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CLUSTERS AND COLLECTIVE LEARNING NETWORKS: THE CASE OF THE COMPETITIVENESS CLUSTER 'SECURE COMMUNICATING SOLUTIONS' IN THE FRENCH PROVENCE-ALPES-CÔTE D'AZUR REGION

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Clusters and Collective Learning Networks: The Case of the Competitiveness Cluster ‘Secure Communicating Solutions’ in the French Provence-Alpes-Côte d’Azur Region

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Abstract. Since the development of the knowledge based economies, clusters and clusters policies have been the subject of increased interest, as sources of knowledge, innovation, and competitiveness. The paper focuses on a case study drawn from the French cluster policy, the pole of competitiveness ‘Secure Communicating Solutions’ in the French Provence-Alpes-Côte d’Azur Region, based on two high tech clusters, Rousset – Gémenos and Sophia-Antipolis. The policy aims to provide the firms incentives to build network relations of heterogeneous actors to trigger innovative processes. The analysis of the collaborative R&D projects of the pole provides insights on the nature of the collective learning networks working in the clusters as well as the prevailing organizational forms resulting from the firms strategies. It show that knowledge spillovers are not simply “in the air” but very specific of the learning networks and clusters from which they belong. Clusters thus need to be analyzed jointly with networks in order to understand the processes underlying their innovation capacity.

Keywords. Collective Learning Networks, Knowledge, Innovation, Clusters, Cluster Policy, Social Network Analysis.

1. Introduction

Areas where clusters of new high technology firms are to be found attract attention as potential breeding grounds for future industry. Because of the potential in terms of wealth and job creation, there is considerable interest in explaining how these high tech centres develop and can be encouraged. They have often been considered as an embodiment of the knowledge based economies which govern the evolution of our societies and overcome the continuous waves of obsolescence of knowledge and technology (Foray, 2005).

The role of clusters, i.e. localized concentration of horizontally and vertically linked firms, to create and sustain competitive advantage has been definitively imposed by Porter (1989) and acknowledged by the literature (Malmberg and Maskell, 2002; Martin and Sunley, 2003; Porter, 1998). Clustered firms have been shown to grow and innovate faster than non-

clustered ones (Audretsch and Feldman, 1996). But these processes are neither straightforward nor automatic.

Knowledge is far from ‘being in the air’ in existing clusters (Cassi, Plunket, 2013), it is increasingly agreed upon that it cannot be assumed beforehand that all firms in a cluster are involved in local networks of collective learning (Breschi, Lissoni, 2001, Bell, Giuliani, 2005, Giuliani, 2005, ter Wal, 2013). Some firms can be excluded from the processes of collective learning because of competition, some others can simply lack of the absorptive capacity (Cohen, Levinthal, 1990, Lazaric *et al.*, 2008) necessary to enter in these processes. Geographical proximity is neither a necessary nor a sufficient condition to access knowledge, other dimensions of proximity, organizational or cognitive, have been developed (Boschma, 2005, Torre, Rallet, 2005) which can account even more than co-location. Many studies have shown that the creation of knowledge is less and less an isolated process internal to individual firms but a collaborative process involving networking of heterogeneous organizations (Caloffi *et al.*, 2012).

The pace of innovation and technological progress going with the globalized knowledge based economy deepens the basic role of these networks. Powell *et al.* (1996) have evidenced that the R&D intensity or level of technological sophistication of industry is positively correlated with inter-firm alliances. These alliances have grown rapidly since the mid-1980s, especially those aimed at technological learning and knowledge creation (Nooteboom, 1999, Nooteboom *et al.*, 2005); they enable established firms limited in their pursuit of opportunities by their existing capabilities and experience to combine heterogeneous resources, renewing the economy over time (Penrose, 1959, Garnsey, 1998). The locus of innovation is thus to be found in networks of inter-organizational relationships (Powell *et al.*, 1996).

Clusters can trigger externalities leading to economic performance (Krugman, 1991, Porter, 1990) or innovation, knowledge creation, learning as processes of social interaction between individuals or firms in networks (Boschma, 2006, Fleming, Frenken, 2006, Saxenian, 1994). But clusters and networks do not necessarily coincide. As ter Wal (2013) clearly states following Visser (2009, 168 –169), “clusters refer to spatial concentration processes involving a related set of activities in which context firms may but need not cooperate. Conversely, networks refer to cooperation in the form of knowledge exchange between firms and other actors that may but need not develop these links at the local or regional level”. Furthermore, the relations between clusters and networks have not a deterministic optimal form. A basic seminal reference to capture the implications of networks on clusters remains Markusen

(1996). The nature and intensity of interactions are not associated with physical proximity, but with the organizational structure that governs these interactions (local and external) between firms and institutions. A clear, relevant taxonomy for cluster configurations is derived from the nature of interactions which can also serve as a basis for analyzing localized knowledge-creation processes.

Clusters and networks have thus to be tackled together. The relevant issue this paper will attempt to address is the local collective learning networks working in clusters.

“Cluster” and “Competitiveness” are among the most popular buzz-words of our time, the first being implicitly a solution for the second. At least as much as researchers, policymakers have thus turned to be interested in clusters and networks. The implementation of cluster policies as relevant for firms to cope with the challenges of the knowledge-based economy as well as the growing complexity of technology management has been promoted worldwide. Cluster policies, cluster strategies, cluster development programs... have been actively developed (Uyarra, Ramlogan, 2012, Giuliani, Pietrobelli, 2011) “to promote economic development by forming and strengthening inter-organizational networks”.

After the ‘Inter-ministerial Committee for Spatial Planning and Development’ of September 14th 2004, this policy has taken a specific form in France that was referred to as “Poles of Competitiveness”¹. The French policy consists on ‘increasing top-down pressures on regions or local areas to position themselves’ (Kiese, 2006), i.e. to build projects of development based on their technological capabilities or knowledge bases, the definition and governance of the projects being entrusted to firms and research institutes, the heterogeneous actors involved in the processes of creation of knowledge and innovation.

The paper focuses on a specific pole located in the French region of Provence-Alpes-Côte d’Azur (PACA), the pole “Secure Communicating Solutions” (SCS). The pole is particularly interesting for our purpose related to clusters and collective knowledge networks dynamics. It is indeed a matter of bringing together complementary skills in order to create new synergies between different kinds of partners, between different clusters, and between different types of technologies. The aim in microelectronics is to merge skills from “the silicon to uses” to address the markets, to reduce or resolve organizational and cognitive distances.

¹ “Pôles de Compétitivité” is the French name of the policy, translated here as “Poles of Competitiveness”; “Competitiveness Clusters” is another translation, more often used in the literature.

Section 2 presents the policy and the clusters supporting the pole SCS. The pole aims to foster collective R&D networks of heterogeneous agents and produces basic sources of information on these processes. The paper does not intend to evaluate the policy as such. It builds on the R&D networks identified through the pole to characterize the specific organizational forms of knowledge creation and the collective learning processes at work in the clusters. Section 3 presents the relevant database resulting from the working of the pole and the methodology implemented in the related empirical analysis. Section 4 implements a social network analysis of this database to characterize the organizational forms promoted by the firms and embedded in the clusters. Section 5 focuses on proximity issues and identifies the different types of learning networks in the clusters. Section 6 concludes.

2. Innovation in policy

2.1. The “Poles of Competitiveness” renaissance

In the French context, the policies aiming at competitiveness have taken and still take a specific form, referred as “Poles of Competitiveness”. They are embedded in the French economic analysis tradition as they can be linked to the works of François Perroux. “Poles of Competitiveness” policies have been used at the end of the seventies to facilitate the emergence and development of “strategic” sectors regarding the international division of labour, and presided the definition of industrial policies. It is important to notice that in this conception the poles are defined according to a strict sectoral approach without any territorial dimension (Longhi, Rainelli, 2010).

The reference to the poles has disappeared from the eighties with the decline of industrial policies. They reappeared in a renewed form in 2004 in the French public policy in line with the cluster strategies promoted by the European Union. These new Poles of Competitiveness have been defined as the new French industrial policy, aiming at reinforcing the specializations of the economy, strengthening the attractiveness of the territory and favoring the emergence of new activities via synergies between research and industry. They are defined as “the combination on a given geographic space of firms, training institutions and public or private research centres engaged to generate synergies in the execution of shared innovative projects. The partnerships can be oriented towards a market objective or a scientific and technological domain” (Interministerial Delegation for Territorial Competitiveness and Attractiveness’, 2005).

The key words of the definition of the poles are “collaborative innovative projects” entailing heterogeneous actors. The poles are not financed directly by the public policy; their members only are financed when the R&D projects they propose to dedicated calls are selected. The policy aims thus basically to provide incentives to foster local interactions, cooperation, to strengthen the performance of the clusters regarding innovation and creation of knowledge.

Interestingly the SCS pole is built on two existing clusters resulting from the old French industrial and regional policies of the last century, the microelectronics activities in the ‘Bouches du Rhône *département*’, along an axis running from the town of Rousset to the town of Gémenos, and the high-tech activities of the ‘Alpes-Maritimes *département*’, broadly centered on the technology park of Sophia-Antipolis. They were both created *ex nihilo*, but in different ways. The former originated in the context of various plans intended to develop a technology sector, in this case microelectronics. The latter originated in the context of regional policy, supported by a public policy of decentralization and public investment in telecommunications infrastructure, but without any specific technology project.

These exogenously generated public creations rooted in the territories either gave rise to endogenous processes or they disappeared. In the case of the PACA region, two clusters with local endogenous dynamics emerged, but as we shall see, they had very different organizational structures, based (to quote Markusen, 1996) on the *hub-and-spoke* and the *satellite platform* forms respectively. The pole of competitiveness, product of contemporary public policies, is meant to “bridge” elements of a value chain dispersed in the two clusters. Geographical, organizational and cognitive proximities issues (Boschma, 2005, Torre and Rallet, 2005) will have thus to be tackled.

2.2. Public policy constructed clusters: Rousset and Sophia-Antipolis

The microelectronics cluster in the town of Rousset is a pure product of the traditional French industrial policy, which was centralized and made up of plans implemented by “national champions”. The plans have led to the creation from scratch of the company Eurotechnique in the industrial area of Rousset in 1979 to build and develop the industry, followed by the government-led location of Thomson-EFCIS, Nanomask (later Du Pont Photomasks), different merging which gave rise to the group SGS-Thomson Microelectronics, called STMicroelectronics, and the development of a dense cluster of subcontractors (Daviet, 2000,

2001, Garnier and Zimmermann, 2004, Mendez *et al.*, 2008, Rychen and Zimmermann, 2000). A second phase was characterized by the founding of the company Gemplus, now Gemalto, and the emergence of an innovative industrial web between Rousset and the neighboring town of Gémenos, where Gemplus was located. Gemplus has been created as a spin-off of Eurotechnique-Thomson Components based on a radical innovation, the design and production of cards. It has triggered a movement of endogenous development based on local capabilities. The area grew as a hub-and-spoke cluster in the Markusen taxonomy, large firms surrounded by a dense set of specialized sub-contractors.

Nevertheless, the microelectronics industry still experienced crises and threats of large companies which had to close down. These crises led to the founding of various associations with the aim of consolidating activities. In particular, the creation of active industrial associations (CREMSI, which later became ARCSIS, PROMES, etc.), which were founded by the management of the large companies with the aim of creating linkages between industry and science, including SMEs, and seeking and obtaining public support for the implementation of projects (Zimmermann, 2000). These actions were coupled with the creation of large research institutes, gathering elements that had until then been disparate. At the time the cluster policy was implemented, there was thus already a well-designed structure for interactions in the Rousset-Gémenos cluster.

Sophia-Antipolis is the core of the pole area based on the Alpes-Maritimes. It is the result of regional policies promoting the creation of high-value-added activities implemented in the context of spatial planning. This project was born in a region without any industrial or academic tradition; its only resources were linked to its main activity at the time, tourism. The success of the project was determined by the involvement of Pierre Laffitte, a former director of the 'École nationale supérieure des mines de Paris' who created and stimulated the project, of France Télécom which gave Sophia-Antipolis an advanced telecommunication infrastructure, and the proximity of an important international airport (Longhi, 1999). Up to the beginning of the 1990s, Sophia-Antipolis grew through the accumulation of external resources. The project benefited from the French policy of decentralization, with the IT centers of large French firms which moved there, and from the 'multinationalization' of the 1970s and 1980s, when American companies set facilities in the European market. On these bases, Sophia-Antipolis took off through companies being attracted by the quality of the available (telecom) infrastructures to set up and manage their European markets or their

global telecommunication networks. In addition, the project attracted education and research centers, which contributed to the emergence of a qualified labor market.

The project grew as a satellite platform in the Markusen sense: a system of rich exterior relations (albeit poor in local interactions) led from outside for external markets. Resources were fundamentally internalized within the companies, the absence of local resources or their strategies having led them to build self-contained ensembles. The growth slowed considerably at the beginning of the 1990s with the economic crisis that struck the computer science activities. But basically the factors of success of Sophia-Antipolis, a platform endowed with efficient infrastructures to develop markets or activities were at odds with the new phase of globalization. Another organizational form had to be built.

Industrial associations played a considerable role to face the crisis and favour the emergence of collective processes in Sophia-Antipolis. In particular the association Telecom Valley grouped together all the telecommunications and microelectronics actors, including large and small companies and research centers. To face the risks of de-localization, it aimed at highlighting the skills that were specific to Sophia-Antipolis and its indisputable importance at the European level. Finally, the emergence of mobile technologies and Internet led to a revival of the cluster, with these technologies originating within a number of local companies, making Sophia-Antipolis a key location in the European high-tech industry. The establishment of facilities by large corporations no longer took place by means of huge investments and transfers of human resources, but through knowledge-led strategies, the establishment of small units that took advantage of the skills and qualified resources produced or already available locally.

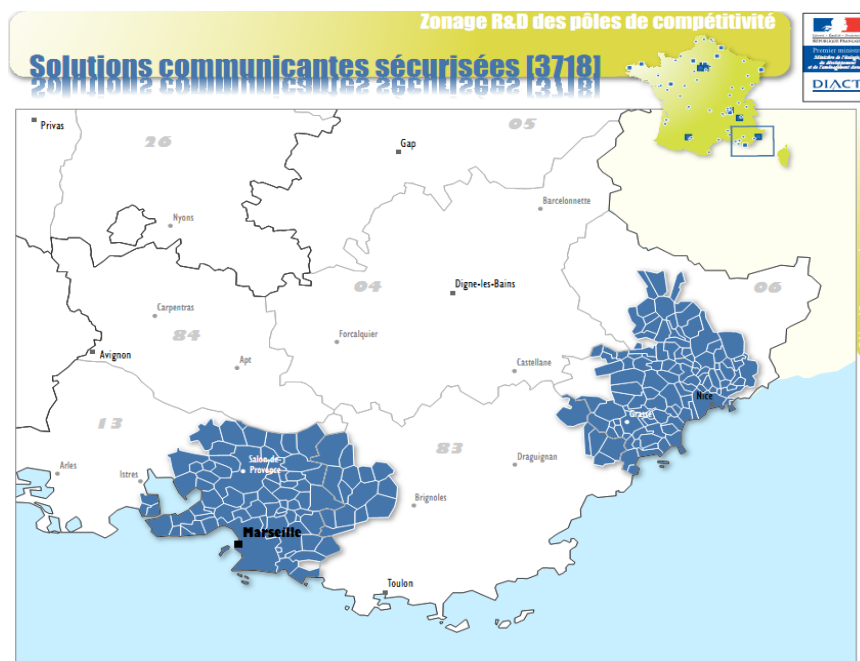
3. The pole SCS: definition and relevant database

The pole SCS draws on resources from both of the clusters described above. Relations between them were relatively underdeveloped, but organizational linkages have begun to be formed through the establishment of platforms (CIM PACA) in microelectronics financed by the Region and the *département* of Alpes Maritimes. The platforms aimed at making available software components by world leaders based in Sophia-Antipolis to firms and research institutes. ACSIS and SAME, the microelectronics associations of each of the two clusters, promoted this operation. With the French government's call for tenders for poles of

competitiveness, the idea of creating a broader project that brought together all the actors in the region arose, still under the influence of the associations, ARCSIS, SAME, Telecom Valley, and crystallized as the SCS pole.

The pole was created around the idea of bringing together the leaders in microelectronics, telecommunications and software to cover the entire value chain from silicon to its uses on the markets and take advantage of the convergence of these various industrial sectors. It groups together local actors in two clusters located in areas of the ‘*Départements*’ of Bouches du Rhône [13] and Alpes Maritimes [06]². Needless to say, the pole does not involve all the “*Départements*” as such. Its boundaries are discontinuous and endogenous. It does not cover the areas of administrative units, but rather the agglomerations of resources (“R&D zones”) that make up the project. The territory is endogenous as its frontiers are defined with the project of development it supports, which matches the resources involved in.

Figure 1. Map of the pole SCS



Source. <http://competitivite.gouv.fr/>

The pole does not also gather all the firms and institutions of the areas it covers. It has the institutional form of French ‘Association’ acting for its members; one has to join formally the association, to pay fees, to be involved in. The pole has involved around 600 members over its

² These numbers refer to the French *départements* units nomenclature. Hence, [06] Sophia-Antipolis (Alpes Maritimes) and [13] Rousset-Gémenos (Bouche du Rhône). For the sake of simplicity, we will use *département* numbers to refer to the clusters, speaking of [06] or [13] projects or partners, or [0] when an external partner is involved in a project.

history, some (the large firms, the research institutes) are permanent members, others (the SMEs) enter and exit depending of their R&D projects, for an annual average of roughly 250. The members benefit from the governance body of the pole, which fosters the emergence of innovative, collaborative projects, supports the participation of SMEs in projects, and assists the members and their projects up to labeling and involvement in a call.

The core of the activity of the poles of competitiveness is made of R&D projects. These projects do not cover entirely the formal inter-firm R&D alliances and even more the informal local network relationships related to knowledge, learning and innovation in the clusters. They are a specific subset of the collective learning networks, with a form imposed by the rules of the games of the poles and the call addressed, usually partnerships involving necessarily SMEs and research institutes, rules some firms consider restrictive enough not to compete for public research subsidies. Nevertheless, a lot of R&D relationships are today mediated through the poles which provide reliable information on previously unknown collaborative activities. The projects labeled by the governance system of the pole forms thus a good proxy to grasp the local R&D activity, the nature of local interactions and local collective learning networks, as well as linkages with external partners.

The pole has labeled 447 R&D projects during the period 2005–2014 under analysis, which indicates a sizeable amount of activity. This database is the basic information used to highlight the collective learning networks running in the pole. It gathers the main characteristics of the projects: the nature of the call addressed, basically calls specifically aimed at poles and financed by an inter-ministerial fund [FUI], calls by the Regional Council [CR] and calls by the National Research Agency [ANR], dedicated to more basic research; the location and nature of the project leader (industrial group, SME, academic institute, association); the location and nature of the partners involved in the project (industrial group, SME, academic institute, association); the status of the labeled project, selected (financed) or not in the call addressed.

4. The SCS collective learning networks

The 447 R&D projects implemented in the pole SCS have involved 760 different partners, 22.2 % for [13], 13.6 % for [06] and 64.2 % are external to the clusters! Nevertheless, many partners belong to one project, some are involved in dozens, defining 2378 project – partner

relations. The 'effective' shares of the different clusters are the following, 29.5 % for [13], 21.3 % for [06], and 49.2 % for external partners, whose roughly 20 % belonging to the region 'Ile de France'! This significant portion of external project leaders testifies the acknowledgement the clusters have earned in specific skills. As we will see, the local leaders build also important external partnerships to access remote knowledge. The literature has emphasized this last issue through the concept of 'gatekeepers of knowledge' (Allen, 1977, Morrison, 2008; Rychen, Zimmermann, 2006). But regarding the high-tech cluster another way is similarly relevant, the access to local specific knowledge by distant partners and its insertion in external clusters or learning networks.

The selection process related to the calls has been favorable for the partners involved: 44 % were selected on the whole, but in a very imbalanced form, from 48 % for [13] to 43 % for [06] and 42 % for [0], or from 61 % for the FUI call to 29 % for the ANR, or from 54 % for the large groups to 39 % for the academics involved in projects. The unselected projects are obviously important to consider, as they account for a part of the informal interactions between the different firms, the institutes of research. Even if not exhaustive, the projects provide a relevant proxy of the formal and informal interactions and alliances governing the collective learning networks feeding knowledge creation and the organizational forms of the clusters.

The database of these projects allows to approximate the collective learning networks running in the pole SCS. The properties of the networks can be derived from a social network analysis according to the following methodology. The R&D projects database forms a bipartite network linking the projects to the partners involved in, partners being large group, SMEs, academics. The different partners associated in a project are supposed to form a complete undirected graph, as they are involved in a collaborative process. A one-mode network of the partners can be derived from the original bipartite network; a node will represent a partner and the links connecting pairs of nodes their involvement in a common collaborative project, or collaborative learning process. Some links can thus have a heavy weight as the same partners can be associated in many different projects. Some partners can also be involved in various projects, but not necessarily with the same actors.

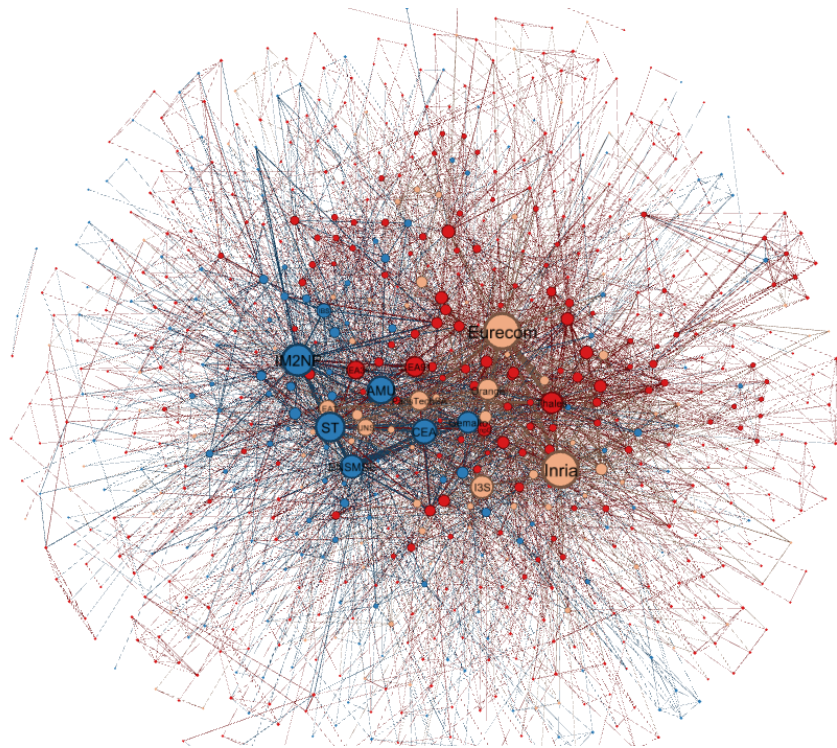
The large number of labelled projects has led to numerous interactions within the SCS cluster. The collective learning networks related to the R&D projects of the pole result in 760 nodes and 4787 edges, i.e. 4787 "partnerships" relations. The graphs of the networks and the

analysis of the associated centrality measures give interesting insights on the clusters. The figure 1 presents these graphs of the pole SCS using the Fruchterman-Reingold visualization algorithm, which displays the most inter-connected nodes close to each other. The following conventions have been adopted for the nodes attributes: nodes representing partners located in [13] are blue, in [06] are yellow, in [0] are red, the relative size of nodes in a graph is proportional to their degrees, i.e. the number of nodes that the node is connected to, the width of an edge to its weight. Figure 1 shows the networks of the partners involved in the labeled project and in the financed projects for all the SCS projects and for the FUI projects respectively.

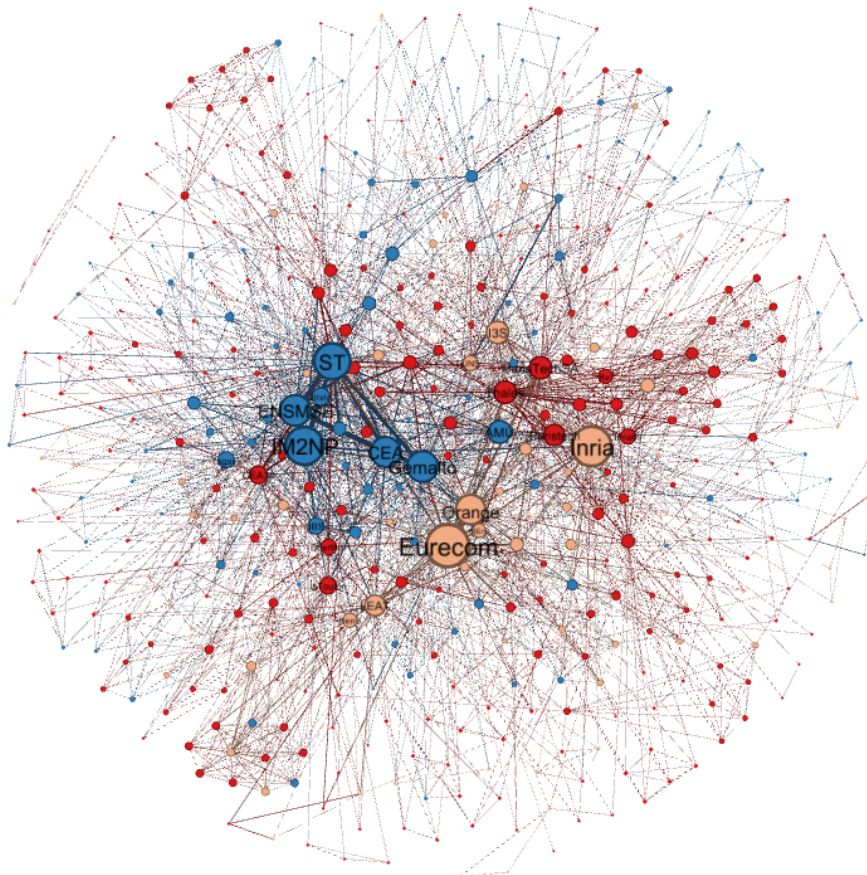
The graphs show core-periphery structures, i.e. groups of highly inter-connected nodes, the core of the partnership networks, connected with peripheral nodes. These last nodes are strongly connected to the core, but not much inter-connected, as the analysis *infra* of the distribution of degrees will confirm. These core-periphery networks have often been considered as efficient for learning processes and viability of the high tech clusters. They allow spreading information quickly (Borgatti, 2006). They are also a condition of the resilience of the clusters (Crespo *et al.*, 2013), the firms or institutes of research involved in strong ties in the core access to weak ties in the periphery to renew knowledge bases and sustain the innovative processes. The notion of periphery does not refer to geographic distance, but to the properties of the networks, and often cognitive distances.

Figure 2. SCS collective learning networks

SCS R&D labeled projects



SCS R&D selected projects



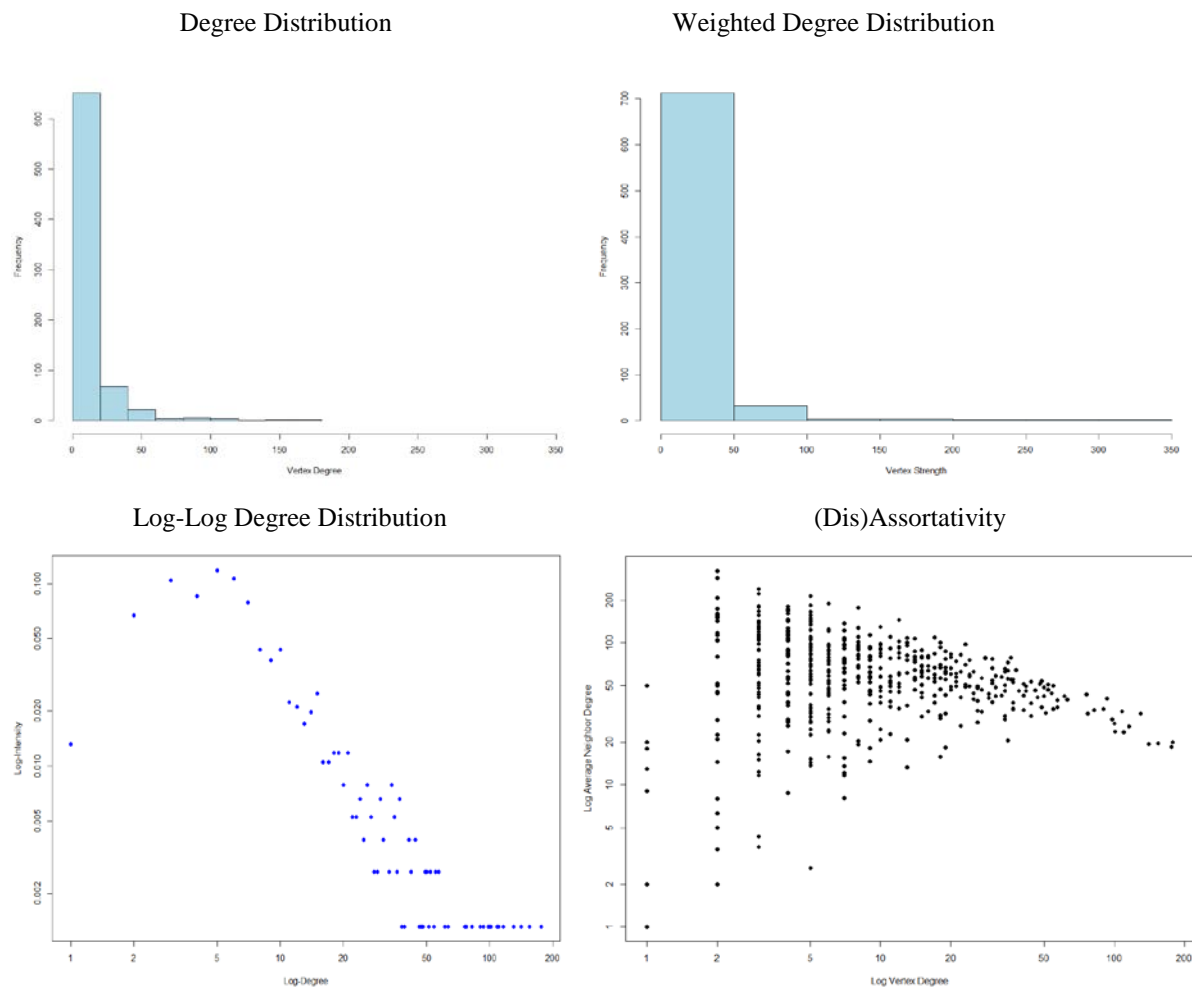
Source. SCS and own calculation

As already emphasized, the partners external to the regional clusters play an important role; they are in the periphery of the graphs and involved in the process of renewal of the knowledge base, but also in the core of the networks. The graphs of the labeled projects and even more the one of the financed ones highlight different organizational forms of the clusters. The core of [13] is made of dense and balanced inter-connected relations of large firms (STMicroelectronics, Gemalto), research institutes (ENSMSE, IM2NP, AMU) and some related SMEs, when [06] is mostly restricted to institutes of research, at the exception of Orange, in fact the research center of Orange located in Sophia-Antipolis. The large groups of Sophia-Antipolis³, Texas Instrument, IBM, Amadeus... are not present in the core of the pole, even if active in industrial associations and permanent members of the pole. Most are international groups. Nevertheless path dependency linked to the organizational form of satellite platform on which the cluster has grown is certainly part of the explanation. Figure 3 presents some centrality measures derived from the analysis of the SCS network.

Different centrality measures have been used to characterize the involvement of the partners in the collective learning network, degrees and weighted degrees (i.e. first the number of nodes that a node is connected to, and second the number of nodes that a node is connected to weighted by the weights of the edges), betweenness centrality, displayed in table 1. The degree distribution of R&D networks is highly skewed, the weighted one would be even more. Some firms or organizations appear central in the network, working as brokers. The shape of the distributions recalls the preferential attachment of Barabasi and Albert (1999), some nodes attracting entrants. The log-log plot in figure 2 shows a nearly linear negative trend in the log frequency as a function of the log degree after degree 2, and an important tail of low frequency nodes, highlighting a very heavy skewness.

³ <http://www.sophia-antipolis.org/index.php/sophia-antipolis/les-entreprises>

Figure 3. Centrality measures.



Source. SCS and own calculation

Beyond the degree distribution, it is important to understand how nodes of different degrees are linked with each other. The last plot of figure 2 represents the average degree of the partners of a given partner in the collaborative learning network. It figures the assortativity of the network, i.e. the correlation between the centrality of a partner and the centrality of all its partners. As the quadratic form of the cloud evidences, the partners of lower degree tend to link partly with partners of lower degree, but mainly of higher degree, and the partners with higher degrees with lower ones. The network is disassortative, as in many technological cases (Newman, 2003), the core and the periphery are better connected. As explained in Crespo *et al.* (2013), the core is more open and peripheral actors holding new or disruptive knowledge can link and benefit from the well establishes core partners to find opportunities of knowledge combinations to address new markets. The governance of the pole helps also to spin new linkages and supports SMEs.

The table 1 presents those partners which make the core of the network, ordered according their weighted degree. It emphasizes the characteristics of the clusters supporting the pole, [06] is deeply involved with research institutes, when the core of [13] is well balanced between important industrial and research partners. Interestingly, an external partner appears as the sixth most important actor of the pole, all calls mixed. It disappears when the analysis is restricted to selected FUI.

Another measure of centrality, betweenness centrality, is worth to be considered. The index measures how often a partner appears on shortest paths between all others partners of the network. Knowledge exchanges within the network are likely to flow through the high betweenness partners. They can perform brokering role across the clusters as they connect otherwise disconnected partners. In the case of the SCS pole, this role can be played within a cluster, between the clusters of the pole, or towards clusters external to the pole. The main institutes of research of the pole are central and connect otherwise disconnected large and small firms. Two large cohesive firms, ST Microelectronics and Gemalto play also a pivotal role to bridge the different elements of the pole, heterogeneous actors and clusters.

Table 1. Centrality measures

SCS collective learning network					
	Partner	Cluster	Degree	Weighted Degree	Betweenness Centrality
Eurecom	Lab	6	176	344	39028.8
ST	LG	13	141	306	20000.5
IM2NP	Lab	13	154	300	28585.8
Inria	Lab	6	178	299	37965.9
CEA	Lab	13	116	235	12390.7
Thales	LG	0	101	229	11460.8
ENSMSE	Lab	13	110	222	12868.6
Gemalto	LG	13	100	186	11322.4
FUI collective learning network					
	Partner	Cluster	Degree	Weighted Degree	Betweenness Centrality
ST	LG	13	92	181	10928.4
ENSMSE	Lab	13	67	122	4687.3
IM2NP	Lab	13	73	111	5064.6
Gemalto	LG	13	60	105	5102.9
Eurecom	Lab	6	69	103	8460.2
Orange	LG	6	56	88	6082.8
AMU	Lab	13	64	83	5563.9
CEA	Lab	13	43	79	1846.2

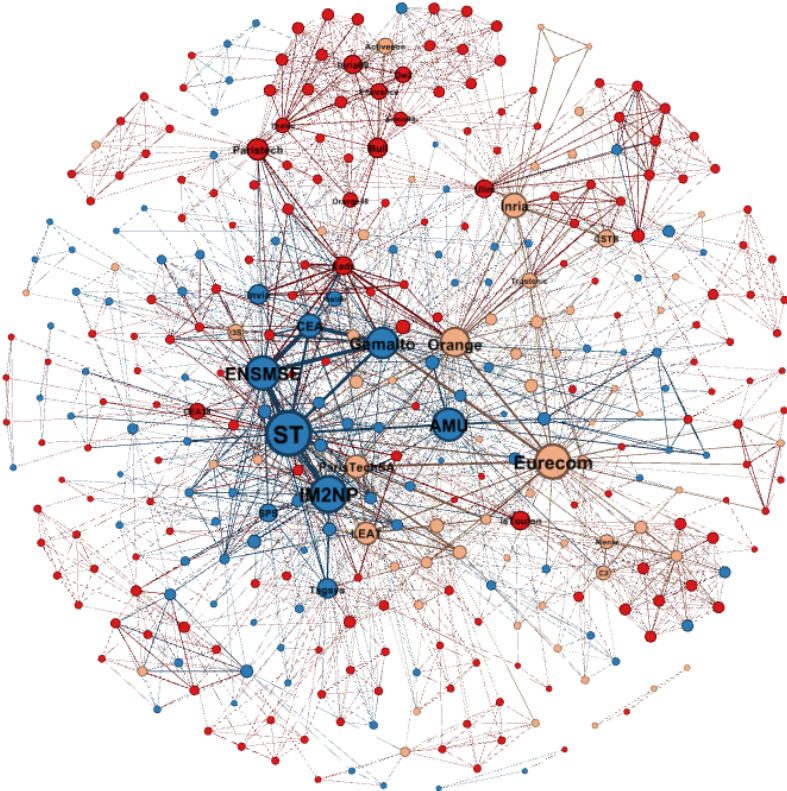
Source. SCS and own calculation

The restriction of the exhaustive database of the R&D projects to the FUI projects provides a proxy of the learning networks feeding knowledge creation in the industrial system. From the creation of the poles, the FUI organizes twice a year calls devoted to supporting R&D collaborative projects dedicated to firms, large and small, and research institutes belonging to at least one pole. The pole SCS has labeled 107 FUI projects, on which 60 have been financed.

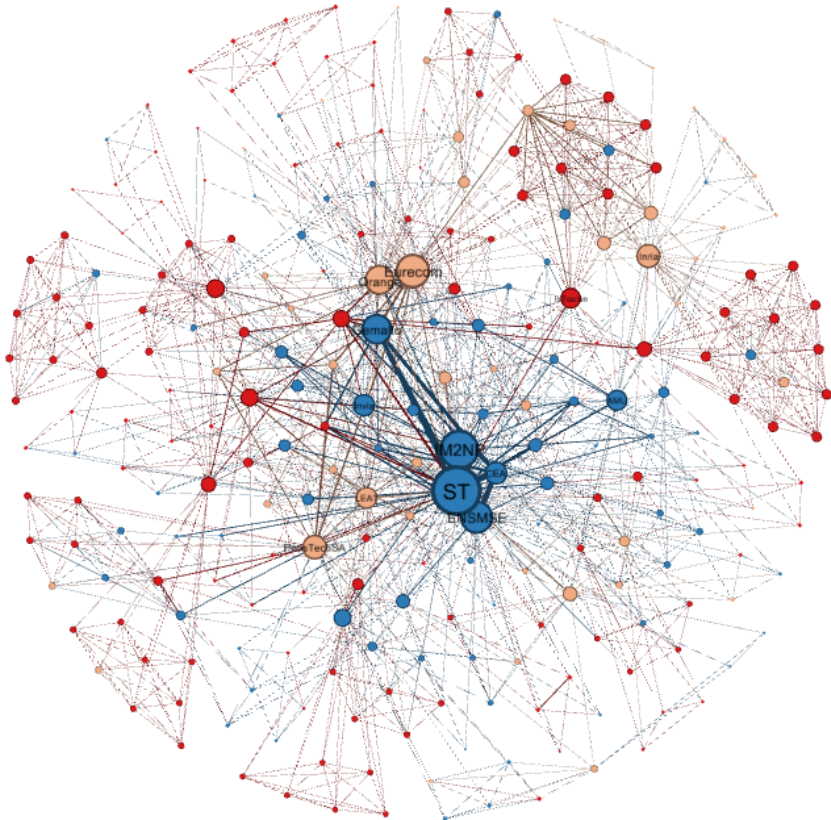
Figure 5 shows the graphs of the labeled and selected FUI learning networks. Regarding our clusters, different main features emerge from inspection of the graphs. The existence of a strong and balanced core in [13], gathering heterogeneous actors, firms and research institutes, which appears robust after the selection process. This core is stable across the different graphs, from the labeled SCS projects to the selected FUI projects, revealing an embedded collective learning network. In [06] a similar core does not emerge, a salient feature being the shortage of firms there, to the exception of Orange. Contrarily to [13], the structures of the SCS and FUI graphs are highly unstable there and do not reveal a stable core, rather key actors working as hubs. Some pivotal partners from [06] are close to the partners of [13] which make up the core of the whole network. But another important actor of [06], INRIA, is disconnected from the core and inserted in a dense set of external relationships. The table 1 shows the pivotal role of [13] in the core of the learning network. ST microelectronics stands as the highest betweenness partner, followed by Eurecom and Orange. These members are brokers connecting disconnected elements of knowledge, and drawing bridge across the clusters.

Figure 4. The FUI collective learning networks: labeled and selected projects

FUI R&D labeled projects



FUI R&D selected projects



Source. SCS and own calculation

5. Proximities

The aim of the pole of competitiveness policy has been to trigger R&D networks to reinforce clusters, and in the case of SCS to create in some sense a new cluster in terms of cognitive and organizational proximities, merging the technologies and knowledge bases of heterogeneous actors from the prevailing clusters, building value chains to address the markets starting from R&D and innovation. The analysis of the SCS pole highlights the forms of the networks that have endogenously emerged. In fact, it appears that several levels have to be tackled to capture the whole induced processes at work:

- within cluster networks, the organizational form emerging between the local partners involved in the collective learning processes;
- in-between clusters networks, the bridges between Rousset-Gémenos and Sophia-Antipolis, to take advantage of weak ties (Granovetter, 1985) and structural holes (Burt, 1992), eventually to trigger the emergence of in-between strong ties and recompose the core;
- distant clusters networks finally, clusters are open, evolving complex systems (Garnsey, Longhi, 2004), local and global linkages of the firms are pivotal to their resilience, their involvement in innovative networks. Just as firms form more and more R&D alliances (Powell *et al.*, 1996, Nooteboom *et al.*, 2005), clusters create mutual external links as different knowledge bases have to be merged. Intra-cluster strong ties, high level of embeddedness, can trigger lock-in effects in declining technological paths and question the resilience of the cluster (Crespo *et al.*, 2013). The existence of weak ties to access remote knowledge can fuel the learning process. 'Knowledge pipelines' (Storper, Venables, 2003, Bathelt *et al.*, 2004) have to be built to renew and reinforce the local buzz, the adaptation of the core to changes. Nevertheless regarding high tech clusters, pipelines have also to allow external partners to reach the local knowledge bases to feed their own learning process with non-redundant distant knowledge. A balanced exchange of inflows and outflows of knowledge has to be maintained to secure the viability and growth of the high tech clusters.

In the SCS pole case, the prevalence of disassortative learning networks linking cores and peripheries as well as the huge involvement of distant partners seems to be a sign of the renewal of the knowledge bases and of the acknowledgement of the local capabilities. These dynamics are seemingly well rooted in the two clusters considered, but despite the existence of brokers like ST, Eurecom or Orange, the ties between them are perhaps limited compared to the potential bridges.

Beyond the centrality measures, the weights of the different edges linking the partners gives an important information on the structure of the cores of the pole and the clusters, the cohesiveness of the related networks. The distribution of the weights is highly skewed, confirming the core – periphery structure of the networks. Indeed 80 % of the edges are of weight 1, and 16 % of weight 2 in the SCS learning network. The table 2 presents the most weighted edges for the SCS network, and then for the FUI related one, the industrial learning network.

Symbolically, the heavier edge of the networks links Eurecom [06] and a distant partner located in the region Ile de France, attesting the involvement of the pole in large innovation networks. Incidentally, Ile de France is very close and deeply inserted in the pole learning networks. This link is associated to ANR projects, as it disappears in the FUI network. The edges related to [06] involve indeed mostly research institutes, with a pivotal role of Eurecom, which stands as some kind of hub. Orange again is the most involved industrial partner.

Table 2. Short heads of the edges weight distribution

SCS network			FUI network		
Partner1	Partner 2	Weight	Partner1	Partner2	Weight
Eurecom [06]	Thales [00]	19	CEA [13]	ENSMSE[13]	10
CEA [13]	ENSMSE [13]	18	CEA [13]	Gemalto [13]	9
IM2NP [13]	ST [13]	17	ENSMSE[13]	Gemalto [13]	9
CEA [13]	Gemalto [13]	16	ENSMSE[13]	ST [13]	9
Eurecom [06]	ParisTechSA[06]	16	IM2NP [13]	ST [13]	8
ENSMSE [13]	ST [13]	16	Gemalto[13]	ST [13]	7
CEA [13]	ST [13]	14	CEA [13]	ST [13]	6
ENSMSE [13]	Gemalto [13]	13	Eurecom[06]	Gemalto [13]	6
Eurecom [06]	Orange [06]	12	AMU [13]	ST [13]	5
3Roam [06]	Eurecom [06]	10	Atmel [13]	ST [13]	5
CEA [13]	IM2NP [13]	10	Eads [00]	Orange [06]	5
Eurecom [06]	Inria [06]	10	Eurecom[06]	Orange [06]	5
Gemalto [13]	ST [13]	10	Eurecom[06]	ParisTechSA[06]	5
CEA38 [00]	IM2NP [13]	9	3Roam [06]	Eurecom[06]	4

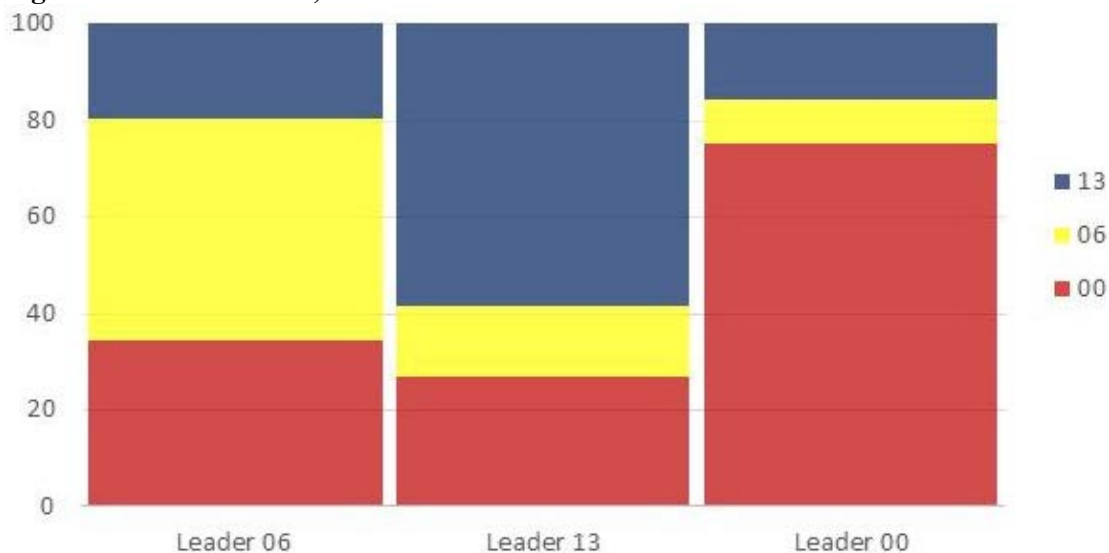
Source. SCS and own calculation

The case of [13] is very different; a core of cohesive partners emerges linking strongly industrial and research partners in a balanced way, with equally heavier edges linking industrial firms together, research institutes together, and firms and research institutes as well. When considering the edges of the FUI learning network, the same core of [13] emerges and gathers the same heterogeneous partners, when [06] links mainly research institutes with

research institutes. The industrial learning network of the pole is clearly located in [13]. With the exception of Thales, the heavier weighted edges link partners of the same clusters, in-between significant edges link Eurecom, Gemalto and ST, the main brokers of the pole. The in-between links fill the periphery of the networks, and could be considered to feed the innovativeness of the core.

Finally the intra, inter, and distant links have been addressed building three different networks, the one made of projects whose leaders belong exclusively to [06], the one made of projects whose leaders belong to [13], and the one led by distant partners. [13] is the larger network, with 342 different partners, against 285 for [06], obviously eventually involved in different projects, with rates of selected partners involved in of 45.5 for [13] against 34.5 % for [06].

Figure 6. Partners: intra, in-between and distant



Source. SCS and own calculation

The percentages of partners from intra, inter, and distant cluster partners in these networks highlight the nature of the proximities. The intra share is 58.5 % when the leaders belongs to [13] and 46 % for [06], the inter shares being 15 and 20. Interestingly, the shares of distant partners are 26.5 and 34 % respectively. For [06] the shares of intra and distant partners are quite important, the one of inter cluster being less significant. The cluster is then very open to its distant environment. The share of intra partnerships prevails in projects led by [13]. Nevertheless the basic feature to notice is the very important involvement of distant clusters

in the pole, the relative shares of distant partners being larger than the in-between relations whatever the leader considered, [06] or [13], but particularly for [13].

When the leader is distant, the partners are also obviously distant; the share of [13] in this network is 16% when the one of [06] is 9 %. Contrary to often preconceived ideas, the share of [13] is important, the specificities of the local knowledge bases of the cluster appears largely acknowledged, as the ones of [06]. The pole has certainly contributed to this increased visibility of the local capabilities. The insertions of [06] and [13] are also very different, 20 and 33 % respectively in FUI projects, 72 and 62 % for ANR, the partners involved being 14 and 17 % respectively for large firms, 18 and 34 for SMEs and 67 and 48 % for institutes of research. One is clearly academic research oriented when the other is more balanced and significantly industry oriented.

Summing up the different features highlighted from the analysis of the collective learning networks, the organizational forms of the clusters appear somewhat different. Paradoxically, to infer from the Markusen taxonomy (1996), one has a core and periphery organizational form, when the other is somewhat more hub and spoke oriented, the edges linking the hubs being lighter.

5. Conclusion.

The pole of competitiveness policy has targeted the development of collaborative network relations in selected clusters, and basically produced detailed information on these R&D networks of heterogeneous actors. This information can be considered as a good proxy of the informal and formal alliances implemented by the firms. The paper has allowed to characterize the organizational forms of the clusters from the emerging structure of the collective learning networks. The results are in line with the seminal work of Markusen (1996) and the works on proximity: different forms of cluster emerge, even in the same pole. Path dependency related to the local and external forms of interactions is very robust, the history of the clusters, the specificities of their emergence can be found in the characteristics of the R&D networks at work. Diversity is a pervasive characteristic of the clusters.

Knowledge, learning, innovation, clusters are considered as keys for competitiveness. The diversity of the learning networks revealed in the paper questions the policy, built on the mode 'one size fits all' (Todtling and Trippl, 2004, Crespo *et al.*, 2015). The industrial groups of Sophia-Antipolis are not deeply involved in the pole. Paradoxically these firms are not standing alone, they are historically open and involved in distant knowledge networks, as the research institutes, but certainly more oriented towards international alliances and not

organized around a strong cohesive core of large heterogeneous actors as in Gémenos – Rousset. The paper has confirmed, if necessary, that clusters and networks have to be analyzed together. The characterization of the collaborative learning networks structures precisely shows the strategies, behavior developed by the firms to build their knowledge bases and innovative processes, and the way these processes govern the working of the clusters. Knowledge spillovers are not “in the air” but very specific of the learning networks and clusters from which they belong. The project of the pole of competitiveness SCS which aims to merge distinct knowledge bases born from distinct collective learning networks embedded in distinct clusters raises difficult obstacles to unlock. The pole has nevertheless supported the financing of many collective learning networks gathering heterogeneous partners, the strengthening of the core and cohesive actors of the clusters and the increase of in-between knowledge relationships.

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