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Spillovers diffusion inside networks of cooperation: the role of temporary geographical and organisational proximities

EMILIE-PAULINE GALLIE

MATISSE,
UNIVERSITE PARIS 1 SORBONNE,
106-112 Bd de l'Hopital,
75647 Paris Cedex 13,
France

epgallie@univ-paris1.fr

Tél : 01.44.07.81.59
Fax : 01.44.07.81.55

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Abstract:
The objective of this article is to examine the diffusion of spillovers within technological cooperation. More precisely, we shall ask to what extent permanent geographic proximity, defined, as co-location by the geography of innovation, is really necessary to benefit from spillovers when agents cooperate. It turns out that co-localisation is not a sufficient condition; geographic proximity is often required but it can be temporary. This condition must be linked with organisational proximity to be effective. Then, it appears that spillovers are not "in the air(s)" but in networks.

Keywords: Spillovers, Technological cooperation, Geographic proximity, Organisational proximity, A-spatial network

JEL – codes : L2, O1, R1

1. INTRODUCTION

Knowledge is, today, considered as the main source of economic growth (OECD, 2001). As scientific and technologic knowledge is widely cumulative and progressive (Foray, 2000), the interest for this good increases as soon as its role is analysed in the innovation process. Knowledge creation is then a function of the anterior knowledge stock. It is guided by past discoveries, inventions and errors.
Creation mainly resulting from new combination of existing knowledge, firms must try to benefit from diversified knowledge sources in order to innovate. Knowledge spillovers are one of these sources. They can be defined as knowledge benefit acquired by a firm or a person who is not responsible for the initial investment (Almeida et Kogut, 1999)
Griliches' prior work (1979) establishes that knowledge spillovers do exist and that they matter a lot to explain the economic growth. This is confirmed by the literature on endogenous growth. Ever since, many scholars have been interested in this subject and more specifically on their impact and diffusion. Geographical distance became soon the central matter of these studies.
This can partly be explained by two theoretical events in economics. First, in the late 70s, economists started to model imperfect competition. They allowed to explain growth difference between firms and by extension between regions. Second, evolutionary theory (Nelson et Winter, 1982, Dosi, 1988) distinguished tacit knowledge from codified knowledge. This differentiation, now common, is based on the degree of knowledge accessibility and on its nature (Malerba and Orsenigo, 2000). Tacit knowledge is, by definition, not explicitly described. At contrary, codified knowledge is perfectly explicit[1]. These two types of knowledge do not require the same mechanisms of transmission. Tacit knowledge is usually transmitted by face-to-face interactions as learning this knowledge entails experience through social relations and apprenticeship-relationships (Foray, Lundvall, 1996, p.20). Codified knowledge can be transmitted as a message or any other formalised support, such as a scientific article (Cohendet, Llerena, 1999). This sort of knowledge can then be transmitted without any interactions.
These two events lead to underline that economic growth difference can be explained by knowledge access. The question of knowledge transfer and consequently of spillovers is associated with that of geographic proximity. The importance of co-localisation is confirmed by a stylised fact about the success of SME in the so-called "Third Italy" (Becattini 1990). These firms had economic and innovative performances by being localised in bounded geographic areas. As a consequence, scholars were induced to ask the question of the foundations of the agglomeration of economic activities.
Therefore, because of the tacit nature of knowledge, it is widely admitted that spillovers are localised. This result partly justifies economic policy that leads to the building of technopoles, clusters.

In the same time, knowledge creation has become more and more of a collective phenomenon, all the more as knowledge is divided and dispersed (Machlup, 1983). Interactions between agents allow to nearer complementary knowledge pieces and to combine them, in an original way. This explains widely why firms have resorted, in an increasing way, to technological cooperation since the 80s (Hagedoorn, 2002). But contrary to what one could expect, cooperation is not always local.

[1] Codified knowledge is a « message which can be manipulated like information » (Foray, 2000, p.48).

The objective of this article is to examine the diffusion of spillovers within technological cooperation. More precisely, we shall ask to what extent permanent geographic proximity, defined, as co-location by the geography of innovation, is really necessary to benefit from spillovers when agents cooperate.
The section 2 examines the local dimension of spillovers. Despite a consensus on this result, it appears that on the one hand, economic models have difficulties to take into account the geographical dimension and on the other hand, only few of them study the channels of spillovers diffusion. These two limits reduce the significance of the result obtained. This leads us to analyse knowledge flows and to question the need of co-localisation to catch them.
A particular form of interaction, the technological cooperation, is studied in section 3. The objective is to show why this organisation can be viewed as a vector of spillovers.
In that respect, as cooperation is realised with local or remote partners, section 4 examines the conditions of spillovers diffusion. It turns out that co-localisation is not a sufficient condition; geographic proximity is often required but it can be temporary. This condition must be linked with organisational proximity to be effective. Then, it appears that spillovers are not "in the air(s)" but in networks.

2. LOCAL DIMENSION OF SPILLOVERS

The literature on innovative milieus and clusters (Saxenian, 1994, Beccatini, 1990) underlines the importance of interactions and exchange of knowledge between agents located in these areas. In fact, knowledge considered as the most useful in the innovative process, is generally tacit. It is widely acknowledged that tacit knowledge requires geographical proximity.
These works underline the development of a new local industrial organisation, which offers additional economic performances for the firms due to spillovers. These approaches consider that the concentration of activities allows spillovers diffusion according to the nature of knowledge.
However, these approaches postulate more than they demonstrate, the effectiveness of the need of geographic proximity for the spreading of knowledge spillovers. In fact, the empirical analyses are mainly case studies which do not propose actual tools to measure spillovers. Moreover, they evaluate the role of different actors and their interactions in a given limited geographical area, without looking at the connexions with the other areas. The argument retained is that the essential knowledge for innovation is tacit; its diffusion requires face-to-face relations. Spillovers which come from innovation are then necessarily tacit, hence their localised dimension. Geographic proximity[2] is a postulated necessary condition for knowledge transfer.

Models of the geography of innovation try and verify the role of geographic proximity in the circulation of spillovers. However, despite a certain consensus, they face a few limits.

[2] Agents are considered as being geographically close to each other when they can have daily face-to-face relationships.

2.1. CO-LOCALISATION AS A VECTOR OF SPILLOVERS: MODELS OF GEOGRAPHY OF INNOVATION

The models of the geography of innovation measure from which distance spillovers can impact the geographic unity performance. The common problematic consists then in modelling spillovers and their local dimension.
Autant-Bernard and Massard (1999) identify four types of models in this approach, each of them developing a particular method to measure the spatial dimension of spillovers :

- Patent citations are viewed as markers of externalities: the article by Jaffe, Trajtenberg and Henderson (1993) is based on the idea that if spillovers are localised, a firm will use preferably the stock of the local knowledge. They test the correspondence between the localisation of patent citations and the localisation of original patent. For the patents granted in 1980, citing patents are in general, localised in the same geographic area than the cited patent. The authors conclude that spillovers are localised.
- The second type of models deals with geographic concentration of innovation: Audretsch and Feldman (1994) show that R&D activities are more concentrated than those of production. They infer that this result is the sign of localised spillovers existence.
- The third type develops the concept of geographic coincidence to test the importance of geographic proximity: Jaffe (1989) studies the impact of university R&D on the knowledge production of the firms. He tests a function of knowledge production (Griliches, 1979) with exogenous variables such as firms and university R&D, and geographic coincidence. He establishes that spillovers spreading are favoured by geographic coincidence between universities and firms.
- The last approach is focusing on local interactions: those models will be developed latter. They reach the same kind of conclusion.

Despites the diversity of methods used, these models all conclude on the existence of spillovers and on their geographic bounded flows, confirming the results of the previous approaches. In fact, they reach the same conclusion from the point of view of the analysis of the agglomeration of the activities (Anselin et al. 1997). Scholars examine the part of spillovers using the prior works of Marshall (1920). Spillovers are the foundations of agglomeration of activities and firms. They are geographically bounded. Thus firms must be localised near the source of the spillovers to benefit from them. In fact, as innovation naturally produces spillovers (because some knowledge are not perfectly appropriable), agglomeration is much more pronounced in these activities than in production (Audretsch and Feldman 1994). In other words, being at proximity of the sources of spillovers is a necessary and sufficient condition to benefit from spillovers.

2.2. CONDITIONS OF THE TRANSFER OF SPILLOVERS

Two elements require to be more deeply studied in order to confirm the need of geographical proximity. First, these approaches face problems to model spatial dimension, reducing the significance of these results. Second, the question of spillovers diffusion is, paradoxically, little studied. Indeed, few models analyse the conditions to capture and use spillovers and the canals of transmission. In this case, the central role of geographic proximity is postulated.

2.2.1. A partial measure of space

As we noticed, the objective of the geography of innovation is to model both spillovers and their spatial dimension. But studies face difficulties to do it simultaneously. They model either space or spillovers and they are obliged to suppose the remaining dimension.

One difficulty[3] they face is to model spatial dimension. Some models suppose that there are spillovers and they measure their effects. The local dimension is then often pre-defined by the authors, using administrative unity: Jaffe (1989) utilizes States, Anselin et al. (1997), the county, Autant-Bernard (2000) the French "departement". If these unities are practical as they allow to obtain figures and statistics, they do not allow to measure local networks specificities, showed by the approach of districts.

Moreover, there are few comparisons with other geographic spaces. The models test the existence of spillovers inside a geographically bounded zone. Finally, the measure of geographical proximity (coincidence…) is pre-defined by authors but these indicators are not neutral on the results (Anselin et al., 1997).

It seems then interesting to attempt to take into account these limits in order to consolidate their results. However, other studies show that when policies are implemented in order to make profit of the results, put in evidence by the geography of innovation, geographical proximity, on its own, is not a sufficient condition to spillovers flows.

Indeed, the models of the geography of innovation essentially test the local dimension of spillovers. They do not include explicative variables which could explain this result. Being near the sources of spillovers allows to catch them. Filippi and Torre show, through the example of the implementation of a Network of Technology Diffusion, that geographic proximity is not a sufficient condition to capture spillovers. We rapidly present this case study.

Believing in the crucial role of geographical proximity, Public Authorities have implemented Networks of Technology Diffusion in different French regions in order to encourage knowledge transmission in Small and Medium Enterprises. This implementation on local level is based on the tacit dimension of knowledge. NTDs support a policy that aims to ensure, by means of different types of incentives, the primacy of synergies at a local level, presupposing that these synergies are conducive to development. The hypothesis is that constructed geographical proximity (that means decided by authorities) is conducive to the diffusion of knowledge.

The policy consists of creating local network, when they do not exist, or of supporting cross-cooperation between partners belonging to different "worlds" such as university, firms of different sectors... The authors compare these policies in three different regions (Corsica, Aquitaine and Rhones-Alpes). Despite differences of economic development in these three entities, the results are similar in the three and very divergent from original objectives. The co-ordination between spontaneous and institutional networks remains partial, and more often than not, the original objectives of public authorities have not been reached or are modified in the course of action. The main result is that institutional network find difficulties to connect with private network because of the heterogeneity (Rhones-Alpes) of this latter or of its frontiers which are much further that those of region (all of three).

[3] Another difficulty is to model spillovers but it does not give rise to a more thorough study, as it is not the heart of our subject here.

This case study shows then that geographical proximity, as the only condition for knowledge transmission, fails as a form of proximity that organises the activities of innovation. It can easily be deduced that spillovers cannot flow in such a configuration.

Then, as geographical proximity, on its own, does not consist of a means of spillovers transmission, it is crucial, in order to understand this activity to study their means of transmission. This has become more important since the recent work of Autant-Bernard (2000). She attempts to get round the fact that models bound *a prior*i the space in which spillovers are supposed to exist. Taking into account three levels of localisation ("departement", neighbour "departements" and other), she puts in evidence that spillovers diffusion is locally stronger but that it is as well geographically larger, more particularly for spillovers coming from public research. This tends to confirm the results of Anselin et al. (1997). Even, if more studies have to be done in this direction, these first results need to be explained, as the diffusion is not anymore only local.

2.2.2. From a logic of diffusion to a logic of learning and interaction

The approaches of the geography of innovation suppose that being at proximity is a necessary and sufficient condition to benefit from spillovers. This is based on two hypothesises: first, following Marshall quotation, spillovers are "in the airs", they are freely available; second, everyone is able to capture spillovers. The only restriction to diffusion is that, according to knowledge transmission, spillovers are local public good.
Today, the hypothesis of perfect availability of information has been widely given up by the different approaches of economics. It is widely admitted that there is a cost to knowledge acquisition. Knowledge is not available for all in the same way. It is then impossible to consider that knowledge circulates freely in the airs.

In that respect, it becomes necessary to analyse the conditions of spillovers diffusion and the relationship between the transmitter and receiver. First, a pre-requisite "organisational" condition is necessary: The models presented until now suppose that agents are able to use spillovers. In fact, spillovers are not simply a free emission of knowledge by one agent but they are knowledge pieces used by other agents. The definition of spillovers indeed implies that someone necessarily exploits them. Then, if knowledge is accessible (thank to interactions, patents...), agents must first be able to absorb and understand it to benefit from it. Second, the analysis of the interactions must be reinforced to explain spillovers spreading. The models of the geography of innovation mainly do not consider the channels of transmission. As we noticed, they test the co-localisation of the activities. Only few models (the latest category of models) view interactions as channels of spillovers diffusion. They may contribute to modify the relation between spillovers and geographic proximity.

Firms' absorptive capacity

Contrary to the traditional analysis (Arrow, 1962), access to knowledge is not free. To benefit from knowledge externalities, it is necessary to possess the related competences and know-how. Then, firms must develop their absorptive capacity (Cohen et Levinthal, 1989) in order to identify, understand and exploit external knowledge. This concept can be defined as the level of external knowledge that a firm can use. It is a function of the internal R&D level and of the external knowledge characteristics. More precisely, it depends on the stock of knowledge and on its diversity. The more a firm has varied knowledge, the more it is supposed to be able to absorb spillovers.

Thus, R&D does not only allow the production of new knowledge but it also allows to increase the capacity of the firm to assimilate existing knowledge. Taking into account the absorptive capacity leads to limit the impact of spillovers. In fact, all the firms are not able to benefit from them. They must reach a critical R&D threshold and possess knowledge that is technologically close to the emitted spillovers[4].

It is interesting to notice that Cohen and Levinthal (1989) do not tackle the question of localisation of the agents in their analysis of the conditions of the absorption of spillovers. They only insist on the technological distance between the transmitter and the receiver of the spillovers. In that respect, we conclude that geographic proximity is not a sufficient condition to benefit from spillovers.
Moreover, if these authors underline the importance of this capacity, they precise neither the channel of transmission of spillovers nor the organization in which the absorptive capacity is developed (Bach and Lhuillery 1999). In other words, they do not analyse which types of organizations link transmitter and receiver of these spillovers.

Interactions facilitate the circulation of spillovers
Cockburn and Henderson (1998) consider that if absorptive capacity is necessary to identify and use external knowledge, it does not constitute a sufficient condition. Studying knowledge externalities between public research and private research, they consider that despite the traditional sources of spillovers (articles, conferences), firms must develop « active » cooperations with public laboratories if they want to capture spillovers from these institutions. This study underlines the need of contact with the source of spillovers and then the role of interactions.
In the same way, Zucker et al. (1994) show the role of interactions rather than co-location. Their first model establishes that innovative performance of biotechnology firms is positively associated with the total number of articles by local university "star" scientist (at least in California, the State where they realise their survey). They conclude that spillovers are localised. However, in the second model, they differentiate the scientists who are in relation with at least one firm (linked scientists[5]), the pure academic researchers and the affiliated researchers (i.e. integrated in the staff of the firm). Researchers of the latest two types do not product positive effects on the firms' performance, contrary to the first ones. Then, inside a territory, it is not so much the geographic proximity that account as the nature of the relations between agents. Indeed, the public researchers, localised in California but without links with firms, do not produce any effects on firm performance. Their results are then very interesting as they enlighten us on two points: first, geographic proximity is not sufficient to benefit from spillovers emitted by university. Second, spillovers must be analysed through the study of interactions.

The main idea of these models is that one of the privileged channels of spillovers is interaction. Going further, Zucker (2001, p.22) clearly shows that when there are no links between agents, there cannot be spillovers diffusion. However, these models do not sufficiently take into account the spatial dimension. The first model does not even evoke space. The second one only studies the spreading inside a given geographic area, California. It concludes that co-localisation is not a sufficient condition but as it does not give any information of the spillovers coming from further zone, it is impossible to know if it is a

[4] Moreover, contrary to the traditional analysis, the existence of spillovers leads to an increase in R&D spending.
[5] Linked scientists are those who have co-published with researchers of a biotechnology firm but who do not appear in the organisation chart of the firm (at the difference of affiliated scientists).

necessary condition. Moreover, these models only study public-private relations. It would be necessary to test other types of relations and to include spatial dimension.

The results of the approaches on districts and the geography of innovation conclude on the local dimension of spillovers, mainly because of the tacit nature of knowledge. However, these models suppose more than they demonstrate these results. The difficulty of modelling space and the analysis of the conditions of the transmission of spillovers lead to question these results. More precisely, we have showed that co-localisation is not a sufficient condition to catch spillovers. On the contrary, it appears that being in touch with the source of knowledge and to possess a certain absorptive capacity are central conditions for that purpose. The logic of diffusion must be then narrowly linked to the one of learning. In that respect, we wonder if all spillovers are bounded in space and more precisely, if it is possible to capture them at a distance. For that purpose, interactions must be more studied, in order to propose other spaces of diffusion.

3. TWO APPROACHES OF THE RELATION: COOPERATION AND SPILLOVERS

Griliches (1998) points to the importance of interaction between actors instead of the rather freewheeling involuntary character of spillovers.
"Knowledge is not like a stock of ore, sitting there waiting to be mined. It is an extremely heterogeneous assortment of information in continuous flows. Only a small part of it is of any use to someone at a particular point of time and it takes effort and resources to access, retrieve and adapt it to one's own use. Thus models of externalities must perforce be models of interaction between different actors in the economy" (Griliches, 1998, cited by Veugelers and De Backer).
Among a vast number of transmission channels (patents, colloquies, publications, workers mobility…), technological cooperation seems interesting to study as a form of organisation in which links between the transmitter and the receiver of spillovers can be analysed (what required Bach and Lhuillery, 1999). Moreover, cooperation has become a very sought-after organisational form to have access to external knowledge sources (Mowery, Oxley, Silverman, 1996). Thus, Hagedoorn (2002) notices that on the one hand, firms turn in an increasing way to technological cooperation, especially in high-tech industries, since the 80s; and that on the other hand, partners frequently belong to different geographic zones. Cooperation contributes to the creation of networks of which frontiers are not localised. Moreover, such an organisation requires important knowledge transfer between partners to reach their collective objective of innovation. Finally, cooperation is a means to increase the absorptive capacity[6].
Despite Griliches "recommendations", this choice can seem surprising as on the one hand, cooperation relationships are usually at least partly market relations, and on the other hand, the standard literature considers cooperation as a means to internalise spillovers (2.1.). However, previous studies analysed mainly involuntary spillovers (Veugelers and De Backer). At the risk of modifying their definition, involuntary as well as voluntary spillovers are studied in this article. Incomplete contract theory can partly explain the concept of

[6] The process of auto-reinforcement can be noticed as absorptive capacity is required to cooperate but cooperation increases it (Mangematin and Nesta, 1999).

cooperation as a vector of spillovers. Nevertheless, this approach tends to assimilate cooperation to a one-shot game. The specificities of knowledge and of the innovation process must then be taken into account. It results in the idea that voluntary or involuntary knowledge transfer between organisations generates important spillovers (2.2.).

3.1. A TRADITIONAL ANALYSIS: COOPERATION AS A MECHANISM OF SPILLOVERS INTERNALISATION

The neoclassical theory considers spillovers as market failures, as they have an influence on agents without going through price mechanisms. From a standard theory point of view, it is necessary in order to assure market functioning, to overcome thank through internalisation. Internalisation mechanisms aim to compensate ineffectiveness generated by spillovers. This allows to obtain (or to tend to) a pareto-optimal equilibrium.
The resort to other forms of organisation such as the firm or the government, can constitute a means to internalise these failures. More recently, cooperation has appeared as an intermediary solution, less constraining. We present a model by d'Aspremont and Jacquemin (1988) which compares firm's effectiveness with the one in cooperation when there are spillovers.

3.1.1. Cooperation as a solution to the deficit of incitement to innovate

Knowledge spillovers allow to increase the stock of the common knowledge of the society. If social return is higher than the private one, agents face a problem of incitement to innovate. A solution must be found; it must allow to establish an equilibrium between the preservation of creator interests and the maintaining of social benefits.
The resort to appropriation instruments such as patent, secret... is not always perfectly efficient because of the imperfection of these proprietary "rights". It is then widely admitted in economic literature that firm's R&D activities create positive externalities to competitive firms. This leads to an under-investment in R&D in comparison to social optimum (Combe, 1998, p.454). R&D cooperation constitutes then a means to reduce this under-investment in allowing to internalise spillovers.

D'Aspremont and Jacquemin model (1988) constitutes a seminal article of the models which study the relationship between R&D cooperation and incitement to innovate. Authors examine the impact of cooperation on the R&D effort thanks to a Cournot duopoly model. They consider three possible two-step games:

- Firms do not cooperate. They are competitor.
- Firms cooperate only on R&D activities. They remain competitor at the production level (partial cooperation).
- Firms cooperate for both activities (total cooperation).

From a production function with exogenous spillovers, authors calculate the level of R&D spending and of production for these three configurations and for the social optimum. When spillovers are high, the level of R&D spending, in partial cooperation, is superior to the one of non-cooperative situation but inferior to the one in total cooperation[7].

[7] These results are verified by ulterior models. Cf. De bondt (1996) for a review.

Cooperation, when spillovers are important, allows then to increase the incitement to innovate, even if the obtained results are inferior to the one of social optimum. The decision to cooperate is based then on the level of appropriation of innovations.
This model shows that cooperation allows to limit spillovers effects. Nevertheless, this model (and the one which he has inspired) meets some limits.

3.1.2. The impossibility to internalise all the spillovers

Although these limits refer directly to d'Aspremont and Jacquemin (1988) model, most of them can be generalised to the approaches which consider cooperation as a means to internalise spillovers.
The first limit is that these models allow rarely empirical studies. It can be explained by the difficulty to foresee *ex ante* (before the decision to cooperate) the intensity of knowledge created *ex post* with an uncertain probability.
Moreover, this model considers only cooperation between competitors. However, empirical studies show that the types of partners are more diversified.
Furthermore, this approaches which consists of considering cooperation as a means to internalise spillovers, reduce the field of cooperation. According to these authors, it seems that it is spillovers existence that leads firms to cooperate. The analysis implies that firms are identical. They are then perfectly able to develop themselves knowledge but spillovers presence reduces their activity. Cooperation is only a means to overcome market failures.
Finally, this approach considers knowledge as information. According to the hypotheses on information nature, knowledge is then accessible to everyone. However, as noticed, some conditions are required if firms want to benefit from spillovers (absorptive capacity, sector ...). Moreover, literature on Knowledge economy underlines the non-homogeneity of knowledge. These two elements call into question the hypothesis emitted in the model of d'Aspremont et al. (1988), of the exogeneity of innovation appropriability (Combe, 1998).

Besides these first limits, we consider that cooperation allows only a partial internalisation of spillovers following two explanations:
Spillovers issue cannot be reduced to a bilateral problem. Indeed, they constitute a diffuse phenomenon involving a great number of agents linked by direct or indirect, formal or informal, relationships (Massard, 1997). As spillovers benefit depends on their absorptive capacity, on the external knowledge accessibility of the agents …, the transmitter should sign a cooperation agreement with every beneficiary. But it is not in their interest to become apparent. This seems unrealisable, and even it was, transaction costs would be such an amount that firm would have interest to realise no R&D activity. Thus, if cooperative firms reduce the risks of the diffusion of their knowledge, they cannot internalise all the spillovers.
Finally, this approach considers spillovers originating in the R&D results of cooperation. However, if we consider that firms do not have the same initial stock of knowledge, they may be, for their partners, a vector of spillovers. These latter would come from knowledge developed before cooperation. This leads us to distinguish cooperation as a « canalizer » of *ex post* spillovers and cooperation as vector of spillovers. In the first case, cooperation does not aim to suppress spillovers, resulting from collective creation process. It limits only their extent to partners (d'Aspremont et al., 1988; Coase, 1960). In the second case, privileged relationships lead every partner to benefit, during cooperation, from knowledge acquired previously by each of them ; and that without this exchange goes through a market relation. We will go deeply into this last point.

3.2. A NEW CONCEPTION: COOPERATION AS A VECTOR OF SPILLOVERS

The district approaches have, since a long time, underlined the role of local interactions in knowledge diffusion. However, despite the empirical limits, already noticed, let us remember that every interaction, every exchange, is susceptible to be a source of spillovers (Cassiman and Veugelers, 2001). Technological cooperation can then constitute one of these interactions. Technological cooperation corresponds to a common project of the creation of a new product or process (Rullière et Torre, 1995, p.226). The motives for engaging in alliances are numerous, as observed in many studies (Porter et Fuller, 1986, Contractor and Lorange, 1988, Hagedoorn and Schakenraad, 1991). It allows sharing costs/risks, access to partner's know-how/market/products, efficiency enhancement such as economies of scale, synergy effects from exchanging/sharing complementary know-how. This touches upon competitive considerations too, such as influence on other alliance activities, on competitive structure…
Empirical studies show that it is essentially the need to access to complementary competences that leads firms to this form of organisation. The question of the internalisation of spillovers is never directly evoked.

These alternative (or complementary?) strategies to d'Aspremont and Jacquemin's approach, lead to propose different reasons to justify the obvious assertion, previously enounced, that every transfer is a source of spillovers. The existence of incomplete contracts constitutes a first justification, even if it contributes to reduce the temporal conception of cooperation. It is more the characteristics of the innovation process that legitimate the fact that cooperation is a vector of spillovers. Such a result has an impact on the decision to cooperate.

If strategy leads firms to cooperate, the questions linked to partners' control, to the sharing of the results and to the organisation of the relation in general, are not fixed for all that. They generally lead to the signature of a contract. According to the complexity and specificity of these organisations, and to the informational problems, relations of cooperation are submitted to important uncertainties (moral hazard, adverse selection present in every cooperation but also to uncertainties on the innovation process and the use of knowledge). The description of all the future eventualities is then rarely possible. Contracts are incomplete.
These contracts foresee mechanisms allowing to determinate appropriated actions for what would not explicitly be stipulated in the contract. In other words, "a mechanism indicating to agents which behavior they have to adopt, must substitute for routines when these latter are not pertinent any more", (Brousseau, 1993, p.75, translated by the author). It can be, among others possibilities, the re-negotiation of the agreement or the designation of an authority[8]. This role of referee can be attributed to one of the partners or to an external part.

It is surprising that incomplete contracts theory has never been directly linked with the one of knowledge economy. However, the problem of incomplete contracts is fundamental when collaboration is about knowledge because of the characteristics of non-excludability, non-rivalry and tacitness of this latter one. Indeed, even if knowledge is partly appropriable, to make pay the right price is difficult as potential use of this good is uncertain. This leads to reinforce the problem of the incompleteness of contracts.

[8] "Authority is a right of commands, contractually established. It allows to a contractor or a group of contractors to decide of effective use of resources brought by each of them. It is a mechanism complementary to routines. Its existence is justified as soon as these latter are not efficient any more […]. Authority is an answer to uncertainty, which is characteristic of number of transactions and cooperation (Williamson, 1975, 1985)", (Brousseau, 1993, p.75).

In principle, as soon as an unexpected event has occurred, the resort to a mechanism of "relation management" allows to find a solution. This is only possible if the new realised state of nature is observable and verifiable. Let's study the case where one of the partners adopts opportunist behaviour.

In a technological cooperation, the behaviour of one of the partners can involve an unforeseen situation. Thus, when contracts are incomplete, agents can adopt opportunist behaviour. "Opportunism appears when an agent does not respect his engagement" (Brousseau, 1993, p.107)[9]. It generates a problem of moral hazard. This latter "is linked to the loss that an agent occasions when he does not give the counterpart expected by the other and that this latter cannot measure precisely the injury" (Brousseau, 1993, p.107).
Thus, if we consider that agent's engagement is not to use exchanged knowledge for a private use (i.e. beyond cooperation), the non-respect of this promise by the agent is the sign of the adoption of opportunist behaviour. It results then moral hazard problems. The opportunist agent does not give the counterpart of the use of this knowledge (by paying, for instance, the owner). As a principle, mechanisms allowing to take into account this situation should be put in place (resort to authority or re-negotiation of contract).

However, these mechanisms are not always applicable. Indeed, knowledge use is not always observable. Control is made difficult as knowledge is non-rival. The victim partner must follow the knowledge creation process of his partner, during and after cooperation, to be able to observe unexpected use. Moreover, he must be able to measure precisely the prejudice that he suffers.
Moreover, this use can be not easily verifiable. It can be hard to bring evidences that some knowledge have been used, without authorisation. Indeed, firms have their own projects that they develop in the same time that cooperative projects. To prove that external resources contribute to internal research use, can be a difficult task (Lerner et Merges, 1998, p.127). Moreover, it is tricky to distinguish knowledge stemmed from own research to the one captured by interactions.

The renegotiation of the contract or a new decision of the named authority is then impossible; it can sometimes even not be evoked.
Thus, being opportunist, the agent benefits from knowledge he has not paid the price. Such knowledge corresponds to the definition of spillovers. Thus, when opportunist behaviour, non-sanctioned, appears, cooperation relationships are a vector of spillovers.

If the study of opportunist behaviour allows to understand the mechanism of spillovers diffusion inside cooperation, it is however problematic. Indeed, in such a situation, cooperation can be only a one-shot game: the agent which suffers from such a behaviour breaks the contract with the deviant partner. Such a theoretical case does not reflect reality, in which cooperation appears as long and repetitive processes.

To the difficult contractualisation of knowledge, it must be add, in order to understand in what extend cooperation can be a vector of spillovers, the specificities linked to knowledge production. This one is not any more considered as an isolated and impromptu phenomenon but as a cumulative and progressive process. During cooperation, knowledge is exchanged, diffused (voluntarily or not). Some of it are thus, incorporated (embodied), at least partly, by

[9] Williamson (1994) defines it as « the research of personal interest which admits a notion of deceit ».

partners. Such a mechanism can involve a modification of their mental structure and of their thinking framework[10]. Contrary to material assets, knowledge used during cooperation can not be destroyed at the end of the process (it is impossible to suppress knowledge from a brain, and then, to prevent its holder to use it). Agents can then re-use it for their internal research, without being necessarily conscious of doing it. The question of the use of such knowledge for own utilisation, is all the more insoluble because creation process is unforeseen and uncontrollable.
Moreover, some knowledge can be diffused unknown to its owner, according to its tacit dimension. The emitter is able not to be conscious that he has this knowledge; he can then emit them unconsciously (Coriat et Weinstein, 1995, p.124, Polanyi, 1954).

Thus, spillovers issue is very important in the decision to cooperate. Cooperation is a means to access to competences: firms can cooperate for many reasons, but they always attempt to take advantage of the situation to access (without any contract necessarily negotiated) to partners' competences (Mowery, Oxley and Silverman, 1996**)**. Firms cooperate therefore in the hope of capturing spillovers.
More precisely, according to evolutionary theory, firms are different. They have their proper knowledge stocks, linked to their previous activities, and which may meet appropriation problems. Spillovers spreading, inside cooperation, is then, not a game to nil sum. Indeed, every partner may benefit from spillovers, emitted by the other members. However, every one is conscious that he can lose a part of his cognitive advantage, during cooperation, because of the spillovers that he emits[11].

Decision to cooperate results then of an arbitrage between the objective of the maximisation of incoming spillovers and the one of minimisation of outcoming spillovers. The first objective underlines that cooperation allows to develop interactions, vector of spillovers. The second objective is closely linked to the degree of knowledge appropriability of the firm. Inside cooperation, partners attempt to minimise outcoming information flows that do not directly concern the purpose of the cooperation (Cassiman and Veugelers, 2001).

Cooperation is therefore a vector of spillovers. This channel can surprise. However, it owns characteristics similar to the other forms of interactions. More precisely, cooperation appears as a specific organisational form which facilitates interaction and then consequently, spillovers diffusion. Cooperation allows a better access to external knowledge. Indeed, Veugelers (1998) studies knowledge external sources et account seven mechanism to acquire them: Licence, R&D outsourcing, Consultancy, Acquisition of Companies, Purchase of equipment, Communication with other companies, Hiring skilled employees. She shows that firms which cooperate, use more external knowledge sources than those that do not use this organisational form.

This section leads to a new conception of the relation cooperation/spillovers. Contrary to the analysis of d'Aspremont and Jacquemin (1988), we are interesting in the inputs diffused during cooperation, and not on the output resulting from cooperative activities. The resort of

[10] Knowledge acquisition and assimilation mechanisms are not easily envisaged by economists. The introduction of a piece of knowledge in the cognitive system can increase the knowledge stock of the receiver but can equally involve perturbations and then a modification of his structure of thoughts. This is completely uncontrollable by agents.
[11] Firms are not any more symmetric in the sense that they do not receive necessarily as much spillovers as they emit. In return, spillovers diffusion is done in a bilateral way, even if firms do not benefit from the same level of spillovers, this one depends on the characteristics of each one (absorptive capacity, competitive advantage...).

cooperation is an efficient solution to internalise spillovers: this allows to reduce more spillovers linked to the output (i.e. realised by the cooperation) than if research activity had been effectuated by an individual firm. However, this approach does not take into account that each firm has *ex ante* (i.e. before cooperating), a stock of knowledge which can be submitted to appropriability problems. To adopt this hypothesis leads to consider that firms and public institutions are susceptible to emit spillovers at any time; it is not possible any more to consider only cooperation effect on the output of this one.
Cooperation is a vector of spillovers in the sense that such an organisation and the numerous interactions which results from it, facilitate knowledge transfer. Nevertheless, such a conception leads to enlarge the spillovers definition. Indeed, "technological spillovers are most often defined as externalities, whit agents unable to fully appropriate all benefits from their own R&D activities". However, they are sometimes defined in a broader sense. "R&D spillovers refer to the involuntary leakage, as well as, the voluntary exchange of useful technological information" (Steurs, 1994, p.2). In that respect, we adopt the larger definition: " spillovers consist on the transmission, voluntary or not, of information which is free or price is inferior to marginal cost" (Massard, 2001, p.11).

4. "SECRETS ARE IN NETWORKS"

Cooperation is a vector of spillovers. Such a result leads us to be interested in organisations, and more precisely in networks as collaboration is organised as such. In this case, we wonder if the local dimension of spillovers is still verified, as partners are not necessarily close to each other. The literature on districts underlines the role of the local network in the diffusion of spillovers. It insists especially on the contacts that can be developed and the need for interactions to diffuse tacit knowledge. However, in the same time, an important literature appears on the development of networks and underlines their advantages without necessarily referring to the spatial dimension.
A paradox then appears between the two approaches. The empirical facts show that both types of networks (local and a-spatial) co-exist. It seems that the question of co-localisation must be partly replaced by, or at least combined with, the study of organisation. The spatial and organisational conditions of spillovers transfer will be examined, in the logic of networks[12].

4.1. LOCAL NETWORK VS. A-SPATIAL NETWORK

4.1.1. Local network advantages

The models of the geography of innovation conclude on the local dimension of spillovers, according to the tacit dimension of knowledge. Indeed, co-localisation can generate an organisation that links agents to each other. Geographical proximity favours knowledge flows about potential partners and the creation process and that for three reasons:
Geographical proximity facilitates contacts between agents. If they were remote, they would not have the opportunity to meet. Indeed, agents are locally federated by official or more informal common instances such as Industry and Business Chambers, Unions… or local clubs (Autant-Bernard, 2000). This leads them to meet each other, and to know what the others do...

[12] In this section, we will consider knowledge transfer rather than spillovers. Indeed, only the economic nature changes between these two concepts. Their transfer conditions are supposed to be similar and the literature focuses more on knowledge diffusion. As every knowledge transfer can be a source of spillovers, the results on knowledge diffusion can be transposed perfectly to spillovers spreading.

This can help to find new partners as agents have information on the local firms. At equivalent capabilities, they generally prefer working with partners next to them.
Moreover, knowledge production calls for interactions, as new ideas come out from debate. Discussions allow sharing and confronting knowledge. Interactions are more efficient in a face-to-face situation as the discussion is more fluid, more interactive and denser. Here, the communication between agents is also synchronised, which contributes to increase the speed of decision-making. Furthermore, the creation process requires a wide variety in the types of knowledge (tacit and codified), which are present in personal interactions. In that respect, geographic proximity is *de facto* required.
Finally, information seems to circulate more quickly at local level. Jaffe, Trajtenberg and Henderson (1992) put in evidence that the probability of citing a patent localised in the same region is higher in the year of the publishing of the first patent. It decreases with time. In the same way, Feldman (1994) underlines that knowledge crosses more easily corridors and streets than oceans and continents.

Geographic proximity favours interactions, thus tacit knowledge diffusion. Allowing to create relations between different agents, it constitutes an interesting advantage for the diffusion of spillovers and for the building of cooperation.

4.1.2. Network Organisations

At the same time, a large literature vaunts the merits of networks without any references to spatial dimension. There are no agreements on the definition of network. However, in a very large way, it can be defined as a set of nodes or actors (persons or organisations) linked by social relationships or ties. This definition is very general as the actors can be of any types (researchers, firms, clients, furnishers, competitors…). Its aim can be varied such as client-furnishers networks, subcontractor network… The study of all the kinds of networks or of the systemic network (i.e. the one that takes into account all the links between nodes, whatever the nature of the node) will go beyond the objectives of this article[13]. We will focus on a specific but restricting kind of network: the innovative network.
It can be defined as the organisation of heterogeneous relationships that actors develop, engaged in knowledge production with those that try to establish competitive advantages on economic markets (Callon, 1992). It is worth noticing that from that point, the innovation process is not anymore considered as linear. On the contrary, it insists on the role of interactions and retroactions with the different actors involved. The sources of innovation are not exclusively inside firms. They are frequently found at the chinks of firms, universities, furnishers and clients (Powell, 1990). The locus of innovation is not any more inside the firm, but inside the network of inter-organisational relationships (Powell et al., 1996). Thus, firms cannot innovate anymore if they are not inscribed in such an organisation.
The definitions of innovative network (Callon, 1992, Granovetter et al., 2002…) insist on the diversity of the actors in this coordinated organisation (public laboratory, firms, venture capitalists, lawyers, public institutions…). We restrict our analysis to cooperative networks: networks which reflect the relations of cooperation and the links between partners. In other terms, the influence of public institutions, venture capitalists or any other agent which do not impact directly on the innovative process and knowledge transfer is not studied here. The advantages of connectivity and diversity of the network is still acknowledged.

[13] Cf. Von Alstyne for a survey.

This literature puts in evidence a new form of innovation organisation. However, in almost any case, authors do not refer to geographic proximity. For instance, Cassier and Foray (1999) study the organisation of collective innovation in Europe with mentioning the need of co-localisation.

4.1.3. A paradox

There is then a paradox in the literature. Part of it considers co-localisation as a necessary condition to innovate. Another part focuses more on the organisation of the innovation process. It insists on the importance of interactions and the diversity of partners, whatever the geographical distance is.

This *a-priori* opposition can be explained by the changes in the economic system. Of course, geographic proximity facilitates interactions, fundamental in the innovation process. However, empirical facts show that at the same time, a-spatial networks have become more important. Market necessity, the need of competence, not locally available… lead firms to develop relations, and more particularly cooperation with agents localised all around the world. Networks whose frontiers are not any more local appear. Indeed, contrary to literature on « Third Italy », local networks are widely open onto exterior. It can easily be explained: each firm, working on very specific and specialised domains, it is unlikely that a firm find, at local level, all partners that it needs. In fact, according to Cowan and Jonard, 2001, and more generally, to literature on « Small World », this openness is even essential to catch diversity and to maintain a dynamic local network.

This phenomenon is particularly important in biotech sector. Pamolli and al. (2001) show that a relatively small number of local clusters are capturing a dominant majority of biotechnology firms and of public research organisation. However, the tendency towards clustering is accompanied by a parallel process of increasing openness of the original clusters. Recent trends suggest a combination of an increasing number of collaborations and a decreasing proportion of local connections. For instance, in the USA, local ties moved from a high of 40% in 1988 to a low of 8% in 1998 (Owen-Smith, Riccaboni, Pammolli, Powell, 2001), in the context of a rising volume of collaborations. One of the most likely reasons is the need to get access to state-of-art knowledge, wherever it might be located. Thus, local and a-spatial networks co-exist.

We wonder then if local cooperation only allows spillover diffusion, as geographic proximity is widely needed. More precisely, *as cooperative global networks allow interactions and innovations, we wonder if they allow spillovers spreading. We are tempted to answer positively, as every transfer may generate spillovers*. In this case, it is worth wondering what the real conditions to spillovers circulation are, as it goes against the traditional results.

4.2. SPILLOVERS DIFFUSION INSIDE NETWORKS: THE COMPLEMENTARITY BETWEEN ORGANISATIONAL PROXIMITY AND TEMPORARY GEOGRAPHIC PROXIMITY

As noticed, the main argument for localised spillovers is the tacit nature of knowledge. Considering knowledge flows inside an a-spatial network leads to emit doubts on the validity of this result, following two explanations.

If tacit knowledge is localised in the human being (Dosi, 1996), it is largely mobile. This characteristic increases with the augmentation of transport facilities and the reduction of their cost. During cooperation, meetings can be organised between partners when they need it. The rest of the time, actors can exchange by using other means of communication (ICT,

telephone…), especially as codified knowledge is supposed not to be subject to constraints of time and space. Indeed, the innovation process does not require permanent face-to-face interactions. The first steps of cooperation are the ones that require the more interactions. When tasks become more formalised, face-to-face is less important (Rallet and Torre, 2001). At the same time, a study on the impact of ICT in an international collaboratory shows that despite the development and the important use of ICT, the scientists still need to meet to discuss about "Science" and expertise (Gallié et Guichard, 2002). Thus, if geographic proximity is still essential to exchange some knowledge, it can be only temporary (Rallet and Torre, 2001).
The need of meeting is confirmed by many studies on remote collaboration (cf. Studies of the University of Michigan). Thus, along cooperation, localised or remote partners organise numerous meeting (Gallié and Guichard, 2002), they can even exchange personal for the time of the project…. (Gertler, 2001). Network organisation would be based on a need of geographical proximity, this one being permanent or temporary.
However, if geographic proximity, whether it is permanent or temporary, facilitates interactions and then spillovers spreading, geographic proximity is not a sufficient condition. In fact, being localised close to firms or universities does not mean "being in touch" with them.
As noticed, to benefit from spillovers, firms must develop, as a first condition, an absorptive capacity. But it is not enough, especially in the case of cooperation. In fact, actors must understand each other to interact and then to capture spillovers. They must share common language and codes. This form of proximity is qualified as "organisational". There are several different definitions of this concept. It can be defined as "the capacity the agent had to coordinate each other because of behaviour rules, formal or informal, that they acquire according to the membership of an organisation" (Rallet and Torre, 2001). This definition insists on the rules and on the fact that it is built by interactions. However, it does not take into account the cognitive mechanisms.
Gilly and Torre (2000)'s definition seems more appropriated in the case of knowledge transfer. They consider that organisational proximity corresponds to two types of logic:

- The logic of memberships refers to a shared space in which relationships and interactions exist. Their belonging is based on coordination. Agents need common rules to interact.
- The logic of similitarity considers the common cognitive characteristics of the agents. They are close to each other if they share a same space of reference and knowledge.

These two logics are complementary. Indeed, the logic of belonging allows to share organisational behaviour. For instance, interactions between university and firms can be particularly difficult as each one has specific logics and aims, particularly in terms of knowledge appropriability and diffusion (Cassier, Foray, 1999). These problems can be met as soon as different organisations interact. To succeed, they need to develop behaviour rules to coordinate their actions. The second logic is particularly important as soon as agents deal with knowledge transfer (voluntary or not). Agents must share common reference to understand each other. One important element of this second logic is the development, as a preliminary condition, of absorptive capacity for every organisation. In fact, the higher the absorptive capacity is, the higher the probability to share common knowledge is. However, it is not sufficient. They have to share a piece of common knowledge; this sort of organisational proximity is likely higher when actors realised similar activities.
In that respect, some scholars consider that some organisations, such as communities of practices or epistemic communities, can allow the diffusion of tacit knowledge whatever the distance. These communities of practices are defined as groups of workers informally bound

together by shared experience, expertise and commitment to a joint enterprise (Gertler, 2001). They are then a sort of informal cooperation. The commonalities shared by members of the community facilitate the identification, joint production and sharing of tacit knowledge through collaborative problem-solving assisted by story-telling and other nattative devices for circulating tacit knowledge. Organisational proximity is then more important than geographical proximity in supporting the flow of tacit knowledge (Amin and Cohendet, 2000). Tacit knowledge may flow across regional boundaries if virtual community proximity is strong enough. However, geographic proximity can facilitate the development of such communities (Breschi and Lissoni, 2001). This type of organisation can be assimilated to some forms of cooperation. By extent, we hope for the same result in more formal cooperation

Autant-Bernard (2000), one of the rare economists who studies cooperation as a channel of transmission, tests the spatial dimension of spillovers inside this organisation. She measures the scientific collaboration thanks to co-publications. Her analysis shows the positive role of scientific collaborations on the capacity of capturing spillovers. Inside the local network (determined by the French administrative circumscription of the ”departement”), the more agents interact, the more knowledge is diffused. However, their influence is rather weak (even if significant). Furthermore, it appears that remote spillovers are relatively little, explained by scientific collaborations. Scientific collaborations contribute to a narrow extent to explain spillovers diffusion. However, the result shows that the diffusion of spillovers is not always localised. In order to pursuit the analysis, the author underlines the need of taking other forms of interactions such as technological inter-firm cooperations. Indeed, co-publications reflect mainly the collaboration between public researchers. Inter-firm cooperations should be taken into account.

To conclude, these two kinds of proximity are complementary. In fact, geographic proximity is not sufficient. Organisational proximity is a necessary condition but is not sufficient in most cases, as tacit knowledge requires face-to-face relations. Thus, global network and local network do not differ so much. They are based on organisational and geographic proximity. However, the latter is not always permanent. This means that geographic proximity is not synonymous to co-location.

Thus, it is not so much co-location that imports than the belonging to a network in which members are widely interactive. Geographic proximity itself is irrelevant: what accounts is the way links are organised inside this space (Castillo et al., 2002). Secrets are in networks, and that whatever is their spatial dimension.

5. CONCLUSION

The role of network as a means of interconnexion and of diffusion, as well as the concept of temporary proximity, lead us to nuance the need of the co-localisation of firms and public institutions in order to benefit from spillovers. Indeed, results show that spillovers are localised. However, being at proximity does not mean being in interaction. If geographic proximity facilitates interactions, it does not constitute a sufficient condition to benefit from spillovers.

In that respect, we consider networks, in which links between agents are widely interactive, and that whatever the distance that separate them, are vectors of spillovers. Spillovers are localised but remain within the networks. But this does not mean the end of local network: their crucial role continues if they develop both geographic and organisational proximity. We

only propose another space for spillovers diffusion. A more advanced research leads to suggest that local and a-spatial network could be complementary: the first one would facilitate contacts and the access to local work market, more precisely for the small firms. The second one would allow firms to develop relations with partners chosen among a wider panel.
These theoretical results must still be confronted to empirical analysis. If the latter confirms the former, it will be possible to propose recommendations in terms of public policy.

6. BIBLIOGRAPHIE

Almedia, P., Kogut B., 1999, "Localization of Knowledge and the Mobility of Engineers in regional networks", *Management Science*, 45(7), pp.905-918

Anselin, L., Varga A., Acs Z., 1997, "Local Geographic Spillovers between University research and High Technology Innovations.", *Journal of Urban Economics,* 42, pp. 422-448.

Arrow, J.K., 1962, The economic implication of learning by doing, *Review of Economic Studies,* 29, 155-173

D'Aspremont, C., Jacquemin, A., 1988. Cooperative and noncooperative R&D in duopoly with spillovers, *American Economic Review*, 78(5), pp.1133-1137

Audretsch, D., Feldman, M., 1996, "Knowledge Spillovers and the Geography of Innovation and Production.", *American Economic Review,* 86(3), pp. 630-640.

Autant-Bernard C., 2000, *Géographie de l'innovation et externalités locales de connaissances. Une étude sur données françaises,* Thèse pour le doctorat en sciences économiques, Université Jean Monnet St-Etienne.

Autant-Bernard, C., Massard N., 1999, "Econométrie des Externalités Technologiques et Géographie de l'Innovation : une analyse critique.", *Economie Appliquée,* n°4

Bach L. et Lhuillery S. (1999) « Recherche et externalités : tradition économique et renouveau », in Foray D. et Mairesse J. (eds), *Innovations et performances : approches interdisciplinaires*, EHESS, 339-367.

Becattini G. (1990) « The marshallian industrial district as a socio economic notion", in Pyke et Becattini Sengenberger (eds) *Industrial district and inter-firms cooperations* in Ital, International institute for labour studies, Geneve.

Breschi, S., Lissoni, F., 2001, "Localised knowledge spillovers vs. innovative milieux: Knowledge "tacitness"reconsidered", *Regional Science*, 80, pp.255-273

Brousseau E., 1993, *L'économie des contrats : technologies de l'information et coordination interentreprises,* PUF, Paris, 368.

Cassiman B., Veugelers R., 2001. R&D cooperation and spillovers: some empirical evidence from Belgium. *American Economic Review* (à paraître).

Castilla E.J., Hwang H., Granovetter E., Granovetter M., 2002, “The social networks in Silicon Valley”

Coase R.H., 1960, “The problem of social cost”, *The Journal of Law and Economics*, 2(1), 1-40

Cockburn I., Henderson R., 1998, "Absorptive capacity, co-authoring behavior, and the organization of research in drug discovery", *The Journal of Industrial Economics*, vol.XLVI, n°2, juin, pp. 157-181

Cohen W.M., Levinthal D.A, 1989, “Innovation and learning: the two faces of R&D”, *Economic Journal*, n°99, pp.569-596

Cohendet P., Llerena P., 1999, "La conception de la firme comme processeur de connaissances", *Revue d'Economie Industrielle, n°88,* pp.211-236

Combe E., 1998, "Pourquoi les firmes s'allient-elles? Un état de l'art", *Revue d'Economie Politique, n°108 (4),* pp.433-475

Coriat B., Weinstein O., 1995, *Les nouvelles théories de l'entreprise*, Le livre de Poche, Paris, 218

Cowan, R., Jonard, J., 2001. The workings of scientific communities, working paper, 25p.

Dosi G., 1988, « Sources, procedures, and microeconomic effects of innovation”, *Journal of Economic Literature*, 26, sept., 1120-1171

Dose G., 1996, in *Employment and growth in the knowledge based economy*, OECD, Paris.

Feldman, M., 1994, *The Geography of Innovation*, Boston, Kluwer Academic Publishers

Filippi M., Torre A., ???, Local organisations and institutions: How can geographical proximity be activated by collective projects? Internet.

Foray D., 2000, *L'économie de la connaissance,* La découverte, coll. Repère, Paris, p.124

Foray D., Lundvall B.A., 1996, *Employment and growth in the knowledge based economy*, OECD, Paris.

Gallié E.P., Guichard R., 2002, « The impact of ICT sophistication on geographically distant networks: the case of plasma physics as seen from France”, *NPRNet Conference*, Brighton, March 21-23 2002.

Gertler M.S., 2001, “Tacit Knowledge and the Economic Geography of context”, Presented at the Nelson and Winter Druid Summer Conference, Aalborg, June.

Gilly J.P., Torre A., 2000, *Dynamiques de proximité*, L’Harmattan, Paris, 301

Jaffe, A.B., 1989, "The real effects of academic research", *American Economic Review,* 79(5), pp.957-970

Jaffe, A.B., Trajtenberg M., Henderson R., 1993,"Geographic localization of knowledge spillovers as evidenced by patent citations", *The Quaterly Journal of Economics*, août, pp.577-598

Hagedoorn J., 2002, "Interfirm R&D partnerships: an overview of major trends and patterns since 1960, *Research Policy*, 31, 477-492.

Machlup, 1983, *The production and distribution of knowledge in the united states*, Princeton university Press, Princeton

Marshall A. (1920). *Principles of economics*, London, mac Millan.

Massard N., 1997, « Externalités, apprentissage et dynamique technologique, un retour sur la notion de réseau », in Guilhon B., Huard P., Orillard M., Zimmermann J-B (1997), L'Harmattan, Paris, pp.336-355

Massard N., 2001, "Externalités de ocnnaissances et géographie de l'innovation: les enseignements des études empiriques", Séminaire d'experts sur l'économie de la connaissance, CGP, 7 février, p.19

Malerba, F., Orsenigo, L., 2000. "Knowledge, innovative activities and industrial evolution", *Industrial and corporate change,* 9(2), 289-314

Massard, N., 2001, « Externalités de connaissances et géographie de l'innovation: les enseignements des études empiriques », Séminaires d'experts sur l'économie de la connaissance, CGP, 7 février, 19 p.

OCDE, 2001, *Tableau de bord de l'OCDE de la science, de la technologie et de l'industrie: Vers une économie fondée sur le savoir*, Paris.

Polanyi M. (1954) *Personal knowledge. Toward a post critical philosophy,* London, Routledge.

Powell, W., 1990, "Neither market nor hierarchy: Network forms of organization", *Res. Organ. Behavior*, 12 295-336.

Rallet A., 1997, « Les technologies de l'information et de la communication et la coordination à distance dans les activités de recherche d'innovation », *in* Lung (Y.), *Organisation spatiale et coordination des activités d'innovation des entreprises*, 77-96.

Rallet A., Torre A., 2001, « Proximité géographique ou proximité organisationnelle ? Une analyse spatiale des coopérations technologiques dans les réseaux localisés d'innovation », *Economie appliquée*, tome LIV, n°1, pp.147-171

Rullière J.L, Torre A., 1995. "Les formes de la coopération inter-entreprises", *Revue d'Economie Industrielle,* Hors-Série, Numéro exceptionnel, pp.215-246

Saxenian AL. (1994) "*Regional advantage: culture and competition in Silicon Valley and Route 128*", Cambridge MA, Harvard University Press.

Veugelers R., De Backer K., année. « Access to external knowledge : an empirical analysis of alliances as spillover channel".

Zucker, L., Darby M., Armstrong J., 1994. "Intellectual capital and the firm: The technology of geographically localized knowledge spillovers", Cambridge, MA: *NBER*.4946

Zucker, L., Darby M., Armstrong J., 2001. "Commercializing knowledge university science, knowledge capture, and firm performance in biotechnology", Cambridge, MA: *NBER*, 8499, p.42