

Boufaden N., Lourimi S. et Torre A., 2009, The clustering of R&D through the institutional mechanisms in the Paris Region, in Belussi F. et Sammarra A. (eds), *Business Networks in Clusters and Industrial Districts. The Governance of the Global Value Chain*, Routledge, 448p.

The institutional design of clusters: The example of two clusters in the Greater Paris Region

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Introduction

The cluster-based approach, first proposed by Porter, has had undeniable success. Initially developed as a tool of entrepreneurial growth, it is now the basis of many industrial and local systems policies and is used as a development tool by the OECD (2005) and the World Bank (2002). The amount of literature devoted to this subject is enormous and has given rise to much debate about good practices, policies of technology transfer, of development of both human and natural local resources (see for example Karlsson, 2005, or Dunning, 2000). Clusters are everywhere.

Whether clusters serve as objects of analytical studies or of public policies, two points are commonly made with regard to this approach (Hakanson, 2005; Giuliani & Bell, 2005).

1. The first concerns the knowledge (or innovation) exchange interactions between actors, whether they are non commercial, informal, knowledge transfer or creation interactions, or, more rarely, commercial exchanges related to intellectual property rights for example;
2. The second is related to clusters'input-output structure. It is acknowledged that exchange relations between local actors, between suppliers and clients for example, can have synergetic and spillover effects at local level, whether on the goods or on the labour markets.

Both approaches, though very interesting, fail to take into account one variable, which we believe, is essential. It is the institutional dimension, which plays an important role in the functioning and organization of clusters. By institutions we mean the *visible* institutions - that is incubators, venture capital, intermediation organizations or regional innovation centres for example – which play an essential role at local level in the processes of development of

clusters. They are at the origin of many undertakings, promote the creation and growth of firms and facilitate communication and exchange within the clusters through their action at network level.

The one and only objective of this article is to shed light on the role played by institutions in the implementation and functioning of clusters. For this purpose, we base our analysis on the observations of two clusters of the Greater Paris Region, one dedicated to biotechnologies, the other to optics-photonics. In the first section of this paper we shall discuss the institutional roots of clusters, by, first examining their relations with institutions and then by presenting the institutions present in the Greater Paris Region. In the second section, we describe firms' strategic approaches and the nature of their interactions with institutions using the example provided by the biotechnology and optics-photonics clusters of the Paris Region.

I. The institutional roots of clusters

A century after Alfred Marshall developed the concept of industrial district, Michael Porter has given new life to the concept of local system with his cluster based approach in which clusters are defined as « *A geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. The geographic scope of a cluster can range from a single city or state to a country or even a group of neighbouring countries* ». The success of this concept and of the local systems of production associated with it is generally attributed to the existence of internal interactions, of knowledge relations and of the building of mutual trust between the members of the clusters. We wish to show here that in certain situations, the institutional dimension also plays a determinant role; for this purpose we shall first perform a critical examination of the interactionist approach and of local innovation systems and will then present the institutions that are present in the above mentioned clusters.

I.1. Clusters and institutions

According to Porter, the significance of clusters lies in the fact that they provide firms with a favourable environment in terms of competition, specialized input and institutional support. These factors reinforce cooperation between the members of the cluster and facilitate the diffusion of knowledge, and in doing so improve strategic positioning processes and enable firms to identify the "best practices"; in short they improve the competitive advantage of the firms located within the cluster. Porter sees a cluster as a self-reinforcing system that stimulates the competitive strategies of the firms in the cluster and hence the competitiveness of its members. This process depends in part on personal relationships and face-to-face communication and networks, and puts the stress on the relation between the social network and firms competitiveness theories (Martin & Sunley, 2003).

The success of these clusters can be explained by going back to the very foundations of the interactionist approach, i.e. the input-output relations between the actors of the local systems, particularly between firms. It is the growth pole approach – proposed by Perroux or Myrdal – that prevails here, with the idea that local systems of production rest on the agglomeration of firms with complementary activities. Buyer-seller relations develop between firms located in the same cluster and create positive synergies in terms of local or territorial

development. Indeed, an increase in the production volume of one of the firms – particularly if it is a large organization – results in increased purchase volumes and therefore in an increase, upstream, in the production volumes of the firms that sell intermediate goods to the former. Gradually, the effect spreads throughout the whole productive structure, among suppliers or sub-contractors, and leads to an increase in the local system's total production volume. We see here that this approach has limitations in that it is only valid when the local production system is constituted of complementary, rather than isolated, industries, which is not the case of all clusters. Further, it is based on the hypothesis that the effects spread mechanically throughout the production structure, which is far from being validated; indeed some local firms might quite possibly prefer to buy all or part of their supplies from suppliers located outside the cluster.

The second explanation, interactionist in nature, is far more widespread. It is related to the idea that clusters are places, which by nature facilitate the diffusion of knowledge between the local productive units. The hypothesis is that knowledge transfer is more effective when it takes place within a geographically restricted area – clusters in this instance – or, in other words, when it occurs between actors that are located in proximity to one another. This geographical proximity is supposed to be advantageous because it is thought to make the transfer of knowledge between the members of a local system easier and faster than it is between partners that are geographically distant from one another. It also facilitates the implementation of cooperation or partnership projects between firms, laboratories or universities located within a cluster.

This approach rests on two founding principles, principles that also explain the existence and the success of clusters:

- the first principle concerns the cooperation or collaboration opportunities provided by the presence, within the same geographical area, of different productive organizations. Thus, geographical proximity is thought to facilitate contacts. Not only does it enable the different actors to meet more easily – without having to spend time and money on long and expensive trips- but it also enables them to interact as often as necessary and thus to develop tighter relations with one another. Thus, geographical proximity reduces transport costs as well as the transaction costs related to distance, by enabling actors to conduct inexpensive face-to-face interactions. But, from a more dynamic point of view, it also facilitates the implementation of common projects through the development of learning relationships: the different actors learn to know and understand one another, to work and collaborate together. Network type relationships based on trust can grow through the development of closer interpersonal relations that sometimes grow into friendships outside work.

- the second principle concerns the characteristics of the knowledge exchanged by the actors; knowledge the transfer of which requires geographical proximity, which clustering provides. This principle can be summed up as follows. Innovation activities are believed to be related to the possibility of producing or acquiring knowledge and in particular scientific knowledge emerging from public or private research. But this knowledge is characterised by its imperfect appropriability, in other words by the fact that it does not easily remain the sole property of its creator: it can be reproduced or imitated. The imperfect appropriability of knowledge results in the existence of many spillover effects generated by innovating firms and benefiting other firms in the same sector, or that link together researchers belonging to different organisations. These effects are known as knowledge spillovers, effects that only occur among firms that are located in proximity to one another because of the particular nature of the knowledge exchanged. According to Polanyi (1962), this knowledge can be divided into two distinct but sometimes-complementary categories: tacit knowledge and

codified knowledge. The latter, which includes all written sources, or those that are easily communicated through manuals or books, can be transferred over long distances, and can therefore be reproduced or copied by people who took no part in the initial process of creation or innovation. But the other type of knowledge, tacit knowledge, is incompatible with distance. It can only be imitated through observation, practice, and learning; it resides within human beings and within their daily behaviour and can only be communicated through face-to-face interaction. The advantages of the co-location of research activities and of innovating firms are clear here. Thus, organizing innovation activities at local level, promoting spatial proximity or the development of clusters appears necessary.

These two interactionist approaches are based on “naturalist” or “mechanical” assumptions, and although they are centred on the relations that exist between the different economic actors, they only attribute a limited role to these actors. In the case of input-output relations, these processes are above all mechanical and rest on the belief that there exists a perfect knowledge transfer between industries, and do not take into account the strategies of the actors, the different production costs, or the respective competencies of the local and external suppliers. As for the approach in terms of local transfer of tacit knowledge, it is based above all on a naturalist hypothesis: it is the very characteristics of knowledge that explain the co-localization of research and innovation actors, and not the latter’s strategies. In comparison, the approach in terms of cooperation or collaboration focuses more on the actors’ strategies. But it is still based on the hypothesis that these actors – whether they are firms or research laboratories – are driven together by their respective interests and are pushed naturally to interact with one another. The example of technology transfer organizations is often mentioned in this context, but little attention is paid to their role and position within local production systems or clusters.

Yet, a large number of institutions and organizations play an essential role in the creation and development of clusters. Need we remind the reader that most technopoles, scientific parks and clusters were created as a result of decisions made by local Public Authorities, the State or by the decentralized departments of the latter; and that many organizations exist for the purpose of helping entrepreneurs start and develop new ventures, of helping the latter develop relations with other organizations or facilitating their interactions with the milieu. Not to mention the fact that, in the field of innovation, knowledge creation and transfer, these activities are performed under the aegis of, or thanks to, organizations such as, centres for knowledge exchange, or agencies for the promotion and support of innovation. Clearly, clusters cannot only be described in terms of inter-firm relations. Indeed, local institutions play an essential role in the functioning and development of clusters at two levels at least: firstly, these institutions, through global and local development policies, determine the structure and organization of the cluster; secondly, they play a crucial role in the creation and development of relations between local firms.

The role of institutions in technological change has been emphasized in many studies about innovation systems (Lundvall, 1992; Nelson, 1993). Indeed, the complexity and uncertainty that characterize technological innovation processes make it necessary to mobilize a variety of actors and competencies, but also an institutional body comprising institutions or organizations capable of supporting innovation, of providing an organizational framework of rules and standards (Coriat et al, 2002). The mission of the institutions is to coordinate interactions between the different organizations and actors of the system, as well as knowledge utilization. They do so by promoting fundamental research, technological transfer

and the creation of firms, or by providing financial or organizational support. But what role do they play at spatial level, particularly in clusters?

I. 2. The institutional structures of the biotech and optics-photonics clusters of the Greater Paris Region

The research studies we have conducted in the biotech (Bellon, Plunket & Boufaden, 2005) and optics-photonics industries (Lourimi & Torre, 2007) of the Greater Paris Region have enabled us to identify, within these two clusters, four main categories of institutions. The latter are grouped according to their main objective that is the provision of financial support, of infrastructures, of access to networks of actors in the economic and the research arenas.

I.2.1. Financial institutions

The main mission of financial support institutions is to promote innovation in firms and laboratories by financing the innovative projects the actors of the cluster wish to undertake. Four categories of financial support institutions have been identified in the Paris Region:

1. The institutions specialized in providing financial support to young innovative businesses, by offering venture capital and start-up funds. Because the needs for financial support of small innovative firms change according to their stage of development, several types of institutions, such as venture-capital companies, traditional banks or the capital market, come into play in a successive or complementary manner. Generally, when entrepreneurs create a new business, part of the initial capital comes from their own savings or from friends and family (“love money”) and another part comes from “traditional” local financial institutions. They sometimes also obtain support from *business angels* when the latter are convinced of the technological potential of the project. This initial capital contribution is used to start the business, gain access to technology (license negotiation), employ consulting experts to help them create and develop a business plan they need to attract financial support from private investors.
2. The institutions that help finance the innovation projects undertaken by firms. This category of financial support includes subsidies and loans granted to firms to help them develop innovation projects [OSEO (a public organization that provides support to SMEs), CRITT (Centre for Innovation and Technology Transfer), and various types of financial support from the public authorities...].
3. The institutions that provide support (in the form of subsidies or loans) for cooperative innovation projects [“poles de compétitivité”, RRIT (Research and Technological Innovation Networks)...].

I.2.2. Institutions that provide facilities and infrastructure

The first mission of these institutions is to support firms (young innovative firms or high tech SMEs) by offering them access to facilities and infrastructures that match their needs. Among them are:

- Incubators (for example, Incuballiance or Genopole). These organizations provide guidance and support to individuals with projects to create innovative firms; their support consists of providing training related assistance, advice, financial aid, and industrial premises within the incubator. Incubators are located within or in close proximity to scientific centres, so as to maintain close relationships with research laboratories (researchers, young doctorate holders); Individuals with this type of projects are for the most part former students or employees of these research laboratories and have access to the scientific and technological resources available in the centre. Incubators also offer financing solutions for the pre-start-up phases of projects, including equity investment, loans, etc. Through these different modes of intervention, incubators help young entrepreneurs and assist them to perform cover the marketing, tax-related and legal administrative tasks expenses and offer coaching or training services adapted to the project's needs.
- Specialized incubators (International Partnership for the Hydrogen Economy at the Ecole Polytechnique of Paris, or Innov'Valley in Marcoussis). These organizations provide premises to high tech SMEs that need access to specialized, broadband network infrastructures etc.
- Traditional incubators, comprising institutions that provide non specialized premises to entrepreneurs that wish to start or develop a business in the Paris region (Business parks).

I. 2.3. Institutions promoting the transfer and application of scientific knowledge

These organizations play a more or less important role in firms' processes of development depending on the maturity of the industry (emerging or mature industry) and on the origin and nature of the technologies involved (technologies developed from the knowledge produced by public research organizations, or from the knowledge accumulated by the industry over decades of activity).

The industrial biotech sector for example, cannot operate coherently without the implementation of tools promoting the transfer and application of the scientific knowledge created through academic research. Since the 1999 law on innovation was adopted, several organizations have been founded to promote the development of research activities. Among them, let us mention the Curie Institution for Medical and Clinical Cancer Research Applications, Pasteur BioTop, the DRITT-SAIC (Industrial Relations and Technology Transfer/Industrial and Contract Activities) of the Paris IV University, etc). A certain number of private organizations of this type have also emerged: the FIST (France Scientific Innovation and Transfer, subsidiary of the CNRS and of OSEO) and Inserm Transfert (a limited company and private subsidiary of the Inserm). Finally, incubators such as Paris Biotech, Pasteur Bio-Top, Agoranov also strive to transform scientific and technological inventions into viable and innovative businesses.

These institutions intervene in different ways depending on the sectors. Thus, in the biotech sector they are a crucial component in the process of creation of new businesses; whereas in the optics-photonics sector they do not always come into play. In this more mature industry, this process of creation does not merely consist in the transformation of the knowledge generated by public research into technologies. The process is often initiated by actors of the industry itself (joint ventures, large groups selling factories, or selling off parts of their operations to other entrepreneurs, creation of new businesses by engineers from universities or engineering schools).

I.2.4. Networking institutions

A cluster is run on the basis of two strategic priorities consisting of developing competencies and reinforcing the network to which the various firms belong. The first priority is related to the organization of training programs, conferences, seminars, symposiums, which help improve and consolidate researchers, technicians and engineers' knowledge in particular fields of application. It can also consist in organizing meetings about specific topics between firms and regional research laboratories. The second priority is to reinforce the interactions between the different actors of the network and to generate synergy effects, by promoting the implementation of cooperative research and innovation projects, facilitating a better and more efficient utilization of the knowledge generated by public research and helping SMEs develop relations with large national or international corporations. Several institutions make it their mission to centralize relevant information - on which innovation is based - so as to help firms gain quicker and cheaper access to the resources and services they need, such as advice or information about partners, platforms or national / international requests for proposals, etc. This category of institutions includes organizations such as the Local Productive Systems that specialise in specific industries (optics, electronics and software in the case of Opticsvalley). It also includes clusters that specialize in one specific field, such as the Evry Genopole, specialized in genomics and bioinformatics.

I. 2.5. And “hybrid” institutions, which operate at various levels...

These four categories of institutions are not alone in performing the functions described above. Other types of institutions, such as « pôles de compétitivité » for example, operate at various levels by helping firms finance their innovation projects on the condition that the latter cooperate with different actors of the cluster (large groups, SMEs, public research laboratories). Thus, this category of institutions plays the double role of financier and network facilitator. In the case of the optics-photonics and biotech sectors of the Paris Region, the « pôles de compétitivité » that play this role are the Medicen Paris Region cluster (in the fields of life sciences and health-care technologies) and SYSTEM@TIC Paris Region (in the fields of complex systems).

A study of the strategic approaches adopted by firms in the optics-photonics and biotech sectors of the Greater Paris Region shows that the various types of institutions (those providing finance, those promoting knowledge transfer, and those reinforcing networking) are used differently by firms depending on the phase in the production cycle and on their positioning on the value chain. This is what we shall analyse in the second section of this paper.

II. Strategic models of firms and interactions with the institutional environment: the case of the biotech and optics-photonics firms in the Paris Region.

Research on the innovation and development strategies implemented by biotech and optics-photonics firms in the Paris region shows that firms often make use of the services provided by the different types of institutions so as to obtain the type of support they need to achieve their goals. Beyond this general observation, the diversity of the possible interventions reveals that the nature of the support provided depends on the characteristics of the industry and on the phase of development the firms have reached. In the case of biotechnologies, the primary role of institutions seems to provide the necessary (financial and

material) conditions for the creation of new firms: The cluster can be likened to a gigantic incubator. On the other hand, the institutional optics-photonics cluster seems to both provide financial support to businesses for (collaborative or individual) innovation projects and to facilitate networking between the different organizations.

II.1. The case of the biotech cluster

The slow development of the French biotechnology industry is often attributed to the “cultural resistance” of researchers, who only recently became aware of the benefits of transforming the knowledge they produce into technologies and business opportunities. Yet, mentalities have changed since the 1999 law on innovation and research was implemented. The law provides a legal framework that promotes and facilitates the creation of innovative technology businesses, particularly by young researchers, students or employees of the public sector. The latter are authorized to participate, as members or directors, and for a certain period of time, in the creation of a new company. At the end of this period they must choose between returning to the public sector or leaving it to stay in the company. For a maximum period of 6 years, they are seconded and therefore retain their civil servant status.

The measures and programs implemented, since the 1999 law was adopted, to promote knowledge and technological transfer have had remarkable results in terms of business creation. In our sample¹, half the firms created since the early 1990s are either spin-off from research laboratories (CNRS, CEA, INRA, Pasteur Institute, INSERM) or firms created, independently, by researchers. The contribution of research to the creation of firms has increased dramatically since 1999, with a peak in 2001. Since then economic growth has slowed down and funding has become scarcer. Furthermore, a succession of governmental measures have been introduced to improve the legal and tax framework under which young innovative firms are created (financial contribution to the creation of new innovative enterprises by the French Research Ministry, public subsidies and start-up funds, the Common Funds for Investment in Innovation, research and development tax credit, etc). These elements underlie the analysis of strategic groups of firms and of the interactions between businesses and institutions within the Paris biotech cluster.

II.1.1. The different strategic groups in the Paris biotech cluster

The biotech cluster comprises four strategic groups of firms with very different modes of development. Four “business models” have been identified, on the basis of the factors that define the nature of a firm’s activities and explain the origin of its turnover, its results and of their evolution (Plunket & Boufaden, 2007). Four strategic dimensions are taken into account: knowledge transfer, financing, collaborations and markets.

A. The “product oriented” strategy group

This model is mostly used by research-based firms under five years of age, and developing technologies that have applications almost exclusively in the health-care sector. They are often spin-off from public research organizations; they pursue a long-term development strategy and do not seek to sell their technologies but rather to develop them further. The activities are based on internal and collaborative research. Less than one fourth

¹ See box 1 in annexe

of these firms have (commercial and productive) partnership agreements with organizations outside the Region, and one firm out of three have products in the clinical or evaluation stage of development. These firms' development potential is real but their strategies are very risky, for two reasons: 1) their activities do not enable them to be financially self-sufficient in the short term since only 8% of them have sold property rights and only 8% have commercialised products. 2) investors are reluctant to finance companies whose strategy is based almost exclusively on the expectation of profitability in the long term.

B. The “dual, product oriented” strategy group

This group comprises firms that engage in the long-term development of products while performing service activities that can generate profit in the short term. Their technologies have applications in the health care sector primarily, but 30% of these firms develop technologies that have applications in bioinformatics. They are all involved in collaborative R&D projects with partners in and outside the Paris region. Their approach to product development is characterised by a high level of R&D activities, and products in the clinical or evaluation stage of development. They commercialise their technologies in various ways, in the form of services provided to other organizations, subcontracting or platform leasing. These firms' medium term approach seems less risky than that of the previously mentioned group because they have developed strategies of service provision and subcontracting based on the research they perform. Thus, they derive sufficient income from their activities to operate. Their challenge consists of finding the right balance between short and medium term exploitation (the production and commercialisation of an existing technology) and long-term exploitation (development of new technologies).

C. The “dual, service oriented” strategy group

Most of the companies in this group are less than five years old and have an above average number of employees. Their activities are based on research and they derive their income from trading or licensing property rights. They all have (commercial and productive) partnership agreements with organizations outside the Paris Region and most of them collaborate with organizations within the Region. These firms enjoy a high level of financial autonomy because their research activities are oriented towards the sale of patent rights and because they get most of their total turnover from royalties. Just like the firms in the above-mentioned group, their situation is stable enough to ensure their medium term development but their long-term future depends on their achieving a healthy balance between the production and the marketing of technologies.

D. The strategic group oriented towards “non health care related products”

This group comprises firms whose technologies are used in the fields of agriculture, bio-informatics, environment and food related biotechnology. They pursue a long-term development strategy centred on the marketing of their products, and thanks to which they enjoy relative financial autonomy. This marketing strategy rests on agreements with a network of commercial and productive partners, outside and in the Paris Region. Their activities are based on internal and collaborative research performed with partners both in and outside the Region. Furthermore, 25% of these firms are spin-offs of large industrial groups that are liable to provide them with financial support. Given the areas in which these firms specialize, their production does not involve long and costly clinical trials; however we

observe some reluctance on the part of venture capitalists, which might be due to the difficulty to identify the potential of value creation of their activities.

This typology implies different development prospects and different needs. Some of these needs are material needs (access to premises, to technology platforms), some are service related (for the elaboration of a business plan, forging relationships with other organizations, for gaining access to knowledge) or financial needs (obtaining financial support, gaining easier access to venture capital). Because biotechnology companies are dependent, for their development, on these resources, they turn (sometimes very reluctantly) to existing institutional organizations for support. However, relations with these institutions often fail to have the expected results. This is due to the fact that their performance also depends on the nature and on the stage of development of the activities conducted by the firms.

II.1.2. Interactions between firms and institutions in the biotech cluster

In order to analyse the interactions between firms and institutions in the biotech cluster, it is necessary to thoroughly examine the kind of relations these firms develop with each category of institutions (as described in section I.2.).

A. The relationships between biotech firms and financial institutions

Biotech companies interact with different types of financial institutions during their lifetime. One of the most remarkable facts is the prevalence of regional financing arrangements such as the allocation of start-up funds or of public subsidies. Besides these funds, *business angels* and *love money* generally serve to finance the creation stages and the launch of the firms' activities. Together, these different actors finance almost 65% of the needs of biotech firms in the Paris Region (Bellon et al, 2005).

3 to 5-year old companies have easier access to venture capital. Half of the financing of these firms comes from the Region, 25% from national institutions and another 25% from international institutions. Biotech firms in the "product oriented" strategy group have these characteristics, which is probably due to the fact that 44% of these firms have products in the clinical stage of development and 24% have products in the evaluation stage. The same applies to firms with a « dual, service oriented » strategy. The financial stability (achieved thanks to the royalties earned through licensing) of these firms and the R&D activities they perform play in their favour and increase their chances of obtaining venture capital. However, things are different for firms with a « dual, product oriented » strategy and for those oriented towards « non health care related products ». Among the former, only 7% have had access to venture capital, because they dedicate a good part of their resources to the provision of services whose profitability is not significant. For different reasons, firms specializing in technologies related to agriculture, bio-informatics, food related biotechnology and the environment are also unattractive for venture capitalists (only 8% of these firms have access to venture capital). Venture capitalists find it difficult to identify the potential value creation of their activities.

Once biotech firms have been in operation for at least 6 years, they obtain venture capital more easily. Approximately 70% of the venture capital comes from financial organisations located outside the Paris Region. Thus, these firms seem to turn towards investors outside Paris for support but they are not necessarily successful in obtaining sufficient funds to ensure their development. Indeed, although the percentage of venture

capital in the overall financing of firms increases, the latter remains insufficient to cover the high costs of product development and of clinical trials, in the case of firms specialised in health care technology.

B. The relations between biotech firms and institutions that provide infrastructure

The support provided by the various types of institutions can also be material. Several organizations provide premises to young researchers/ entrepreneurs to enable them to develop their projects. Furthermore, many young entrepreneurs, particularly those who previously worked in public research laboratories, do not have the managerial skills that are necessary to run a business. They need support and guidance concerning the legal and administrative aspects of the creation of the firm and those related to intellectual property rights. This is the role played by incubators to which the government has decided to allocate 23 millions Euros, through the launch of the “incubation – start-up capital of technological firms” call for project proposals.

Chambers of commerce are the most appreciated partners of firms that are starting up and that need support in terms of management (legal aspects, accounting...). These firms turn to chambers of commerce – rather than to consulting firms - for support in drafting business plans or in performing a market survey. Knowledge transfer institutions, on the other hand, are hardly mentioned, which is all the more surprising as over one third of the firms in our sample are spin offs from knowledge transfer units of research organizations such as Pasteur Bio-Top, INRIA, Inserm Transfert, etc. Apart from providing premises to young researchers, these knowledge transfer centres fail to deliver the very services they were created to provide. Actions that would actually promote the transfer of knowledge are limited and in some cases non-existent.

Initially, a biotech spin off is a very small organization that is heavily dependent on financial support and on assistance in the skills required to perform knowledge transfer in the field of biomedical research, and in particular in human health biotechs. Environmental or food biotech companies are generally spin offs from larger organizations that provide them with the support they need for their development.

C. The relations between biotech firms and “Networking” institutions

Although it is generally acknowledged that the support provided by the various institutions contributes significantly to the success of incubation, creation and start-up stages, their role in helping start-ups forge relationships with other strategic actors and in the diffusion of strategic information is considered less significant by entrepreneurs. For a biotech company, collaboration in R&D and /or production and marketing are essential stages. The complexity of the technological process of innovation requires that firms gain access to a wide range of skills. Collaboration with public research organizations or other firms can give a start-up company access to the complementary skills that are necessary to the success of its projects.

For biotech companies that adopt a product oriented strategy or a “dual, product oriented” strategy, collaboration in R&D is essential. 92% of the firms in the first group (and 100% of those in the second group) have R&D collaboration agreements with partners in the Paris region. Because one third of the firms in this sector are spin offs from public research laboratories, and because in another third at least one of the founders is an academic

researcher, public universities and laboratories are considered to be their natural business partners. Networking institutions play a relatively insignificant role in helping these firms develop R&D partnerships with other firms.

When a firm plans to develop or market a particular product, finding partners and having access to new networks of actors becomes essential to its survival and development. This is the case for firms whose main activities are centred on research and development of new technologies and on the sale of patent rights or on technology transfer agreements. 100% of these firms have agreements with commercial and productive partners located outside the Paris Region. Given the narrowness of the local market, several institutions, such as Evry Génopole or the Chamber of commerce, play the role of intermediaries and organize events to enable firms to meet potential partners. But the survey shows that the contributions of associations such as France Biotechnologie or the Club Alpha, in helping firms finding commercial, financial or research partners are the most valuable.

In the context of technology watch strategies, access to information concerning new scientific opportunities, technological possibilities and market evolutions are crucial questions. Biotech firms seek information concerning the market structure, their competitors, new technological niches, scientific discoveries, new alliances formed by competing firms, mergers and bankruptcies, and they do not rely on the services of any particular institutions to gain access to this type of information. The informal relationships these firms develop with clients, suppliers, consultants or other entrepreneurs – often outside the Paris Region - represent one of their main sources of information.

II. 2. The case of optics-photonics cluster

Most firms with optics-photonics know-how have developed in the framework of the “Great Technological Programmes” implemented by the French governments between the Second World War and the 1970s. These programs were aimed at boosting not only the defence industry, but also the sectors considered strategic by the State (Nuclear, spatial, aeronautic technologies, telecommunications, etc). Their objective was to equip France with key technologies, in order, particularly, to strengthen the country’s independence vis a vis the other superpowers (Mustar & Laredo, 2002).

The creation of the CEA ², which took place in the context of these programs, largely benefited the Greater Paris Region by initiating the emergence, and during the 1950s, the development of the optics-photonics industry in various districts of the Region. Several phases of development of the optics-photonics industry can be distinguished (Decoster, Matteaccioli & Tabaries 2004). The first phase, between 1950 and 1960, saw the development of subcontracting firms created by former employees (qualified workers and supervisors) of the CEA. In the 1970s and 80s, a second phase saw the emergence and development of a new type of SMEs with greater technical know-how and involved in more complex subcontracting relations consisting of rich and intense knowledge exchange. In the 1990s, after years of development, the optics industry of the Paris Region faced an important workforce reduction (of approximately 30%). These elements underlie the analysis of strategic groups of firms and of the interactions between businesses and institutions within the Paris optics-photonics cluster.

² Commissariat à l’Energie Atomique (the French Atomic Energy Commission), formerly called the Center for Nuclear Research.

II.2.1. The strategic categories of firms in the optics-photonics cluster of the Paris Region.

The optics-photonics cluster comprises four strategic categories of firms that differ significantly in terms of how they innovate and position themselves on the market, in terms of their capacity of negotiation with suppliers and clients and of competitive pressure. These differences have an impact on the way in which each group interacts with its environment to meet its specific needs.

A. The “radical technological breakthrough” strategic group

What characterizes “technological breakthrough” start-ups is the fact that their goal is to introduce, on the market, competitive products based on an entirely new technology. The solutions developed on the basis of recent knowledge do not necessarily have a pre-identified market and were not developed in order to respond to a specific need of the market. This is the *techno-push* approach³. Their ability to impose themselves on the market depends, among other things, on the cost/performance ratio of their new technology and on their being able to set new standards on the market. For these reasons, the “breakthrough” start-ups of the Paris Region develop strategic relations with public research laboratories (access to infrastructures, to expertise...) but also with “early users” (operationalisation phase/ processes resulting from new knowledge). Our studies show that the laboratories these start-ups interact with are, for the most part, located in the Paris Region. And even though proximity seems to count in their relations with research laboratories, it does not seem to be central to their interactions with “early users”. These key characteristics determine how “breakthrough” start-ups interact with the local institutions that support innovation.

B. The “high tech SME” strategic group

The “high tech” SMEs are characterised by a high level of internal R&D that enables them to develop and market many innovations on a regular basis. They tend to specialize in one generic technology (infrared, laser technology...) on the basis of which they develop a wide range of products for use in one or two sectors (health care, automobile, aeronautics, environment, defence, telecommunication...). Hindered by constant competition from substitute products (electronics, electro mechanics...), these SMEs have little negotiating power vis-à-vis their clients (generally large firms). As a result of these characteristics “high tech” SMEs mostly develop relations with other firms in the framework of projects of development / adaptation of existing products to the needs of the market, for example, and also, to a lesser extent, with research laboratories so as to gain access to expensive infrastructure and specific skills.

C. The “high technicality SMEs” strategic group

The “high technicality” SMEs are characterised by a high level of technical specialization, and by the production of limited series of products and customized goods for use in precisely defined market niches. The firms in this strategic group have little

³ The source of the new knowledge is the research conducted by large public laboratories, which are at the forefront of their respective technological fields, and have the ability to convert the results of their research into products.

negotiating power with their clients (large firms, large research laboratories) because they supply small quantities of non-strategic goods; but they enjoy strong negotiation power with their suppliers. There is no identified, immediate threat from substitute products, which is due, among other things, to the weakness of the markets, which do not attract the interest of firms that target mass-markets (large firms with many facilities in low cost countries). But they are likely sooner or later to face competition from new substitute technologies with more favourable cost/performance ratios, and which might then endanger the very existence of the firms that have adopted this strategy. Because of these characteristics, these SMEs mostly develop subcontractor relations with large corporation or research laboratories. They seldom interact with these large firms or research laboratories as partners, nor do they participate in the co-development of products.

D. The “large leading firms” strategic group

One of the characteristics of these large “leading” firms is the internationalisation of their R&D and production operations. Their activities have spillover effects on the local economy in that they purchase products from suppliers, develop technologies with SMEs or research laboratories and determine current and future consumer preferences in terms of products and services. Their negotiating power with clients (the State or private market) is balanced and they enjoy strong negotiating power with their suppliers. Finally, the short and medium term threat of competition from substitute products is rather weak. The latter is all the weaker as the large corporations have the financial capacity to buy the firms that develop products and processes based on radically innovative technologies.

II. 2. 2. The different kinds of firm-institution interactions within the optics-photonics cluster

The existence of different strategic groups of firms in the optics-photonics cluster is related to that of different behaviours in terms of interactions with external actors. An examination of the different types of interactions shows that each group of firms develops specific types of relational networks so as to strengthen its innovation and production capacities and therefore be competitive on the market.

A. The relations between optics-photonics firms and financial institutions.

The initial stage in the development of “technological breakthrough” start-ups necessitates close and frequent interactions with financial institutions. The times has not yet come to market, or even develop a product: in the initial stage they must focus on ensuring that the project they are undertaking is viable from a technical, market and industrial property viewpoint. This stage cannot therefore be financed by investors who demand profitability, and necessitates the intervention of public (or para-governmental) institutions that propose pre-start-up funds. Three sources of pre-start-up funds are available in the Paris Region: the public research organizations at the origin of the innovative idea, the French Research Ministry via the program of financial contribution to the creation of new innovative firms, and finally, “local initiative platforms” (Scientipole Initiative). In the second (creation) and third (initial development) stages, the financing question becomes even more crucial; indeed start-ups depend on the financial support of the different institutions in order to be able to launch their activities, develop products and test them on the market. The conventional financial market and venture capitalists are relatively absent during these early stages, but this absence is compensated by start-up funds often provided by the State or by institutional investors

(CDC, OSEO, Region, IdF, CG...). During the fourth and fifth stages of development (take off and growth) the sales of the start-up increase, its products get adopted by the market, and the firm needs financial support in order to be able to pursue its commercial development and to continue innovating on an already existing product. This is when venture capitalists and banks come into play.

High tech SMEs forge close relations with financial institutions, in the context of individual or cooperative innovation projects undertaken with large corporations or public research laboratories. This second category of financial support enables them to gain access to a network of firms (large corporations, particularly) and to share the risks and costs associated with R&D projects. Thus, « Pôles de compétitivité », which have gained momentum in the last few years, have attracted this category of firms. “High technicality” SMEs also seek public funding to help them develop innovations internally, but they have less relations with financial institutions, because their activities are less centred on innovation and their financial situation is more precarious.

Finally, the large firms interact mostly with institutions that provide funds to help finance R&D projects or large-scale industrial development projects. Thus, the large “leading” firms develop close relations with local institutions (« Pôles de compétitivité » in particular), but also national (ANR, AII) and European institutions (through the Research and Development Framework Programme or of European programs outside the EU).

B. The relations between optics-photonics firms and “knowledge transfer” and “infrastructure support” institutions

The relations between “technological breakthrough” start-ups and “infrastructure support” institutions such as incubators are central in the first stages of the creation of a new firm. Once the project has matured and the technological concept is validated, premises must be found, and this is where relations with institutions such as incubators come into play. Thus, the relations between “infrastructure support” institutions and start-ups are vital for the latter, for they involve much more than the mere provision of premises to firms. Indeed, incubators not only offer premises at preferential rates, but they also provide coaching services to new firms. Specialized incubators also help start-ups connect with other institutions that provide support to firms.

“High tech” and “high technicality” SMEs and the large “leading” firms interact less than other types of firms with the institutions that provide infrastructure, because they have no difficulties in finding appropriate premises in the Paris Region.

C. The relations between optics-photonics firms and “networking” institutions

When “technological breakthrough” technologies reach the stage when they can launch a product on the market, their goal is to reinforce their position in the industrial world. Thus, the start-ups that spin off from public research organizations switch from a research oriented to an industrial oriented network. At this stage of development, production and commercialisation of new products firms are confronted with problems related to human resources management, to the growth of their market (increase of production capacity, commercial strategy, recruitment of new production staff) and to its pursuit of R&D activities. At this stage, firms need to position themselves strongly within innovation networks (SPL, CCI, « Pôles de compétitivité ») so as to be able to develop relations with new partners.

High tech SMEs also interact with institutions that help them establish links with thematic networks (SPL, « Pôles de compétitivité ») so as to expand their relations with local organizations, increase market and R&D partnership opportunities, and gain access to information concerning the activities of other local organizations (competitors, clients, suppliers, public research). “High technicality” SMEs use networking institutions differently to the way they are used by the previous two strategic groups. Their primary goal is to increase their market shares rather than to develop technological partnerships. Thus, this group of SMEs uses networking institutions as a way to gain access to new prime contractors.

Large firms also interact with institutions that develop innovation networks, in order to establish links with all the actors in the local clusters (start-ups, SMEs, laboratories). Large firms use these networks as a complementary channel of access to locally produced knowledge. And so, in this case, it is the networks that seek to mobilise large firms, so that they can benefit from the latter’s expertise and innovation and business capacities.

Conclusion

The aim of this article has been to contribute to the debate on the institutional dimensions of clusters, by analysing the various tools that are available to local actors and how they are used by entrepreneurs. The studies conducted on the biotech and optics-photonics clusters of the Greater Paris Region have enabled us to distinguish four main categories of local institutions: Financial institutions, institutions that provide infrastructure, knowledge transfer institutions and finally, networking institutions. Secondly, we have shown that the relations between firms and their institutional environment vary according to the category the firms fall into and according to their level of development in terms of production and innovation. This has enabled us to reveal the similarities and differences between the two clusters (See table below).

The specificities of the relations between the biotech and the optics-photonics clusters and their institutional environment, in the Greater Paris Region

Firm /institution Interactions	Financial Institutions	Infrastructure and knowledge transfer institutions	Networking Institutions
Biotech cluster	Public funds for new firms’ start-up and creation stages Firms struggle to finance the more advanced stages of production and commercialisation. Shortage of venture capital.	Incubators and organisations that promote the transfer of technological and academic knowledge play an essential role in the generation of new biotech firms. The support offered by these institutions is often limited to the provision of premises and of access to internal databases.	Local marketing policies aimed to attract potential partners for local firms. The firms perceive these policies as having little impact. They conduct a permanent information watch so as to establish links with new networks.
Electro-optics Cluster	Start-ups, High tech SMEs and large firms have close and frequent interactions with financial institutions. Goal: Develop projects elaborated internally or	All categories of firms develop relations with institutions that provide infrastructure. But these interactions are only vital for the development of “technological breakthrough”	All categories of firms develop relations with networking institutions: - start-ups seek to strengthen their position in the industrial world, by finding “early users” for example.

	reduce the costs of (individual or collaborative) innovation projects	start-ups; start-ups which are particularly dependent on these institutions' support during the first stages of their development.	- High tech SMEs look for partners to develop their R&D or industrial projects - High technicality SMEs seek access to new markets.
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These results seem to confirm the importance of the role played by local institutions in the creation and the short and long-term development of clusters of high tech firms. However, beyond the institutional framework put in place in order to provide support to high tech firms, there exist significant differences according to the various high tech sectors observed. We note, for example, that an important number of “knowledge transfer” institutions such as incubators are present in the biotech cluster, which tends to indicate that these institutions play an essential role in the creation of new enterprises and in the transfer of academic knowledge. Most firms present in the cluster were created and developed in an incubator, which is hardly surprising in that the biotech sector in France is relatively young. The first generation of biotech firms, which developed and manufactured products of traditional biotechnology, emerged in the 1980s. But the biotech sector only got truly organized in the late 1990s with the emergence of the second generation of firms, which concentrated on molecular biology. As for the optics-photonics industry, it is more mature as it started in the 1960s-70s. This is the reason why organizations such “network facilitators” play an essential role in the organisation of the optics-photonics cluster. Firms that belong to industries that have reached a high level of technological maturity turn to institutions that can help them develop links with new partners, find new clients, and more generally that can help them reinitiate the process of innovation, which is essential to their ability to maintain a competitive advantage in the face of increasing global competition.

Bibliography

- Aharonson, S. B., Baum, J.A.C. & Feldman, M.P., (2004). *Industrial Clustering and the Returns to Inventive Activity: Canadian Biotechnology Firms, 1991-2000*, Danish research Unit of Industrial Dynamics (DRUID) Working Paper, 04-03.
- Bellon B., Plunket A., & Boufaden N. (2005), *Etude sur les Biotechnologies en Ile de France*, http://www.adislab.net/docs/RAPPORT_CDC.pdf .
- Coriat B., Weinstein O., (2002). Organizations, firms and institutions in the generation of innovation, *Research Policy*, vol.31, pp. 273-290
- Decoster E., Matteaccioli A., & Tabariés M., (2004), Les étapes d'une dynamique de territorialisation : le pôle optique en Ile-de-France, *Géographie, Economie, Société*, volume 6 n° 4, pp. 383-413
- Dunning J., (2000), *Regions, Globalization and the Knowledge-Based Economy*, Oxford University Press, Oxford.
- Giuliani E., Bell M., (2005), The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster, *Research Policy*, February, 34, 1, 47-68.
- Hakanson L., (2005), Epistemic communities and cluster dynamics: on the role of knowledge in industrial districts, *Industry & Innovation*, 12, 4, December, 433-463.
- Karlsson et al., (2005), *Industrial Clusters and Inter-Firm Networks*, Edward Elgar, London.
- Lourimi S., Torre A. (2007), Le secteur de l'Optique en Ile de France Sud. Un cluster ? *Territoires du Futur*, Mai, Vol. 6, 57-68.
- Lundvall B-A., (1992). *National Systems of Innovation: Towards a theory of innovation and interactive learning*. London: Pinter.
- Martin R., Sunley P., (2003), Deconstructing clusters: chaotic concept or political panacea? *Journal of Economic Geography*, 3, 1, 5-35.

- Mustar P., Larédo P. (2002), Innovation and Research Policy in France (1980-2000) or the disappearance of the Colbertist State, *Research Policy*, 31 (1), p.55-72.
- Nelson R.R., (1993). *National Systems of Innovation: A comparative Study*. Oxford: Oxford University Press.
- OECD, (2005), *Business clusters, promoting enterprise in central and eastern Europe*, OECD, Paris, 242p.
- OST (2006). *Indicateurs de Sciences et de Technologies*, sous la direction de Ghislaine Filliateau, Economica, Paris.
- Plunket A., Boufaden N., (2007). *Quels « Business Modèles » pour les entreprises de biotechnologie de l'Ile-de-France ?* Working paper ADUS, University Paris South.
- Swann, P., Prevezer, M., (1996). A comparison of the dynamics of industrial clustering in computing and biotechnology, *Research Policy*, 25 (7): 1139-1157
- Traoré, N., (2004). Canadian Biotech firms' creative capacity: on the role of absorptive capacity, relational capital, learning, and firm characteristics, *International Journal of Biotechnology*, 6 (1), 1-19.
- World Bank, (2002), <http://www.worldbank.org/poverty/scapital/whatso.htm>

Annexes

Data and method of analysis of the biotech cluster

The Greater Paris Region is home to the largest number of French biotech firms (approximately 40%). The share of the region in the national scientific and technological production - estimated by the number of European patents applied for or granted in the fields of biotechnologies and pharmaceutical technologies – is 57.1%. These firms are located across the whole of the region but there are a few agglomerations of firms in the region (Paris, Evry Genopole, Saclay). The Paris Region benefits from the presence of a world-renowned fundamental research infrastructure. It is the national leader in the fields of medical research, fundamental biology and applied biology/ecology, in terms of publications. This situation contrasts with that of other European countries such as the United Kingdom or Germany, where the regional distribution is more uniform. ...We find that the Paris Region is more specialized in medical research than in fundamental biology and applied biology/ecology and that it comes third behind the PACA and Rhone Alpes regions in these two scientific fields (OST, 2006).

Biotechnologies are more and more defined as a set of generic technologies that are applied to several domains such as human health care, agriculture, the environment, agri-food and bioinformatics (Swann & Pevezer, 1996; Traore, 2004, Aharonson et al, 2006). For this reason it is difficult to identify biotech firms and evaluate their R&D activities on the sole basis of the nomenclature of French activities (the NAF code). In order to study the characteristics of the biotech firms located in the Paris Region, it is necessary to identify the firms by using the main public directories available. The study is based on a sample of 61 enterprises selected following several data collection stages and after cross-referencing the data from different directories:

- The “Biotechnologies France” directory (managed by the Research Ministry)
- The Genopole directory (Evry industrial cluster)
- The directory of the Association for the Development of biotechnologies and bio-industries
- The “France biotechnologies” directory (professional association of French biotech companies and their partners).

Synthesizing these directories made it possible to establish a list of 458 private law companies located in the Paris Region and participating in biotechnology activities (headquarters, R&D, production, commercialisation, service provision, consulting agencies, and venture capital). These firms we contacted telephonically so as to identify those which perform R&D in the field of biotechnologies and fulfil the following criteria: 1) Perform R&D in the Paris Region; 2) use and / or produce biotechnologies in the R&D process; This exercise reduced the list to 244 companies. Among them, 107 accepted to answer a questionnaire, between June 2004 and June 2005; 61 of the answered questionnaires could be used.

This survey has been conducted in the framework of a research project implemented by the ADIS (Paris XI University) and received the support of the Research institute of the Deposit and Consignment Office CDC. Once the survey was completed, a report presenting the main results and an analysis of the structure of the biotech industry in the Paris Region was written (Bellon, Plunket & Boufaden, 2005).

Data and method of analysis of the electro-optics cluster

The Paris Region is home to over 550 firms with activities in the field of optics-photonics and employing over 16700 people; that is about half of the country’s potential workforce in this field. Within this industrial network, 123 companies employing 6400 people have been identified as conducting activities of production and development of goods and services based on optics-photonics technologies. Most of the companies are concentrated in the South West of the Paris Region and more specifically in the Essonne and the Yvelines *Départements*, which concentrates approximately one quarter of the total workforce of the electro-optics industry of the Paris Region, and over one third of the total public research workforce (BIPE, 2003). The main markets of optics-photonics companies are those of information and communication technologies (optics-photonics components), the spatial and defence industry (infrared imagery, missile guidance systems, laser rangefinders...), health care and life sciences (lasers in the field of biotechnologies, digital radiology...), scientific instrumentation (microscopy and lithography making use of far-ultraviolet radiation...), industrial production (laser prototyping, optical sensors, laser marking...) and other markets (light emitting diodes that have higher luminous efficiency than traditional incandescent bulbs).

The study is based on a sample of 44 economic actors in the optics-photonics cluster of the Paris Region. These actors were identified using the databases developed by Opticsvalley. We conducted interviews with representatives of 21 industrial entrepreneurs (the Greater Paris Region is home to 123 industrial firms

specialized in optics-photonics), 9 public research laboratories, 6 organizations providing support to enterprises (organizations for economic development, local chambers, CRITT...), 5 public departments (Regional council, General Councils, agglomeration communities...) and 3 financial institutions. The questions were related to the organization of the firms' activities, their innovation strategies, to how they network and to the role of geographical proximity. This study has been conducted in the framework of a research project implemented by INRA (UMR SAD-APT) and the ADIS (Paris XI University) and received the support of 6th Framework program of the EEC.