%)	Small (61%)	Small (64%)
Country of location	China (28%) Norway (19%) India (16%)	India (67%) China (19%)	India (34%) China (18%) Sweden (16%)	Sweden (54%)
Level of Innovation	World level	World level	Firm level	Firm&Industry level
Type innovation	Product innovation	Process innovation	Product&Sevices	Product&Services
Tier	Tier 1 (67%)	Tier 2 (66%)	Tier 2 (52%)	Tier 3 (87%)
Global sources of technology	27%	35%	31%	23%
Global collaboration	44%	90%	27%	52%
Global exploitation	15%	74%	25%	24%
Global generation of innovation	6%	49%	4%	5%
Comment	World leaders in product innovation and also in services.	World leaders in process innovations and support innovation.	Most of the firms that are not innovative at all are in this cluster.	Incremental in product innovation.

* Location refers to the location of the unit analyzed, which may not necessarily coincide with the country where the headquarters are located (in case of MNCs).

5. Discussion

Our initial hypothesis was that firms located in developed countries were grouped in clusters with world level innovations and more internal networks; while firms located in developing countries tend to be grouped in clusters that present firm or industry level innovation and more external networks to compensate for lower capabilities.

From our empirical analysis we found that the type of country *per se* is not a determinant of innovative performance, or a specific dimension of globalization of innovation. We argue that different factors are important determinants of innovation performance and globalization of innovation, such as firm's characteristics (Plecherro and Chaminade 2010) and strategy (Zander 1999), sector and the region in which the firm is located (Chaminade and Vang 2008; Chaminade 2011). Clearly, world leaders are mainly located in Tier 1 regions, world followers in Tier 2 and the laggards or moderate innovators in Tiers 2 or 3 regions although there are firms from each of the three Tiers in every cluster. From our sample we can argue that the most dynamic sector in terms of innovation intensity and globalization of innovation is ICT. The specific characteristics of this sector play an important role to foster firm's technological capabilities in emerging economies and to link global activities among firms. The global activities among firms and actors in this specific sector have established a specific

dynamism that foster technological capabilities at firms in developing countries and increases the innovation performance. In this sense, our results confirm the findings by the development literature in terms of upgrading value chains in emerging economies by accessing global networks (Unido 2004; Giuliani, Pietrobelli et al. 2005). However, the firm's and sector characteristics play an important role for each specific dimension of globalization of innovation, at the same time, there is an interaction between the different dimensions of globalization of innovation and firm's innovation intensity.

We can argue that firms that show a higher level of global generation of innovation also have higher levels of global collaboration, and global exploitation of innovation. At the same time, higher levels of globalization are consistent with higher innovation performance. However, globalization seems to demand a higher level of innovation in process and support for innovative activities.

Further research will need to go further into the analysis of particular characteristics of firms in each country located in each cluster, in order to better identify that globalization of innovation is driven not only by MNC, but also by standalone companies located either in developed countries or emerging economies.

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