Clusters and inter-firm relations

First results of a study on the optics cluster of the Greater Paris Region

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Introduction:

The cluster-based approach, which has had an undeniable success in the last few years, has been the object of much, often justified, criticism. The latter concerns the vagueness of what some consider as an ill-defined approach as well as the questionable operationality of the latter. Nevertheless, the cluster-based approach has the advantage of bringing to the forefront of the analysis the questions of inter-firm relationships, of their positioning at local level and of the systemic dimension of spatial interactions. In doing so, it shows that the processes of development that occur at local level have three major characteristics, that have not yet been sufficiently explored, but which are rich in potential from both an analytical point of view and from a political and public policy perspective:

- First of all, and as the works in economics of knowledge have underlined, these dynamics are i) largely based on exchanges and knowledge creation, which can lead to innovation processes, ii) and they bring into play various local actors, such as firms, support or intermediation organisations, the public authorities, associations and institutions of all kinds... whose number tends to increase with the sophistication of the modes of production and products manufactured;
- Second of all, the form these relationships take implies that the "local" is in itself a system and that the clusters that are successful are founded on a number of relationships involving different actors who work together in the context of common projects. The notions of networks of actors, of groups of producers, of positive externalities, of collective actions and of local systems of production and innovation serve here to describe the fact that the success of local systems depends above all on the mobilisation of several different actors and on the multiple interactions between the latter, whether these interactions consist of commercial or non commercial, formal or informal exchanges...

Thus, the notion of cluster is interesting, both from an analytical point of view and in terms of public policy implementation. It needs to be explored further even though doubts as to its consistency may be raised. In particular, one may wonder whether there actually exist clusters or local systems that truly rest on the interactions between several different actors. A key question concerns the type of relationships that develop between firms at local level. This is what we discuss here. Our paper is based on an empirical analysis conducted at local level (in the Greater Paris region) and has a double objective:

- Provide a new overview of the notion of cluster and take a critical look at it, basing ourselves on the recent analyses of inter-firm relationships and on the new developments in the geography of innovation;

- Analyse the type of inter-firm and inter-organisation relationships that exists in the Greater Paris region and draw some information as to what form a possible optics cluster may take, on the basis, in particular of a study of knowledge exchange and innovation at local level.

The text is structured as follows: Firstly, we make a critical appraisal on the notion of cluster, starting with a discussion on the main elements of definition of the notion of cluster, before analysing the reasons for its success and discussing on what rests the mechanism of clusterisation. In the second section, we try and highlight the main characteristics of the optics industry in the Greater Paris region. Finally, in our third section, we describe the form that the cluster has taken and discuss the role played by geographical proximity in inter-firm relationships at local level.

I. A critical appraisal on clusters

Since Porter (1990, 2000) brought back into fashion a term previously used by Schumpeter, the success of clusters has not faltered. On the one hand, it has delighted land planners and local development specialists who see it as a powerful tool of intervention, on the other, it has caused many sleepless nights for researchers, who find it difficult to agree on a common definition.

i) Elements of definition

If the term "cluster" is used as a new way of qualifying the local forms of organisation of innovation activities, it is difficult to define its exact content or to clearly distinguish it from concepts that were used before: innovating milieus, technopoles, technological districts... Porter himself, does not help much when he claims that a cluster is a "geographically close group of interconnected companies and associated institutions in a particular field, linked by common technologies and skills". A similar definition would apply to most localised groups of organisations. So much so that Feser (1998) has found that "despite the intense interest in industrial clusters expressed by policies of economic development in Europe and North America, there is little consensus about the precise meaning of an industry cluster, the dynamics underlying cluster growth and development, and the policy initiatives that would help build and strengthen clusters". Yet, their success is undeniable, and seldom has an economic concept generated such passion, particularly in the field of local policies.

Initially the concept of cluster was applied to "success stories" such as Silicon Valley among the most famous. The latter houses, within a geographically limited area, a network of small high-tech firms specialised in electronics and connected by buyer-supplier and trust relationships thanks to which the producers can achieve high performance. Technology creation, innovation and high profit rates characterize this 100 year old system, and attract great attention from the local public authorities and from funding organisations such as venture capitalists and business angels. Nokia's success can illustrate another aspect of clusters that is more centred on the development of subcontracting and technical complementarity relations at local level. The Finish cluster, which developed around the world leader in mobile communication, relies above all on the development and exploitation of competencies in the field of information technologies, competencies which all firms present locally share and which the public authorities have sought to develop through technological policies promoting R&D and the training of human resources. Highly

competitive globally, the cluster relies on a network of proximity relations linking Nokia and its suppliers, many of whom are electronic system houses and smaller firms that have found niches, particularly in the field of telecommunication. These firms have formed a highly efficient network of closely interconnected high tech enterprises.

There has subsequently been a tendency towards an all-out extension of the notion of cluster to include systems that are less centred around high technology and whose level of performance are lower, but remain a tool of local or national economic policy (OECD, 2001 and 2005). Thus, we have come to consider, from the viewpoint of development policies, that developing synergies between local firms always proved beneficial, in particular because knowledge diffusion is essential to the good functioning of any organized system. As a result, all policies promoting the development of networks of enterprises have seemed justified. Indeed, the former are believed to help increase the competitiveness of these enterprises, and the "local network" structure is considered superior to other forms of organisation, particularly to a decentralized type of organisation. Naturally, this stance, though it might be an acceptable selling point for attracting firms or subsidies into a given place, is not admissible from the point of view of scientific analysis. More evidence is needed...

ii) The reasons for a success

But what has made the notion of cluster so successful, both with politicians and academic economists? It is certainly not the clarity or precision of its definition. Indeed, the definition of cluster is fuzzy and characterised by an imprecision of terms that has often been underlined in literature (See for example, Martin and Sunley, 2003 or Taylor, 2005), and that has increased with the various reformulations proposed by different authors. Not only has it been impossible up until now to propose a conceptual framework and analytical content for the concept of cluster, but also - as Porter himself seems to have recognized - the latter appears to vary according to the expectations and visions of the public authorities and decision-makers. Furthermore, far from being precisely and coherently defined, the physical perimeter of clusters varies significantly from one study to the next; indeed in some studies the cluster is strictly limited to the zone of innovative activities, while in other studies the cluster includes the whole local district or even region.

It is therefore reasonable to believe, as Martin and Sunley did (2003), that the success of the concept of cluster lies mostly in the deliberately fuzzy character of the concept and of its variants (see, the attempt made by Dunning, 2000) thanks to which it can be applied to different types of areas and can more easily respond to a large number of questions related to local development or technological constraints. One can also argue that the successive facelifts given to a highly plastic notion have allowed it to adjust to trend changes and therefore to remain a good "seller". Whether intentional or unintentional, this fuzziness certainly represents an asset in winning the favour of politicians looking for striking watchwords that can evolve with time.

As far as researchers are concerned, we propose the hypothesis that their interest in the notion of cluster is mostly due to the fact that the latter refers to four major theoretical movements, which in the literature on innovation processes and policies, underline different advantages in terms of performance, competitiveness of local systems or networks:

- It is related to the notions of *knowledge economy* and of "new economy" and points straight to the question of knowledge diffusion at local level and on the crucial role of interactions between the members of the same network

of individuals. Contrary to what Marshall claimed, knowledge is not in the air but circulates between individuals or groups located within a geographical area, through the relationships they develop. This is particularly true of academic research the impact of which seems mostly local (Acs, 2000);

- It allows for the transposition, at local and inter-firm level, of the concept of *network externalities*, which has brought success to the approaches centred on transport and communication infrastructures. The utility of its use by any member of the network is directly related to the increasing presence of other members, integrating the cluster participants into a common interest community;
- It refers to the notion of the *vertical integration* of firms, which generates supra normal profits. Here, it would be more accurate to talk of quasi integration, which gives firms an advantage in terms of market situation, through the sharing of infrastructures - and consequently the reduction of transaction costs - between the participants to one same production process, particularly thanks to non-commercial relationships (Karlsson, 2005). The importance of commercial relations and of performance criteria, must however not be underestimated as they are central to the current interest in clusters, especially as tools of development;
- Finally, clusters are not presented as highly or completely isolated closed systems, but on the contrary as local structures in which particular attention is given to *external relations*, whether they be relations between the firms of the cluster and external firms or the implementation of policies of national or supranational scope that impact clusters. Thus they appear as actors of globalisation, using their comparative advantages in terms of localisation or externalities of proximity in a competitive process that engages firms and institutions in the conquest of markets.

Moreover, setting up a cluster requires that the local production system offers a number of basic characteristics; characteristics that are essential but not sufficient to ensure its successful implementation. These characteristics include the divisibility of the production process (the production of a product or service involves different firms, and various skills), low transport costs (to ensure the commercialisation of the product), the existence of knowledge spillovers based on the existence of trust relationships (networking), and the ability to adapt quickly to the demands of the market (flexibility of the production process).

iii) Back to the concept

In view of such imprecision, it becomes interesting to base the definition of clusters on simple basic aspects. We shall discuss two aspects that seem inalienable: 1) the relations between the different actors are localized; 2) they are organised. Based on this postulate, we can construct a two-way table (adapted from Feser, 1998), for the purpose of determining and classifying the different forms of clusters and their post Porterian variants.

Table I : Where are clusters today ?

Degree of localization of inter-firm relations		*Degree of organisation of inter-firm relations*	
		High	***Low***
	High	1. Porter type cluster	3. Cluster related to a local resource
	Low	2. Cluster with no true local base	4. Dispersed activities

Box 1 represents the case initially identified by Porter, as it is characterised by both a high degree of localization and a high degree of organisation, or what we could call a combination of geographical and organized proximity (see below). Box 2 represents a cluster characterised by firms maintaining a high degree of organisational relations but also by a low level of interaction between the firms and their local environment; this type of cluster fits in the definition of a cluster analysed at national or regional level. Box 3 combines a low level of inter-firm relations with a high geographical concentration of firms. This situation is characteristic of many production systems, which do not fit into Porter's definition, but which today are the targets of innovation policies seeking to promote the development of synergies at local level. Some poles of competitiveness, as well as "clusters" identified in certain developing countries, appear to be in this situation. Box 4 is obviously of no interest as it presents none of the aspects that are constitutive of the notion of cluster.

The difficulty of analysing clusters is revealed once again. Box 1 only fits in the canonical definition of the term, but there is no denying that an increasing number of clusters of the types 2 and 3 are emerging. From a prospective or economic policy point of view, one must also take into account the fact that the life cycle of clusters will be marked by different stages ranging from inception to maturity, and corresponding to changes in the internal organisation of production and innovation activities. For example, one can consider – as the OECD does – that clusters that are at the developing stage are characterised by the setting up of relations between the different local actors and by the learning of network practices through the production of incremental innovations. The firms can then develop complementary activities and participate to a collective learning process that will lead to the production of highly contextualized innovations. In any case, the normative dimension attached today to the notion of cluster calls for the identification of different categories and of different stages of development and modalities of evolution.

II. Characteristics of the Optics industry in the Greater Paris Region

i) The optics industry in the Paris Region: contrasted territorial evolutions

The difficulties of defining the optics industry: a value chain or a sector

Optics has applications in a large variety of sectors such as the health sector, defence, the automobile industry, aeronautics, telecommunications etc. Furthermore, it is an enabling technology which, combined with electronics and software, makes it possible to manufacture finished products (calculators, endoscopes, cameras, RFID, Optical sensing cameras, telecommunications networks). Thus, it features at various levels in the manufacturing of active electronic components, medical imagery and radiology equipment, scientific and technical instrumentation, optical instruments and photographic equipment.
Thus, optics is by nature a transversal activity, and firms that manufacture optics-based products can be found in several "NAF" (Nomenclature of French Activities) categories (331A, 332B, 333Z, 334A and 334B), which do provide relevant information about the evolution of the optics industry in France but do not provide an exhaustive representation of this industry. Similarly, many of these firms do not exclusively develop optical technologies.

Most of the firms that possess know-how in optics developed in the context of the "great technological programs" implemented by the French public authorities between the Second World War and the 1970s. These programs did not only concern the defence sector, but also the sectors considered as "strategic" by the State (Nuclear power, space and aeronautics, telecommunications, defence, etc). The aim of these programs was to equip France with key technologies, in order in particular to reinforce its independence from other great powers (Mustar, Laredo, 2002).

The creation of the CEA[1], which took place in the context of these programs, largely benefited the Greater Paris Region by initiating the development of the optics industry, particularly following the opening of the Saclay centre in 1952, and in the course of the 1950s in various districts of the Region[2]. Decoster, Matteaccioli and Tabaries (2004) whose research focuses on the South West of the Region, have observed several phases of development of the optics industry. 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 relationships consisting of rich and intense knowledge exchange.

After years of development, the optics industry of the Paris Region experienced, in the 1990s, an important reduction in its workforce. Indeed, as shown in the table below, the workforce of the Paris Region optics industry decreased by 29.9% against only 17.9% at national level. The other regions in which the industry is strongly represented – in the Rhone-Alpes and Provence-Alpes-Cote-d'Azur – underwent much smaller reductions than the Paris Region did.

[1] Commissariat a l'Energie Atomique (the French Atomic Energy Commission), formerly called the Centre for Nuclear Research).
[2] Creation of the Limeil Centre (Val de Marne) in 1954 which became one of the CEA centers in 1960; creation of the Vaujours Centre (in Seine-et-Marne), of the Bruyeres-le-Chatel Centre (Essone) in 1955, of the Orsay hospital's Frederic Joliot Centre (Essone) which was responsible for important developments in modern medical imagery; creation in 1958 of the « Saturn » Proton Synchroton intended for research on elementary particles and which, at the time was the most powerful synchroton in Europe.

Region	Number of jobs in the optics industry (2003)	Region/France Ratio in 2003 (%)	Evolution of the number of employees (1992 – 2003)	Evolution of the number of firms (1992 – 2003)
Greater Paris Region	20 590	20,8 %	- 29,9 %	- 16,8 %
Rhône-Alpes	10 002	10,1 %	- 14,3 %	- 17,3 %
Provence-Alpes-Cote-d'Azur	4081	4,1 %	- 4,7 %	- 13,6 %
France	**98 759**	**-**	**- 17,9 %**	**- 16,8 %**

Source : Unistatis data, 2006

This unfavourable evolution can for a large part be explained by structural factors. First of all, the optics industry in the region has been affected by ever increasing competition not only from "industrialized" countries (Germany, Italy, the United States, the UK, Japan) but now also from the new industrialized countries (South Korea, Taiwan...) and by the more recent expansion of the Chinese market which has turned out to be an important factor of relocation. Second of all, changes in the industrial policies of France have had a strong impact on the fabric of optics SMEs in the Region. Indeed, the 1990s saw an important reduction in expenditures related to research and military development[3] (to which the optics industry in the Paris Region is historically related) and the virtual abandonment of the "great programs". These two changes have resulted in a weakening of the fabric of SMEs that were directly or indirectly related to these programs and played a part in worsening the crisis that hit the optics industry. To these factors can be added the crisis that hit the telecommunication sector and the electronics industry in 2001 and which also resulted in a large number of job losses.

The table below shows that these structural and cyclical evolutions have had different impacts on the different geographical zones and "*départements*" of the Region. Only three *départements* seem to have been little affected by the various structural and cyclical evolutions: the Yvelines *département*, in which the optics workforce increased by 34.9% between 1992 and 2003, the Seine-et-Marne in which the optics workforce only decreased by 2.7% and the Essone with a limited decrease in the optics workforce (11.3%).

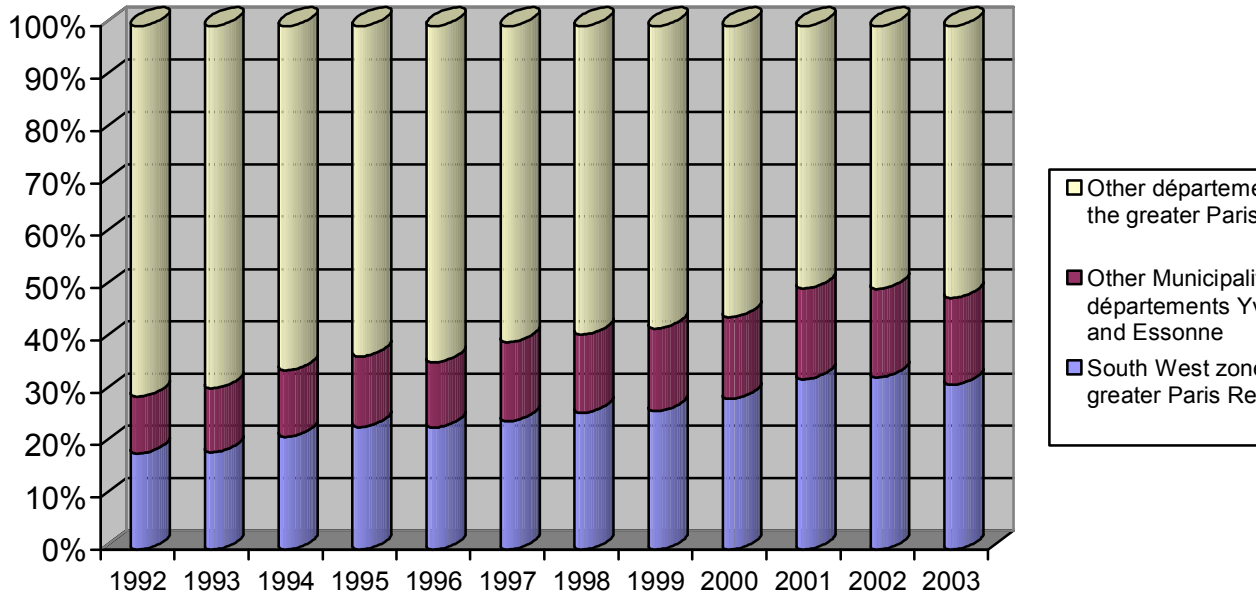
Region	Number of jobs in the Optics industry (2003)	*département* /region ratio in 2003 (%)	Evolution of the number of employees (1992 – 2003)
Paris	880	4,2 %	- 57,4 %
Seine-et-Marne	2278	11 %	- 2,7 %
Yvelines	6653	32,3 %	+ 34,9 %
Essonne	3250	15,8 %	- 11,3 %
Hauts-de-Seine	2651	12,8 %	- 63,3 %
Seine-St-Denis	876	4,2 %	- 50 %
Val-de-Marne	2411	11,7 %	- 39,4 %
Val d'Oise	1591	7,7 %	- 53,2 %
TOTAL	**20 590**	**100 %**	**- 29,9 %**

Source : Unistatis data, 2006

[3] Public spending in defense R&D has decreased from 4.5 billion Euros in 1990 to 2.5 billion Euros in 2001 (Observatory of sciences and technologies, 2004).

Thus, the *départements* situated in the south west of the region have experienced limited job losses and in the Yvelines the optics workforce has increased by 111% in the large firms of over 500 employees[4], which implies that this increase has taken place either because large groups have opened new branches in the *département* or that large groups already located there have increased their workforce. In parallel to this there has been a slight reduction of the workforce in firms employing less than 50 people, in the Essonne (- 9.6%) and in the Yvelines (-2.8%). Together these two *departements* represented, in 2003, 48% of the total optics workforce in the Paris region, against only 29% in 1992. The South West zone of the Paris region[5] represented, in 2003, approximately 31.5% of the optics workforce against only 18.6% in 1992.

Share of the south west of Ile-de-France in the regional optics industry (% of employees)



Source : Unistatis, 2006

ii) The determinants of the evolution of optics firms

While all products marketed by optics firms are based on the same scientific knowledge (the science of photons), the variables that influence the development of firms vary widely. Our research has enabled us to identify four main determinants of the evolution of optics firms in the Greater Paris Region.

The technological speciality: Though based on the same scientific knowledge, the various optical technologies (Laser, fibre optic cable, optoelectronics, photonics, passive optical components, sensors, electronic displays…) have their own characteristics of evolution: growth rate of the market, degree of maturity, technological limitations... Furthermore, optics-

[4] According to Unistatis data

[5] The South West zone of the Greater Paris region comprises 50 municipalities situated between Massy and Saint-Quentin-en-Yvelines (See the list of municipalities in the annex)

based products are liable to face competition from other products that can fulfil the same functions, with a more favourable cost/performance ratio. In the case of long-range transmission lines for example, electronic technologies are favoured over optical technologies to regenerate the signal and ensure efficient information exchange (telephone exchange in particular). Another example is that of the optical technology of atomic vapour laser isotopic separation, a method of uranium enrichment that has not yet reached a sufficiently interesting cost/performance ratio to replace the electro mechanic method.

The products' application sectors: Firms in the optics industry generally develop products that are destined to specific application markets (transport, aeronautics, health care, defence, telecommunications, etc) that also have their own different characteristics of evolution in terms of growth, competitive pressure and technological maturity among other things. Thus, firms that develop the same optical technology (for example the infrared technology) might follow different technological and commercial trajectories depending on the applications they specialise in.

Market positioning: The firm might be positioned in a market niche, with very specific products and know-how, or it might operate in a market segment characterised by more standardised, mass produced goods requiring a combination of specific know-how and more general knowledge. Firms that operate in market niches are generally SMEs or very small enterprises employing less than 20 people and operating in a context of limited competition, or even of "coopetition" between the actors involved, whereas those that focus on larger market segments and specialise in standardised and mass produced goods operate in a much more competitive environment.

The industrial strategy: We have identified two main industrial strategies corresponding to two types of firms. Firstly, there are firms, which we shall call technology "integrators", whose main actions consist in maintaining their capacity to absorb external knowledge and in operating a permanent technological watch so as to keep abreast with competitors. These firms generally belong to the "medium technology" segment of the optics industry. Secondly, there are firms that are "producers of technologies", firms that conduct R&D internally and develop innovative products. These firms belong to the "medium-high" or "high tech" segment of the optics industry.

Beside these four determinants of evolution of optics firms in the Paris Region, our empirical research also reveals the importance of the role of institutions in the development of the local system of production and innovation in the optics industry. Indeed, the local firms establish and maintain important relationships with the "institutional milieu of the Paris Region", a milieu constituted of public and para-governmental organisations in charge of development and promotion and of knowledge and innovation transfer (public research institutions, incubators, economic development organisations, technical centres, innovation agencies…).

This group of technology transfer operators has always played a preponderant role in the emergence and development of the optics industry, particularly via waves of spin-offs that have stimulated the endogenous development of the region, and through important client-supplier relationships between SMEs and large public research laboratories, which have always represented an important part of the local demand for optical technologies. The end of the 1990s saw the emergence of a new type of institutions whose explicit purpose has been to promote the development of the optics "cluster" of the Paris Region (The Opticsvalley association created in 1999, whose mission as a "facilitator" of clusters was extended to

include the electronics and software engineering industries in 2005). More recently, in 2005, the implementation of the competitiveness poles policy (with, for example, the creation of the SYSTEM@TIC PARIS-REGION pole of competitiveness comprising firms that develop optical, electronic and software technologies) is by nature liable to reinforce the role of institutions in the development of the optics industry of the Paris Region and to promote their potential role in structuring production and innovation activities.

Section III. The optics « cluster » of the Greater Paris Region: The results of the IKINET survey

We have conducted field surveys of entrepreneurs in small and large firms, of directors of research laboratories, and of actors of the institutional milieu of the Greater Paris Region[6]. They have provided information on the modes of innovation of optics firms and on their interactions with one another and with their productive and institutional environment.

i) The modes of innovation of optics firms

Optics firms in the Paris Region generally operate in a highly competitive global environment, in which innovation is crucial for the short-term survival (3-5 years) of the firms. The innovation processes they must engage in take different forms depending on the firm's industrial and market strategy. Our empirical study has enabled us to identify three main modes of innovation.

Constant incremental innovation (Market pull):
The goal of this mode of innovation is to ensure that the technologies produced by the firm are high enough for the latter to survive in a highly competitive environment. In this case, the firm does not seek to be more technologically advanced than its competitors; rather it introduces incremental innovations, depending on the new technological knowledge and techniques available, so as to stay abreast with its competitors. The source of these constant changes is twofold: First of all, the firm maintains a technological watch that consists in keeping an eye on the evolution of its competitors' products. Its does so via the Internet, but also during trade shows and conferences, which are attended by the different members of the industry and which as a result are precious sources of evaluation on the technological level reached by competitors and on the improvements to be made to the firm's own products. The second source of constant incremental change is market watch, which consists in observing and identifying changes in clients' needs; this can also be achieved by meeting other actors of the industry during events such as colloquia, trade shows or conferences.

In both cases, the firm must imperatively maintain its capacity to absorb the new knowledge and technologies generated outside the firm so that it can be used to improve its own products. The firm maintains its absorption capacity in two different ways. It can be done through the recruitment of new employees, when certain skills are needed but not available internally, but also by training those among the staff who are capable of "converting" the new knowledge (generally generic knowledge) into product improvements (specific). The second way of maintaining the firm's absorption capacity is to acquire the necessary equipment for the firm to be able to maintain a sufficient level of internal knowledge. This mode of innovation is common in firms that operate on "stabilized" markets, that is on markets that have reached a

[6] We visited 17 firms, 9 research laboratories, representatives of 5 local governments, 3 financial institutions, 6 institutions of economic development.

high degree of maturity. Thus, it is mostly used by medium tech small and medium enterprises of the optics cluster of the Paris Region. Medium tech firms are characterised by the fact that they sell products that have reached technological maturity and whose technical specifications are well known.

Demand pulled incremental innovation (Market pull)
This type of innovation derives from specific requests from clients to the firm to adapt a product to their needs and applications. This does not always necessitate a complete redesign of the product, and can consist in minor modifications so that the product is adapted to market demand. Demand pulled innovation can also result in a more intense client-supplier relationship the purpose of which can be to co-develop a new product on the basis of those that are already available.

This type of innovation is driven by the emergence of new needs in the final markets. In this case the clients ask their suppliers to improve and upgrade their products. This type of innovation necessitates more intense trust-based interactions and relationships between the parties involved than is the case when a firm merely needs to stay abreast with its competitors. Our empirical study has enabled us to identify two key factors that determine the success of the innovation: a) the responsiveness of the supplier. Indeed in a highly competitive environment, the supplier must be able to respond quickly to the needs of the demand side. b) the quality and intensity of the interactions. By establishing and maintaining intense interactions the supplier and client reduce the risk of misunderstanding and accelerate the innovation process. This type of innovation concerns high tech small and medium enterprises in particular. The latter are characterised by the fact that they sell products whose design and production necessitate the presence, within the firm, of a highly skilled workforce and the implementation of processes involving state of the art technologies.

Radical innovation (techno-push)
Radical innovation is the introduction on the market of competitive products with entirely new technological characteristics. The solutions developed on the basis of recent knowledge do not necessarily have an identified market and were not developed in order to respond to a specific need of the market. This is the techno-push approach. The source of the change is the research conducted by the powerful, public and private, laboratories of the region. Some belong to public research institutions while others belong to the R&D departments of large firms, and all are at the forefront of their respective technological fields. The R&D conducted by these laboratories leads to the development of new products, via knowledge transfers to the industry or via spin-off operations.

Introducing new knowledge based products into the market requires a high level of interactions between the supplier - generally a start-up – and the lead user of the product. The intensity of the relationship and the level of trust between the partners are factors that determine the success of the venture; indeed, a close business relationship between the partners enables the latter to adapt the product to market demand, before it is put on the market. Firms that engage in this type of innovation are for the most part start-ups created by former employees of public research laboratories or of large firms' R&D centres. These start ups have in common the fact that the products they wish to put on the market are entirely new and not yet fully operational. Thus, unlike high tech SMEs, which produce operational goods for identified markets, a start up has a low capacity to generate sufficient income in the short term.

An analysis of these three modes of innovation reveals several important points:

- First of all, it is the client-supplier relationship that influences firms' innovation processes the most. Indeed, constant high quality interactions between firms and their final markets are necessary to enable the partners to efficiently perfect or improve existing products. The ability of the supply side to respond quickly and efficiently to the needs of the demand side is also a key to success because not only is there a high level of competition between firms that develop optics-based technologies, but there is also competition from other alternative technologies that can solve the same technical problems and fulfil the same functions as optical technologies;
- Our second finding is that most of the innovations observed in the optics industry of the Paris Region are of the "market pull" type and are based to a large extent on new combinations of existing technologies, hence the importance of technological watch;
- Finally, many of the optics firms in the Paris Region are very small, which reduces their capacity to recruit qualified people, to find funding for their R&D processes and therefore to produce new technologies independently. This prevalence of small firms is not only observed in the optics industry but also in the other sectors of the French economy. The main obstacles to the growth of small enterprises are the lack of sufficiently qualified human resources (engineers and executive managers), regulation or administration related constraints and an unfavourable financial environment (the lack of venture capital for example) (Dumas, 2006).

ii) Local firms and local interactions in the process of innovation

Our study of the optics industry in the Paris Region has enabled us to highlight the existence of a number of firms, organisations of intermediation and innovation promotion and institutions of various natures. This set of organisations, which can summarily be called "The Paris Region optics cluster", has three main characteristics:

- First of all, the local interactions occur for the most part horizontally between the large enterprises, and vertically between large firms and SMEs.
- Secondly, the relationships between the local SMEs are more limited.
- Thirdly, the cluster is quite open to the outside and operates in a highly competitive global environment.

Local interactions of varying intensity depending on the characteristics of the enterprises

Our study has enabled us to identify, at local level, several types of relationships between the firms of the Paris Region, particularly where questions of innovation and knowledge transfer are concerned. A large number of large groups that develop or use optical technologies are concentrated in the Greater Paris Region. Logically, we observe a high level of interaction between these large firms, and in particular the existence of many joint developments of optics based products. But we have also observed a high level of interaction between large firms – both manufacturers and users of optical technologies – and SMEs. Though they take different forms - ranging from simple supplier-client interaction to joint developments of new products - these relationships are, however, mostly vertical, especially the relationships between large groups and SMEs. The nature and intensity of the relationship between large groups and SMEs depends to a large extent on the technological level of the product sold by the small firm. The more advanced the technology involved, the more intense the exchange of knowledge.

Based on these findings, we propose to divide SMEs into three sub-groups:

- The *start-ups*, which have strong local connections, particularly with the "institutional milieu", seek to form joint development partnerships with large local groups, which represent a large and diversified market in the Greater Paris Region. As *start-ups* generally have a « techno push » approach to innovation and develop new products that are based on new scientific and technological knowledge, their first commercial relationship is crucial. Indeed it enables them, via knowledge and experience intensive exchanges, to operationalize their products before introducing them onto the market. These exchanges, which necessitate the definition of common codes and the implementation of detailed agreements – including where technical issues are concerned – require a high level of face to face interaction.
- The *high tech SMEs* often have strong co-development relationships with the large local groups, just as the relationships between start-ups and large firms. Let us note that because of the very nature of *high tech SME*s' activities – which are rich in knowledge creation, diffusion and absorption – these firms have a higher propensity to interact with the research milieu of the region than *medium tech SMEs* do.
- The *Medium tech SMEs*, most of which are sub-contractors or suppliers of large groups, have essentially commercial relationships with the other local firms. However, their markets are for the most part located outside the Paris Region and the few innovation and knowledge-related interactions they have occur with firms located outside the region. For these medium tech SMEs the "territory" variable has little significance.

Firms and modes of innovation in the optics industry of the Paris Region				
Mode of innovation	**Objective**	**Source of innovation**	**Characteristics of the mode of innovation**	**Main type of firms concerned**
Constant incremental innovation (Market pull)	Maintain the firm's product at the same level as those of competitors	Technological watch and market watch	Concerns products that have reached technological maturity. Necessitates that the firm maintains its capacity of absorption	Medium tech SMEs
Demand pulled incremental innovation (Market pull)	Adapt an existing product to a specific demand from a client	Understanding of the need of the client who requests this alteration.	High level of Interaction with exchanges of information and knowledge between the client and the supplier.	High tech SMEs
Radical innovation (Techno-push)	Introduce on the market a new knowledge-based product.	New knowledge produced by (public or private) research laboratories	Essential interactions with the lead users of the products	Start-ups

Limited interactions between SMEs

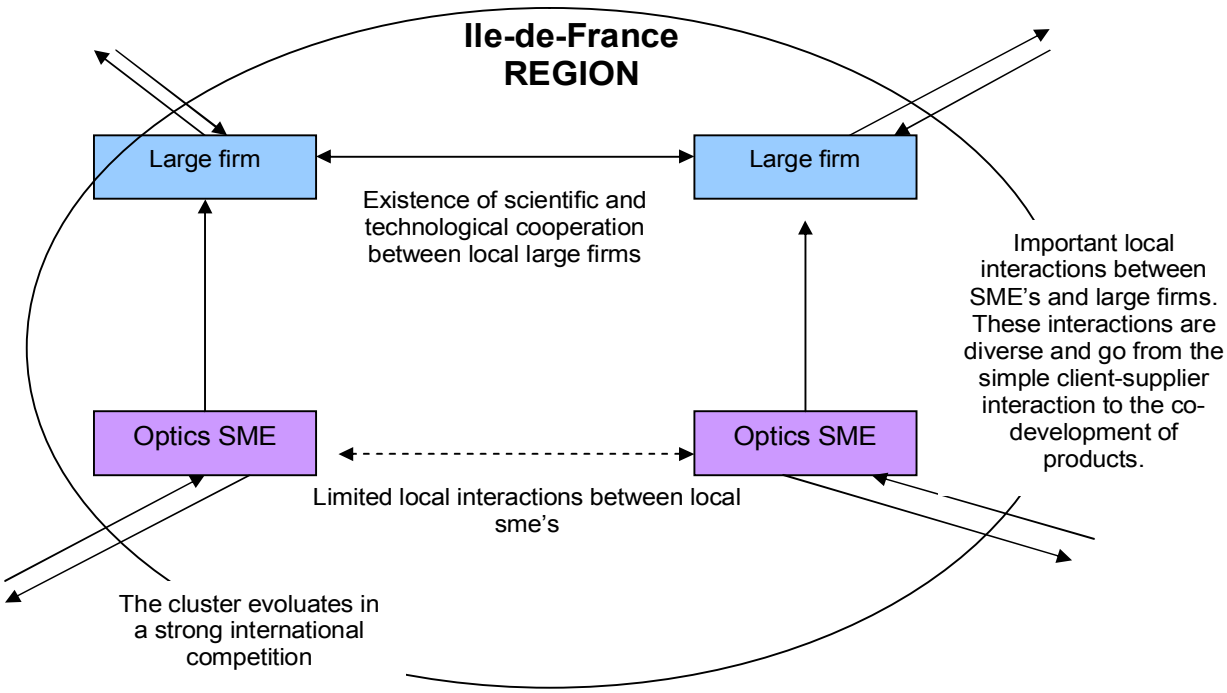
Our empirical study has enabled us to reveal a sharp contrast between the high level of interaction that exists between SMEs and large groups in the Paris Region and the comparatively low level of interaction that exists between the different SMEs. There are two reasons for this. First of all as explained previously, the optics industry is characterised by diversity, and the different actors concerned, who often share the same optics knowledge base, belong, however, to worlds that are governed by different approaches and goals, depending, in particular, on their technological speciality and the sectors of application of

their products. Although they live and work in the same geographical area, they do not belong to the same networks and operate in parallel professional areas. Secondly, the low level of cooperation between the different SMEs can also be explained by the generalized culture of secrecy and by the fear of loosing markets to competitors. The few cases of "hierarchical relationships" (sub-contracting) between local SMEs that we have surveyed are not considered vital and are therefore low in intensity and in knowledge exchange. Thus, geographical proximity plays, at present, a marginal role in this type of relationships. It is not sufficient to generate inter-firm relationships. Let us underline that certain economic development organisations exist precisely for the purpose of stimulating and promoting potential interactions between local firms.

A high degree of openness to the outside world

The optics cluster of the Greater Paris Region is characterised by a high degree of openness to the outside. The categories of firms described above all have intense relationships with various actors internationally. The competition and the markets of optics-based products are globalised and there is a high level of direct competition between, particularly, European, American and Asian firms. This openness of the cluster to the outside increased sharply during the 1990s, when SMEs of the optics industry started diversifying their markets in order to survive the reduction of the national budget for military research and the interruption of funding they had previously been allocated through the "great technological programs". Since the 2001 crisis in the telecommunications markets, there has also been a marked reinforcement of the market diversification strategy.

The Ile-de-France Optics cluster : a hierarchical cluster



iii) The role of geographical proximity in inter-firm relationships

We have been able, through our interviews with certain actors of the optics industry, to identify several types of situations in which geographical proximity plays a role in inter-firm relationships. Among those concerned are *start ups* and *high tech SMEs*.

In the case of *start ups*, geographical proximity proves essential in the firms' relationships with their first clients. The relationship between the SME and the lead user is characterised by intensive knowledge and information exchange. These interactions are needed for the partners to operationalize the product they are developing. They do not always necessitate that the client and supplier be located in proximity of each other, even though geographical proximity allows for repeated interactions between the partners and facilitates knowledge and information exchange between the two, which in turn makes it possible to solve problems more promptly. From this point of view, the Greater Paris Region, in which the largest international groups of the main sectors of the global economy are located, is a place of intense regional interactions and knowledge exchange. Thus the presence of geographical proximity is highly significant. Paradoxically however, the reason for this is not so much that the local entrepreneurs wish to develop relationships with other local firms, but rather that the large groups are located in this region.

High tech SMEs also have important needs for face to face interaction with other firms, particularly when they are in a co-development relationship. In this case, geographical proximity enables the teams of both organisations to meet more often, to communicate more quickly and efficiently with regards to the technical aspects of their projects, to better understand each other's needs and expectations and therefore to co-develop the new products in the most efficient way possible.

The more widespread and mature the technology involved in the product, and the smaller the need for geographical proximity between the firms involved in its production. Medium tech SMEs, in particular, fit in with this description. They have regular interactions with other organisations of the Greater Paris Region but these interactions are low in intensity and therefore involve very few exchanges of knowledge and information.

The role of geographical proximity in the activity of the firm		
Action of the firm	**Role of geographical proximity**	**Main firms concerned**
Introduction on the market of an entirely innovative product (Techno-push)	High level of face to face interaction, which is vital for the success of client-supplier relationship. Necessity of geographical proximity (during the operationalisation phase)	Start-ups, high tech SMEs , large groups
Adaptation of an existing product to the specific need of a client (Market pull)	Face to face interactions are necessary but not as important as in the case of an entirely new product. Need for temporary geographical proximity	High-tech SMEs
Sells standard products that have standardised technical characteristics. (Market pull)	Small (or even non existent) role of geographical proximity	Medium tech SMEs

Conclusion

The aim of this article was to contribute to the debate concerning the notion of cluster, basing ourselves on two convergent approaches:

- provide a new overview of the concept of cluster and on its different analytical and practical dimensions;
- analyse the form taken by inter-firm relationships in the optics industry of the Greater Paris Region, by trying to identify the types of firms that are involved in this process, as well as the form (local or not) and content (particularly in terms of knowledge) of their exchanges.

Our study has led us to re-examine the notion of cluster, and to highlight the main characteristics of the relationships that the optics firms of the Paris Region have with one another. In particular, we have shown that these firms follow three different approaches to innovation (two *market pull* and one *techno-push* approaches). We have also shown that their relationships to space differ according to the characteristics of the firms. Indeed, the characteristics of the firms have an influence on both the intensity of the local interactions and on the spatial dimensions of the inter-firm relationships. However the interactions between the different SMEs of the region are limited and the cluster is highly open to the outside world.

Another conclusion that can be drawn from this study is that inter-firm relationships do not suffice to describe a cluster. Indeed, the results of this study clearly show that the local institutions play a major role in the functioning and development of the cluster, and that this role is at least twofold. These institutions determine the form taken by the cluster, particularly through policies of local and global development; they are essential in the development of relationships between local firms, the development of which is often supported and even promoted by these groups of local operators. Further investigations are needed in this regard.

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Municipalities included in the South West part of the Greater Paris Region

78073	BOIS-D'ARCY	91044	BALLAINVILLIERS
78117	BUC	91064	BIEVRES
78143	CHATEAUFORT	91122	BURES-SUR-YVETTE
78158	LE CHESNAY	91136	CHAMPLAN
78168	COIGNIERES	91161	CHILLY-MAZARIN
78208	ELANCOURT	91216	EPINAY-SUR-ORGE
78242	FONTENAY-LE-FLEURY	91272	GIF-SUR-YVETTE
78297	GUYANCOURT	91275	GOMETZ-LE-CHATEL
78322	JOUY-EN-JOSAS	91312	IGNY
78343	LES LOGES-EN-JOSAS	91345	LONGJUMEAU
78356	MAGNY-LES-HAMEAUX	91363	MARCOUSSIS
78383	MAUREPAS	91377	MASSY
78423	MONTIGNY-LE-BRETONNEUX	91432	MORANGIS
78490	PLAISIR	91458	NOZAY
78524	ROCQUENCOURT	91471	ORSAY
78545	SAINT-CYR-L'ECOLE	91477	PALAISEAU
78620	TOUSSUS-LE-NOBLE	91534	SACLAY
78621	TRAPPES	91538	SAINT-AUBIN
78640	VELIZY-VILLACOUBLAY	91587	SAULX-LES-CHARTREUX
78644	LA VERRIERE	91635	VAUHALLAN
78646	VERSAILLES	91645	VERRIERES LE BUISSON
78686	VIROFLAY	91661	VILLEBON-SUR-YVETTE
78688	VOISINS-LE-BRETONNEUX	91665	LA VILLE-DU-BOIS
		91666	VILLEJUST
		91679	VILLIERS-LE-BACLE
		91689	WISSOUS
		91692	LES ULIS