Social Networks and Innovation Strategies in Knowledge-Intensive Services: the Case of Software

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Abstract

This paper deals with the role of social networks in the innovation strategies of the software for telecommunications sector; although a relatively small segment in the global software industry, this is one of the most innovative. In fact, its products address the demand of the sophisticated and fast changing telecommunications industry, with mobile communications at its core.

The literature has stressed the relevance of social networks for the innovative process of knowledge-intensive firms. Most of these firms, and particularly small and medium sized firms, depend on external resources to complement their built-in capabilities, partly accessed via non-market means. As a consequence, networks have become increasingly crucial for the access to these resources, which are quite diversified. Most of the extant studies deal with aggregate networks; however, the diversity of resources is expected to affect the forms of access, and therefore the configurations of social networks.

In this paper we study disaggregated social networks in two groups of firms, more radical innovators vis-à-vis incremental innovators, according to the type of resource being accessed i.e. technological knowledge and complementary assets.

Technological knowledge has become complex, fast changing and distributed among various players. In the case of software, firms have to interact not only with other domestic and multinational firms in the same sector and universities, but also with customers; the latter are considered a major source of innovation. Complementary assets such as capital, information on potential opportunities, access to markets and highly skilled personnel have become more specialized and sophisticated. Such resources are not totally obtainable through anonymous and stand-alone market transactions. Their access requires interaction, information exchange and very often trust.

Drawing on original information collected through a detailed questionnaire, we analysed a set of 29 firms producing software for telecommunications in Portugal, split into two sub-sets according to the range of innovation (more radical vs. more incremental). We looked for the main factors related to the configuration of the networks developed (composition, structure, size, number of components) to explain the differences in the innovation strategies adopted by the two groups of companies.

Results confirm the existence of contrasting network configurations of radical versus incremental innovators and the value of a fine-grained approach. Our approach can therefore contribute to the debate on the most favourable network configuration for innovation: this depends not only on the range of innovation but also on the resource that is exchanged through the relation.

Keywords: Social networks; innovation; software sector; knowledge networks; complementary assets networks.

1. Introduction

In this paper we deal with firms that create new or significantly improved software products through the creation, use and adaptation of technological knowledge. In doing so, and in addition to in-house knowledge creation, they resort to external sources both via market and non-market transactions, including knowledge spill-overs and networks. We will focus on the dynamic form of non-market exchanges, namely networks (Todtling, Lehner and Kaufmann, 2009). The main goal of the paper is to assess if different ranges of innovation (mostly radical versus mostly incremental) are associated with different network configurations. We add to extant literature by proposing a fine-grained analysis of innovation networks that accounts for two types of resources: scientific and technological knowledge and complementary assets. This distinction, together with the consideration of two different ranges/strategies of innovation can shed light on the divergence of results of empirical studies that address the link between innovation and network configuration.

In section 2 we will present a brief literature survey dealing with different types of networks and their impact on the innovative activities of the firms. In section 3 we analyse the software sector in Portugal and describe the sample of firms. Methodology is presented in section 4, followed by the empirical results in section 5. The last section is dedicated to discussion and conclusions.

2. Network configurations and types of innovation

There is a huge body of literature addressing the role and relevance of social networks for the innovative process of knowledge-intensive firms (Ozman, 2009). The network approach has spread almost entirely across management, organizational, innovation and sociological studies, not to mention the original psychological and anthropological fields (Scott, 2000). Consequently, we benefit from not limiting ourselves to a single discipline to obtain useful insights on the role, kinds and forms of network to address the innovative process.

Firms are endorsed with technical knowledge and built-in capabilities, which are enablers of knowledge creation. This means that not only have absorptive capacity (Cohen and Levinthal, 1990) but also creative abilities; however, they are far from self-sufficient and depend crucially on external resources to complement their own, particularly when they are small and medium-sized. They access these resources – knowledge and complementary assets - through diversified paths, mostly markets and networks.

Technological knowledge has become complex, fast changing and distributed among various players (Powell and Grodal, 2005). In the case of software, firms have to interact not only with other domestic and multinational firms in the same sector (Grimaldi and Torrisi, 2001) and universities, but also with customers from other sectors, the latter being considered as a major source of innovation (Weterings and Boschma, 2009). But innovation requires an array of different resources besides knowledge that are here designated as complementary assets in line with Teece (1986). Complementary assets, which have become more specialized and sophisticated, encompass capital, information on potential opportunities, access to markets and highly skilled personnel. Such resources are not totally obtainable through anonymous and stand-alone market transactions. Access to them requires interaction and information exchange, giving rise to the development of multiple and crucially important networks which join firms, universities, customers, suppliers, service consultants, financial companies, technology transfer agencies and innovation supporting institutions.

Whereas most of the extant literature deals with aggregate networks (Hemphala and Magnusson, 2012), we analyse knowledge and complementary assets networks separately. In fact, we argue that the heterogeneity of resources accessed impacts the forms of access, i.e. is a source of variety in network configuration (Salavisa, Sousa and Fontes, 2012). A second source of variety is expected to be the range of product innovation, i.e. radical versus incremental, a subject that has been addressed by few empirical studies as further discussed.

Innovative activity is both a search activity and a combinatory one. On the one hand, it encompasses intensive efforts aimed at advancing and applying scientific knowledge, and on the other it includes the attempts to generate new out of the old by combining disparate pre-existing knowledge components that are both codified and tacit. The search activity appears to be fundamental in science-based sectors. Combinatory procedures pervade all sectors and usually require the access to resources that are external to the firms. Secondly, and consequently, innovative activity relies upon new knowledge as well as on the available stock of knowledge. Finally, it is mostly a systematic and planned process but serendipity plays a significant role in many radical discoveries.

The creation of radically new products (goods or services) – as well as new knowledge – is favoured by the existence of diversity among separate entities. Kaufmann and Todtling (2001:791) argue that "the key advantage of engaging in external relations for realizing innovation is based on diversity". They claim that routinized behaviour and interaction with similar well-known partners, like customers, may favour innovation but of an incremental type, since radical innovation requires border-crossing relationships with different social systems, such as universities. Accordingly, it is essential to preserve diversity across the connected entities in order to continue generating the new out of the old. In this sense, networks are not only a means used to fill a gap in resources but also a means to provide the innovative firm with diversity in the form of conduits to different worlds.

The relation between the firm's network configuration and its innovative activity has been addressed from two different perspectives: the firm's propensity to innovate and its prevalent kind of innovation, radical versus incremental. The approaches dealing with the innovative propensity can be divided into two main groups. A first group of studies argue that the existence of structural holes in firms' networks is related to their greater propensity to be innovative. The basic reasoning underlying this assertion is that structural holes are associated with an increasing returns brokerage function between separate components of the network, thus providing a large diversity of information sources and access to resources. Thus, brokers avoid the disadvantages of the agents becoming locked-into a restricted and confined world of a limited number of well-known partners who, with the course of time, are unable to bring new ideas, information or opportunities (Burt, 2004). A second group of studies defend the opposite view, that is, innovation is favoured by close, dense networks which are generally associated with social capital. The arguments underlying the latter view consist of the importance assigned to aspects such as trust, cooperation, ease of communication and coordination, share of complex knowledge and learning through repeated contacts and lasting relationships, all of them fostering the generation of innovation (Obstfeld, 2005; Coleman, 1988; Uzzi, 1997; Ahuja, 2000).

Some authors observed that dense networks would probably favour incremental innovation rather than radical innovation, which would find a more advantageous environment in sparse networks (Obstfeld, 2005). Some decades ago, some others had already admitted that incremental improvements would be closely bound to user-producer interaction and learning processes while radical innovations would depend decisively on scientific advances (Freeman, 1992). However, empirical studies that try to identify the actual relations between the configuration of the networks (composition, structure, size, number of components, and so on) and the type of innovation are recent and still scarce. Examples are: Hemphala and Magnusson (2012) reveal the existence of a relationship between openness and radical innovations, on one hand, and density and incremental innovations, on the other; Kaufmann and Todtling (2001) and Todtling, Lehner and Kaufmann (2009) demonstrate the existence of positive relationships between more radical innovations and links to universities and of incremental innovations and links to customers and suppliers; Arndt and Sternberg (2000) show the existence of a relationship between the different geographical scope of the networks and the type of innovation.

3. Empirical setting

The software industry in Portugal dates back to the 1960s when some firms began providing computer services to large companies and government departments often in conjunction with other business services. This situation is similar to some other countries that had no local computing industry other than the affiliates of multinational companies at the time. In the Portuguese case, these affiliates were looking largely for cheap and unskilled labour for assembling operations. Their role in the deployment of the sector is therefore negligible.

Later, an enormous development took place in the software industry with the microelectronics revolution and the upsurge of the first generation of personal computers in the late 1970s and early 1980s. In fact, there was a vast increase in programming abilities before the emergence of user-friendly operating systems. In addition to large software companies that provided customized services to industry, many small software firms were set up which often employed free-lancers to assist their customers in using or adapting standardized software or in developing entirely new software solutions.

The generalization of user friendly operative systems and the entry of large packaged software companies like Microsoft on the market entirely changed the use of personal computers..

Packaged software for the general public has never been a success story in Europe. American companies conquered most of the mass markets, while European software houses avoided direct competition by turning to software solutions and services for large and small businesses.

The rise of the Internet and mobile communications in the 1990s brought a new turn. Internet triggered an unprecedented popularization of computer usage, while mobile communications opened up a new domain of technological innovation at a very rapid pace. The subsequent interconnection of the two areas originated a cumulative process of innovation.

This created an enormous opportunity for the emergence of innovative software start-ups aimed at inventing software modules to be embedded in the equipment, on a self initiative basis or on demand from the customer. It is precisely at this point that our story begins.

The firms we study have benefited from the creation of this new technological market and simultaneously from the existence of very competitive domestic mobile communications operators. Multinational affiliates have also played a role in the development of this sector in a number of ways, namely by hiring their local teams of software developers and by outsourcing or requiring formal partnerships with domestic software houses. Furthermore, they occasionally acquired some small companies to obtain their competencies and products.

There are around 50 Portuguese companies producing software for telecommunications, often as a subsidiary activity. A gradual process has permitted the identification of these companies. To begin with, we interviewed industry experts from the national association of information technology and electronics firms (ANETIE) that provided information on the story of the ICT industry in Portugal and contacts for the firms. At the same time, a detailed search for information was carried out in the business press. A snowball technique was systematically used once the interviews began, by asking the entrepreneurs to identify to the best of their knowledge the rival domestic companies operating in the market.

Not all identified companies were equally relevant to us. Considering the relative importance of the software for telecommunication, we identified a target group of 40 firms and conducted interviews in 29 of these.

Small and medium sized companies predominate in our sample. Taking employment and turnover criteria simultaneously there are only 3 large companies. The average turnover was € 11 million in 2007 and the average number of workers was 104.

Almost all companies (90%) were set up after 1991 and the oldest dates back to 1982. Spin-offs represent more than half of our firms: ten (34%) are research spin-offs - companies whose products are based on research carried out by their founders in universities and other research organizations -, while 7 (24%) are corporate spin-offs.

As for the markets, the majority of firms (62%) export. However, exports play a modest role for most of them and only 5 export more than 40% of total sales. Although domestic firms are the main customers for 57% of our companies, multinational corporations affiliates are the dominant customers for 8 firms (29%) and government agencies are dominant for 4 (14%).

4. Methodology

4.1 Data collection

Data about the firms were collected combining the search for documentary information (data about patents and formal collaborative projects and firms' websites and activities reports) with in-depth interviews with the founders or CEOs. The interviews were based on a semi-structured questionnaire allowing systematic and detailed information about the nature, the relevance and the contribution in terms of resources of each relationship to be collected. They also addressed the firm's activities, strategy and performance, with particular emphasis on innovation and technological development.

4.2 Firm classification according to the innovation strategy

After data collection, we split our sample into two groups: the more radical innovative firms with characteristics similar to science-based companies; and the application-oriented ones, which carry out mostly incremental innovation through technological improvements.

Firms were considered to pursue a radical innovation strategy if they develop software that is new to the market. Fifteen companies fall into this group, developing new mobile platforms for applications in advanced geo-localization, payment systems, fusion between mobile phones and internet and games. Firms were considered to pursue an incremental strategy if they develop services that are not new to the market. Fourteen companies fall into this group, and their main focus is software customization or product improvements.

4.3 Network reconstruction and analysis

The next step was the reconstruction of innovation networks for all the firms, using data from the interviews and from documentary sources. The process of network reconstruction began with the identification of firm-based networks, i.e., inter-organizational ego-networks were the ego is the interviewed firm and the alters are the organizations with which that firm has established relations so as to access relevant resources for the innovation process.

Since previous research has shown that the type of resource being accessed is likely to influence the type of networks being established (Sammarra and Biggiero, 2008; Salavisa et al, 2012), the innovation resources were classified in two different types: scientific and technological knowledge and complementary assets. Accordingly, two different types of network were reconstructed for each firm (Table 1). If we consider both types of resources simultaneously we will get (aggregate) innovation networks. The reconstructed networks are directed, since the ties represent flows from a source to a recipient.

Table 1 – Contents in knowledge and complementary assets networks

Knowledge network	Complementary assets network
R&D Projects S&T Partnerships Patents (partners; providers) Origin of technology Innovation (new ideas) S&T knowledge	Fund sources Facilities providers Service providers (legal, accounting, IP, marketing) Commercial partnerships Information/advice to business planning Management knowledge

The second step of the network reconstruction process was the aggregation of the firm ego-networks, considering all the interviewed firms in each group: radical innovators and incremental innovators. Therefore, we have four different networks. These networks were analysed using several Social Network Analysis (SNA) measures to characterize the morphology, properties of actors and ties and structure. Table 2 presents the measures used in the analysis.

Table 2 – Network analysis

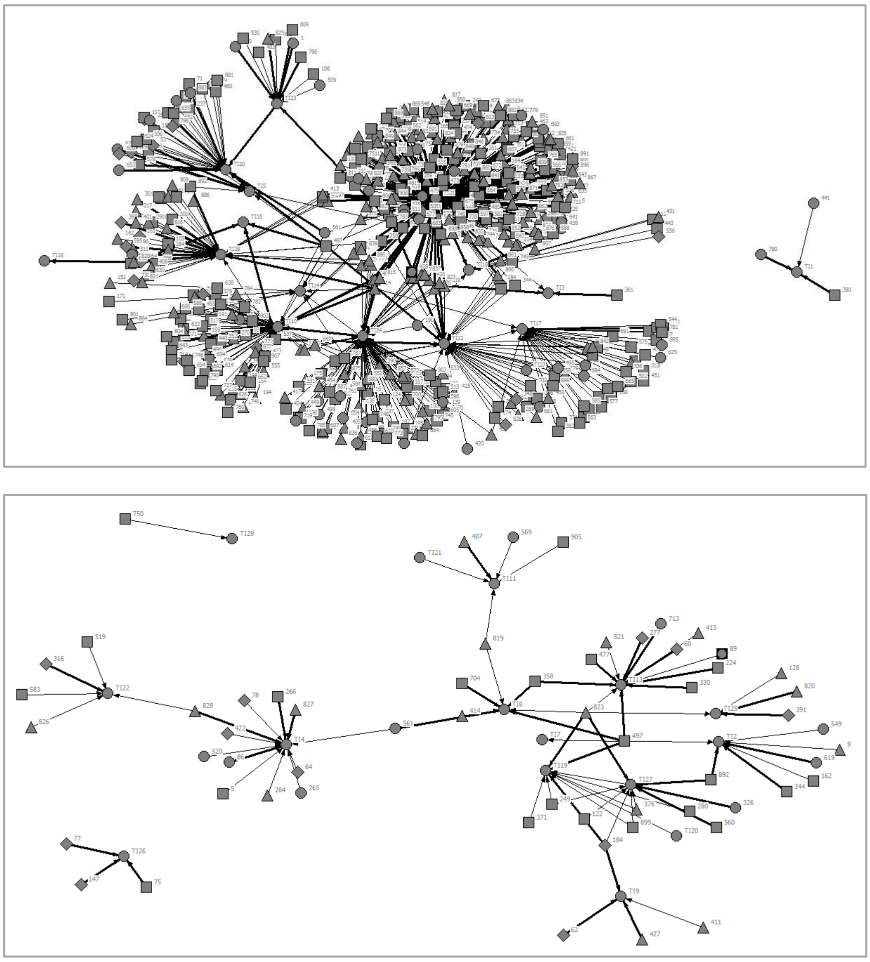
Property	Measure	Definition	Comments
Morphology	Size	Number of elements (nodes/actors and/or ties) that constitute the network	Larger networks mean that a firm can receive a more diverse and complete set of resources from the network.
	Number of components and size of the largest component	A component is a set of connected actors with no relations outside the component. Besides the number of components, the number of actors in the largest component was considered	If a network is composed of a large number of small components, the capacity to access resources is lower.
Actors	Composition	Each type of actor's share in the total number of ties was considered to analyse the relevance of each actor.	Several types of actors were considered: software for telecommunications firms, firms from other sectors, universities and research centres, venture capitalists, S&T parks and other organizations (e.g. trade and professional associations).
	Centrality - degree and betweenness	Identification of the position of an actor in relation to the network interactions	*Degree* centrality is the number of connections an actor has to other actors in the network. In directed networks, we distinguish *indegree* (ties directed towards an actor) from *outdegree* (ties that depart from an actor). *Betweenness* centrality is the number of times an actor lies between each pair of actors.
Ties	Strength – proportion of strong ties	Ratio between the number of strong ties and the total number of ties	A tie is considered strong when one of the following situations occurs: i) the informal contacts take place at least once a month; ii) the tie is used to access different types of resources; iii) the firm establishes both formal and informal relations with that organization.
Structure	Density	Ratio between the number of ties that are present in the network and the total number of possible ties	The debate on the most favourable network configuration is often focused on this measure.
	Centralization	Extent to which the whole network has a centralized structure, i.e. a structure that is organized around its most central points	Centralization measures are based on the actor's centrality. They vary from 0 to 1.
	Clusterization	Average density of the groups of actors around individuals in the network	Reveals the extent to which the firms' partners are connected to each other
	Cohesion	Extent to which a network is divided into cliques with few links between groups. A clique is a sub-set of connected actors. The 2-clique concept is used, i.e. cliques where the actors are connected directly or through a common partner	Only cliques with more than three members are taken into account. An actor can belong to more than one clique

5. Results

The differences and similarities between the networks of the two groups of firms are captured by the network diagrams (Figures 1 and 2) sketched with Netdraw software and by SNA measures (Table 3) computed with UCINET software. In the figures, arrows indicate the resource flow from its source to the recipient. Stronger ties are represented by thicker lines. The shapes of the nodes indicate the organization type: circles are used for software for telecommunication companies, squares for firms from other sectors, up triangles for universities, circles-in-box for science and technology parks, down triangles for venture capitalists and diamonds for other organizations (including trade and professional associations and governmental agencies).

The first striking difference relates to the size of the radical innovators' knowledge network, almost 8 times larger than that of the incremental innovators. Furthermore, universities are more relevant knowledge sources for radical innovators. So the knowledge networks of radical innovators reflect the more knowledge-intensive and science-based nature of their innovation activities.

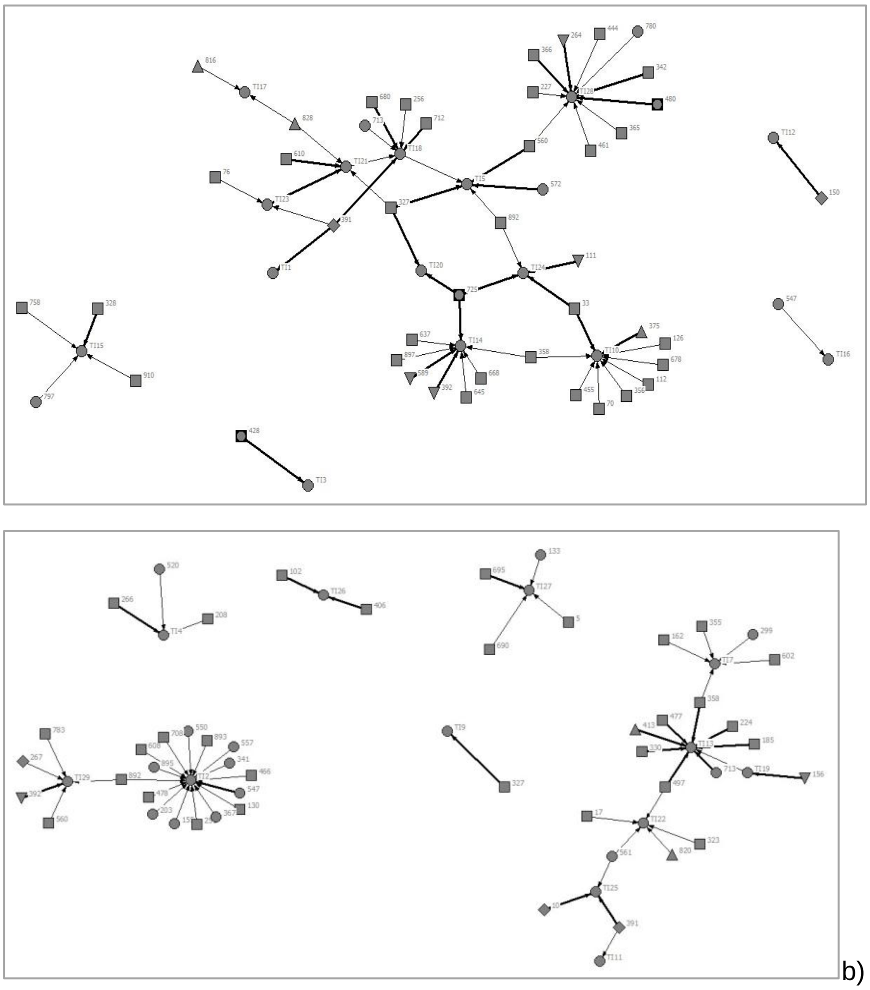
Secondly, there are also significant differences in the structure of the knowledge network of both types of innovator. The radical innovators' network is less dense and has a lower proportion of strong ties. This result is in accordance with the literature that highlights the benefits of weak ties and more open networks in opportunity generation and exploration strategies (Burt, 2004; Hemphala and Magnusson, 2012).



a) radical innovators

b) incremental innovators

Figure 1 – Knowledge networks



a) radical innovators

b) incremental innovators

Figure 2 – Complementary assets networks

Table 3 – Network measure: radical versus incremental innovators

		Complementary assets		Knowledge	
		Radical	**Incremental**	**Radical**	**Incremental**
Size	No. of actors	61	61	560	74
	No. of ties	60	55	628	81
	No. of components of the network	5	6	2	3
	Size of largest component	50	25	556	68
Actors composition (%)	Firms from same sector	33	41	13	32
	Firms from other sectors	48	48	45	30
	Universities	5	3	38	22
	S&T Parks	5	-	0	1
	Venture capitalists	7	3	-	-
	Other	3	5	5	15
Centrality of actors	Degree	0.12	0.10	1.03	0.16
	Betweenness	0.02	0.00	0.68	0.03
Ties	Strong ties (%)	43	33	27	44
Density	Overall	1.87	1.65	1.53	1.89
Centralization (%)	Outdegree	0.32	0.14	0.46	0.38
	Indegree	0.64	0.89	18.32	0.99
	Betweenness	0.00	0.00	0.06	0.00
Clusterization	Clustering coefficient (%)	0.00	0.00	0.13	0.10
Cohesion	No of 2-cliques	25	15	53	22

Furthermore, the knowledge network of radical innovators is more connected, centralized and clustered than that of incremental innovators. This result underlines the need for a more detailed analysis of the actors that bridge the different firm-based ego-networks in each case. These actors, playing the role of knowledge providers to several firms, connect distinct cliques. Table 3 shows that: i) bridges are clearly more abundant in the radical innovators' knowledge network; and ii) the organizations that perform this bridging role differ, with a stronger presence of international actors in the network of radical innovators, namely of foreign universities and telecommunication operators, which are absent in the case of incremental innovators.

Table 3 – Bridges between firm-based ego-networks

	Complementary assets		**Knowledge**	
Bridges between	Radical	Incremental	Radical	Incremental
2 firms	2 national telecom operators (Optimus and Vodafone); 1 MNC from other sector (IBM); 1 national business association	1 national telecom operator (Vodafone); 3 MNCs (Oracle IBM and Microsoft)	4 national firms from same sector, 3 national firms from other sectors, including 1 telecom operator (Vodafone); 4 foreign firms from other sectors, including a telecom operator (Telecom Italia) and 2 MNCs (Alcatel-Lucent and HP); 15 foreign universities; 4 national universities; 1 national S&T park; 2 national business associations	4 national firms from other sectors, including 1 telecom operator (Vodafone); 2 MNCs (Oracle and IBM); 2 national universities
3 firms	1 national telecom operator (PT); 1 national S&T park; 1 national business association	-	6 foreign universities; 5 national universities; 2 MNCs (Oracle and Nokia); 1 foreign telecom operator (Telefonica)	1 national business association
4 or more firms	-	-	1 MNC (Microsoft); 1 national telecom operator (TMN); 2 national universities	1 national university; 1 MNC (Microsoft)
Total	7	4	51	11

The differences between the two groups of firms are quite subtle in the complementary assets networks (Table 2). Their size and composition is similar, although universities, S&T parks and venture capitalists play a more important role in radical innovators' access to these resources. Additionally, radical innovation is associated with a more connected, closed, dense, centralized and cohesive network than incremental innovation. This result stresses the importance of strong relations in the access to complementary assets and the larger overlap between providers of these resources to firms that pursue radical innovation strategies. The analysis of the organizations that perform a bridging role (Table 3) reveals that telecommunication operators are more relevant to agglutinate the radical innovators' network, while MNCs are more important to connect the incremental innovators' network.

6. Discussion and conclusion

This paper addresses the relation between ranges of innovation (mostly radical versus mostly incremental) and network configurations. It adds to the existing literature by considering two sources of network variation simultaneously: the innovation range and the type of resource accessed. As a consequence, we have split innovation networks into knowledge networks and complementary assets networks.

The results confirm the value added of this fine-grained approach since they show that the configuration of networks varies not only with the **type of innovation**, in accordance with previous research (Hemphala and Magnusson, 2012), but also with the **type of resource** that circulates in the network. Furthermore, our approach reveals that the major source of differentiation across radical and incremental innovators relies upon their knowledge networks, taken as isolates.

These results are interesting for two main reasons: 1) most studies deal with innovation networks as a whole (Hemphala and Magnusson, 2012); 2) scientific and technological knowledge appears as crucial to achieve the most sophisticated innovation in software, an industry that is not usually regarded as science-dependent (Grimaldi and Torrisi, 2001; Steinmueller, 2004; Lippoldt and Stryszowski, 2009).

In this study, the relevance for radical innovators of their connections with universities opens up a new perspective in the analysis of this industry. In fact, in comparison with incremental innovators, radical innovators' networks include a large share of universities as opposed to firms from the same sector, pointing to a more science-based profile. In addition, they have developed larger knowledge networks, confirming their need to access a varied set of disperse sources (Kaufmann and Todtling, 2001). Radical innovation is also linked to sparser and more open knowledge networks that enable the access to diversified and non-redundant knowledge, giving support to the arguments of those who advocate the advantages of sparse networks (Burt, 2004).

However, in the case of access to complementary assets, radical innovators resort to close and dense networks; this indicates that a higher level of newness and risk and the consequent need to protect new ideas require strong and trusted relations, thus supporting the arguments of those who stress the advantages of dense networks (Obstfeld, 2005; Coleman, 1988; Uzzi, 1997; Ahuja, 2000).

Our results also show significant differences in the actors that agglutinate the firm-based networks (bridges), connecting different cliques. We found that bridging organizations are more frequent in knowledge networks than in complementary assets networks. Since complementary assets are very specific to each firm, the respective networks are less dense, connected, centralized and clustered network for the access to complementary assets.

In addition, the analysis of bridging organizations permits to conclude that foreign universities and foreign telecommunication operators perform an important bridging role for radical innovators' access to knowledge but not for incremental innovators. In the case of access to complementary assets, the bridging role is mainly performed by national telecommunication operators for radical innovation and by MNCs for incremental innovation.

Some major conclusions can be drawn from this study: 1) methodologically, it appears as necessary to carry out a fine grained analysis if we wish to deepen our understanding of the innovative process of the firms connected with other agents through various networks; 2) innovative activities in software rely heavily on scientific and technological knowledge that is mostly accessed through links with universities; 3) knowledge and complementary assets networks follow different patterns, even for the same group of firms, pointing to a huge resource specificity. In short, our disaggregated approach can contribute to the debate on the most favourable network configuration for innovation: this depends not only on the range of innovation but also on the resource that is exchanged through the relation.

Although it seems that this study has added some understanding to its field, it has some limitations that would demand further research. First, we have dealt with a relatively small sample of companies, albeit submitted to a thorough enquiry; second, this kind of approach should be applied to other sectors and contexts in order to test its generality (see Salavisa et al, 2012, for the comparative case of biotechnology and software).

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