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Technologies : A Brief Theoretical Note**

Par

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Conditions of diffusion of competitiveness clusters' technologies: a brief theoretical note

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July 22, 2015

Abstract

Competitiveness clusters (or innovation clusters) are the focal point of french new industrial policy. They are based on classical cluster model and its well-known agglomeration positive externalities and on benefits of cooperation. After a brief literature review of cluster theory, we focus on the theoretical conditions under which french innovation clusters can foster production and diffusion of technological innovations. Our critical analysis points out three non-exhaustive conditions: (i) the capacity to coordinate and to incitate cooperation in R&D; (ii) the capacity to favor production and technological knowledge transfer; (iii) the capacity to promote and to keep R&D appropriation by cooperating innovators.

Keywords: innovation cluster, coordination, cooperation, installed base, organisational absorptive capacity, collective appropriation.

JEL classification: O20; O30; R30.

1 Introduction

Since the advent of what is now called the economics of knowledge after the seminal book of Fritz Machlup entitled "The Production and distribution of knowledge in the United States" published in 1962, research and innovation activities have become over the years the main factors of growth and competitiveness of firms in industrialized countries. This is how to face strong international competition and relocation of its firms in the early 2000s, France has undertaken in 2004 a new industrial policy based on the model of clusters and using scientific, technological and organizational innovation. This is the innovation clusters-based industrial policy called "competitiveness clusters". The basic idea of competitiveness clusters is to promote cooperation between business networks, territories skills and

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innovation in order to create an innovative environment to strengthen firms competitiveness, employment and growth. Formally, a competitiveness cluster has been defined as "the combination, on a given territory, of companies, training centers and public and private research units engaged in a partnership in order to create synergies around common innovative projects"(Marcon, 2008).

The collaborative R&D projects figure prominently in the new industrial policy and their funding comes from public funds (Interministerial Unique Fund or FUI), state agencies (ANR, OSEO) and local authorities. The R&D projects are seen as a way of structuring cooperation relationship (Dessertine, 2014). Today, there are 71 active competitiveness clusters in various sectors and especially in high-tech sectors such as nanotechnology and embedded software, renewable energy, biotechnology. However since its implementation, competitiveness clusters raises many questions in scientific communities. One of the first concerns is the issue of its governance and coordination of different actors within the clusters (Tixier and Castro-Gonçalves, 2008; Défélix et al., 2009; Gomez, 2009; Retour, 2009). Indeed, each competitiveness cluster has its own mode of governance, in most cases, an association composed of industrial actors, academic and local authorities. This governance involves a positive sum game, a mix of cooperation and competition between the actors. Thus, how the internal organization of the clusters are managed to converge towards common projects of actors who are subject to different legal rules and taxes and whose interests are diverse natures and time horizons. In other words, this goes back to the question of the ability of competitiveness clusters to generate cooperation between actors. Another issue closely related to the first is the role of competitiveness clusters in encouraging production and diffusion of technology innovations. Finally and more generally, in terms of public policy, the new policy raises the question of its role in the articulation of the public/private research policy and industrial policy. It is thus clear that the adequate theory of competitiveness clusters is necessary in the sense that the governance of these clusters depends on both the degree of convergence of actors towards joint R&D projects and the development of an innovative environment capable to incitate, produce and favor sharing and dissemination of new knowledge.

This paper is a reflection on the question of the diffusion of clusters' technology innovations. Thus, through a theoretical approach based on a critical view of the economic literature of clusters, we try to analyze and understand the conditions in which competitiveness clusters can participate in the creation, development of innovative products and processes and their dissemination. For us, three non-exhaustive conditions are necessary: the ability of competitiveness clusters to coordinate and foster cooperation between actors, their ability to promote production and technology transfer and their ability to promote and secure the appropriation of R&D outputs.

The rest of the paper is organized as follow. In the section 2, we highlight the theoretical framework of the competitiveness clusters policy. Section 3 is dedicated to the critical reflection on the conditions in which competitiveness clusters can serve as a support for the production and diffusion of technological innovations.

Section 4 concludes the paper.

2 Cluster-based industrial policies: an overview

It is now well-accepted in the economic literature that innovation is the main driver of economic growth (Solow, 1956). At firm level, innovation is seen as the price to stay on the market. However, innovation activity is inherently uncertain, disorderly and built from complex systems that often require adequate coordination of technical knowledge (Kline and Rosenberg, 1986). According to neoclassical theory only the market (through prices mechanism and competition) has the ability to coordinate economic actors for optimal allocation of resources. In the field of technology, market relationship should therefore encourage involved actors in the creation and use of new knowledge but also regulate and compensate fluctuations in supply and demand (Maskell and Lorenzen, 2004). The market coordination may be sub-optimal in the presence of significant transaction costs related to price mechanisms. Moreover according to Arrow (1962) the market mechanism results in sub-optimal allocation of resources of knowledge in the production of innovation. This is explained by the fact that innovation has a public good feature and its appropriation by innovators remains imperfect. The difficulty of appropriation of the results of R&D reduces incentives to innovate. Therefore, firms underinvest in research and development even if there is a strong system of intellectual property.

To encourage R&D activities and boost firms competitiveness and growth, public policy-makers invest more public funds in supporting private R&D activities and promote collaborative research policy through localized and specialized structures such as clusters. Note that the concept of "cluster" was made famous by Michael Porter in the 1990s. For Porter (2000), "clusters are geographic concentrations of interconnected companies, specialized suppliers, services providers, firms in related industries, and associated institutions (e.g., universities, standard agencies, trade associations) in a particular field that compete but also cooperate". Today, clusters have become the main strategy of industrial policies in Europe and elsewhere (Ketels, 2004). They are associated with firms progress and success in innovation, especially in the field of high technologies (Baptista, 1996). Even OECD uses clusters as the keys of development and growth (Martin and Sunley, 2003). The EU research and innovation policy gives priority to clusters as strategic policy tools for promoting innovation, increasing competitiveness and creating employment.

The implementation of competitiveness clusters is based on a dual logic: agglomeration and geographic proximity. In economic literature, we find the origin of competitiveness clusters in the Marshall's concept of industrial districts (Marshall, 1920). Indeed Marshall's observations on the concept of external economies in localized industries have generated several studies on the benefits of agglomeration and geographic proximity. We learned about that agglomeration is favored by increasing returns to scale and that it increases the intensity of interactions between actors co-located (Arthur, 1989; Ketels, 2004), promotes the availability of

low-costs intermediate inputs and expertises, sharing of common and specialized infrastructures (Krugman, 1991). The agglomeration and proximity also facilitate the transfer and acquisition of tacit and complex knowledge between firms and increase their absorption capacity (Jaffe et al., 1993; Cohen and Levinthal, 1990; Audretsch and Feldman, 1996). In this sense, a cluster provides a local competitive advantage. Clusters promote the strengthening of the network dynamics of companies and therefore enable risk sharing and reduction of static and dynamic uncertainty related to innovation.

In addition to the specificity of competitiveness clusters, note that the definition of competitiveness clusters policy explicitly consider the influence of historical trajectories and organizational contexts of local territories on the dynamics of innovation. In other words, the configuration of the French innovation clusters is characterized by the path dependency¹ of the host localities. It therefore takes into account their values, R&D capacity, industry specialization, historical events, institutional arrangements and means. Thus, because the sectorial specialization in repeated interactions between actors necessarily involves specific assets, a cluster theoretically acquires a competitive advantage but is exposed to the phenomenon of "cluster lock-in", i.e enclosing on itself and so its inability to exchange and interact with the outside.

Furthermore, several studies covered the shortcomings of clusters. According to Martin and Sunley (2003) the concept is fuzzy and is simply a politic tool rather than operational. Baptista (1996) shows that the dynamics of clusters can be a victim of congestion effects such as urban congestion, pollution and the difficulty of coordination between actors. This raises the question of the optimal size or critical mass of competitiveness clusters. In addition, according to Giuliani (2007) and Maskell and Lorenzen (2004), there is a structural difference between clusters and business networks. According to the authors, the business networks are characterized by dense dynamic relationships based on mutual trust, so that clusters are simple knowledge-sharing networks; Giuliani (2007) empirically shows that knowledge spillovers only benefit a small number of firms in clusters. So there is not necessarily conceptual relationship between cluster and potential innovation. Another limitation of agglomeration is the effect of competition that could engage co-located firms to capture the rent and the risk of homogenisation of activities.

3 Technology diffusion inside clusters: conditions

The research on the diffusion of innovations is abundant in IO's literature. The diffusion of an innovation is defined as the process by which innovation is transmitted and/or adopted in time by consumers (Rogers, 2003). Several factors may explain the diffusion: supply and demand (Griliches, 1957), trade-off between ben-

¹The idea of the "path dependency" resulted in this sentence taken from Penrose (1959): "the resources with which a particular firm is accustomed to working will shape the productive services its management is capable of rendering". This expresses the idea that the performance and firms trajectories and organizations are largely functions of their particular history and routines they have accumulated.

efits and costs of adoption, information and uncertainty on innovation, social and industrial environment (Geroski, 2000; Hall, 2003) and communication (Rogers, 2003). The factors that explain diffusion rate may be endogenous or exogenous. The endogenous factors are the intrinsic characteristics of the product and innovative processes while exogenous factors are those related to the socio-cultural environment and industrial organization. In this study, we consider a competitiveness cluster as an external factor and we are interested in its role as an industrial organization or a support enabling co-production and diffusion of technological innovations. For us, the ability of the French innovation clusters to facilitate the production and diffusion of technological innovations must obey three non-exhaustive conditions: (i) its ability to coordinate the actors and stimulate R&D cooperation, (ii) its ability as industrial organization to produce knowledge and to facilitate its transfer, (iii) its ability to promote and secure appropriation of R&D outputs by innovative firms in cooperation.

3.1 Coordination and R&D cooperation

The competitiveness clusters will promote co-production and diffusion of new knowledge if they really generate good strategic interactions and cooperation between the actors around common projects. However, geographical proximity aroused by competitiveness clusters does not guarantee the existence of dense relationships. It does not constitute a necessary coordination support to cooperation between economic agents (Mendez, 2008); it seems rather that geographical proximity is decisive for the most upstream phases of the production of innovations (Carré et al., 2008). Moreover, unlike most clusters and districts, designing and structuring of competitiveness clusters have not made spontaneously. The competitiveness clusters policy was driven by the French State as a new industrial policy; then we can assume that some competitiveness clusters were created for the sole purpose of responding to the opportunity offered by the State for the territories. In this case, it would be called occasional cooperation for the capture of public funds. But even assuming that the policy is set up according to the real potential of stakeholders and territories, the network of actors that started moving inside each competitiveness cluster does not guarantee the quality of relations between them. So, the role of the cluster in the co-production of knowledge is either to activate or to strengthen the links between actors who ignore each other.

The co-production of technological knowledge requires a common or convergent vision; hence the importance of the central role of the governance structure as a coordination and emergence structure of cooperation between actors. According to Calamel et al. (2012), coordination refers to deliberate and intentional actions to structure the partnership activities inside the cluster. It therefore requires a mandatory hierarchic process based on procedures while cooperation rather requires voluntary mutual adjustment. It is therefore for the cluster governance structure firstly to define common strategies for alignment or convergence of cognitive and technological capabilities and expectations of stakeholders, and also to bring out collaboratives projects. The issue of governance leads up to the question

of effective integration of small and medium enterprises and their role in the choice of collaborative R&D projects. We note that to promote the dynamic of business network and the emergence of collaborative R&D projects, clusters often proceed by fairs of projects (e. g. cluster Minalogic), innovation workshops (e. g. cluster Techtera), calls for internal projects (e. g. cluster Axelera) or collaborative days. But all these strategies do not remove the risk of seeing the establishment of a governance around large dominant firms which impose their rules to dominated small firms. For instance, [Bossard-Prechoux and Brechet \(2009\)](#) showed that the process of emergence of collaborative projects is done in several steps and it starts around a core group of large companies to the peripheries composed mainly of small businesses. In fact a theoretical analysis of the structure of governance as a coordination support of cooperation between actors would be necessary to understand the logic of coordination within the competitiveness clusters. For this analysis, one could for example build on the work of Olson "The Logic of Collective action: Public Goods and the Theory of Groups" published in 1971. The analysis should be complemented by empirical research on clusters.

In addition to the coordination issue, there is also the issue of cooperation around common projects. The governance structure should encourage cooperation relationship between clusters' members because the actors' motivation to cooperate is not "natural" but is acquired over time ([Calamel et al., 2012](#)). The inter-firms cooperation not only fits in a logical organization of transactions between contracting but also in a strategic sense, complementarity of firms for innovation ([Abdessemed, 2001](#))². Competitiveness clusters should be the privileged framework of inter-firms cooperation³ inter-firm within the cluster and inter-cluster cooperation. Firms can not continue to manage knowledge in isolation; they do not always have all necessary information for implementation of their competitive strategy and more specifically their technological innovation strategy. So, this implies looking for additional information with other firms and research centers. To do this, cooperation relationship must be increasingly strengthened and contractualized. These relationships should involve both large companies and small ones. Small businesses should be helped and encouraged to be heavily involved to cooperate and interact. Within clusters, they will enjoy the benefits of cooperation that can be esteemed in informational terms (i.e. network effects, spillovers) and non-informational terms (i.e. share of research costs and risk, high probability of successful innovation, etc.)⁴.

²[Abdessemed \(2001\)](#) talks about "transactional approach" of cooperation based on the organization of transactions and related to asset specificity and "strategic approach" of cooperation resulting from the interdependence of firms and based on the joint production resources, innovation.

³For instance in the cluster Minalogic in Grenoble, one often distinguishes between two types of cooperation: outsourcing (asymmetrical relationship) and cooperation properly spoken (asymmetrical relationship). The cooperation relationship is low contractualized and relatively informal.

⁴See for example the work of [d'Aspremont and Jacquemin \(1988\)](#), [Boivin and Vencatachellum \(1998\)](#) and [Miyagiwa and Ohno \(2002\)](#).

3.2 Knowledge production and spillovers

Whatever the model type, the diffusion of an innovation is based on the transfer of information (or new knowledge) from a transmitting source to a receiving entity. Production and transfer of knowledge are central in the competitiveness clusters policy. The clusters will get local competitive advantage in the ease with which they allow the transfer and acquisition of knowledge especially tacit knowledge between co-located firms. Indeed, this form of knowledge is supposed spatially less mobile and the dissemination of related technology is possible through personal contacts and by word-of-mouth (Maskell and Malmberg, 1999). This was showed by Geroski (2000) et Rogers (2003)⁵. The learning of such technology is through a regular practice. Therefore, localized activities facilitate the development of collective learning process and increase innovations diffusion rate. But for that, a competitiveness cluster must: (i) create an enabling environment and be a kind of an installed base of innovations through the network of actors in motion, (ii) promote increase of its organizational absorptive capacity and also boost individual firms absorptive capacity.

3.2.1 Cluster as an installed base of innovations

The diffusion process is often facilitated by the positive network externalities. We note that there are positive network externalities⁶ when an innovative product becomes more valuable for a user with increased number of adopters users for the same product or compatible products (Tirole, 1988). This effect can be direct or indirect when there is an increase in the value of innovation following a large number of complementary products on the market. A competitiveness clusters, being composed of networks, can be seen as an "installed base" or a support of innovations especially when there is a dense network. An installed base measures the number of sold units and currently in use; it is not to be confused with the market share that reflects only the sales in a given period. The positive effect of network is operated within the competitiveness clusters through the sharing of knowledge and information. Thus, the clusters can facilitate the coordination of expectations on the choice of technologies to adopt. Indeed, more a cluster promotes exchanges, communications and R&D cooperation agreements between actors, more classical inefficiencies are generated in networks, i.e excess inertia and excess precipitation⁷, will be avoided. The competitiveness clusters as installed bases of innovations through dense networks can act for the establishment of

⁵According to Geroski (2000), the informational delay for the availability of a new technology may be the cause of differences in time adoption. However, it shows that the adoption of technology can be slower than the diffusion of related information. This is a typical example of "hardware" and "software" highlighted by Rogers (2003). Indeed, even if the source of knowledge exists and is common (e.g. impersonal manuals), diffusion of information (i.e. the software) is done through a experience of use. The knowledge transfer is done by word of mouth.

⁶Formally, there are positive network externalities when $\partial d_i / \partial D_{-i}(x) > 0$ avec $D = D_i + d_i$, which represents the total demand.

⁷These two inefficiencies often pose problems when the time information or reaction are long or when users have opposing preferences on norms and standards to choose.

norms and technology standards and encourage firms to make compatible their innovations in order to promote diffusion and adoption.

3.2.2 Cluster as a booster of firms absorptive capacity

The absorptive capacity of a competitiveness cluster as industrial organization can play an important role in the production and transfer of innovations. The concept of absorptive capacity was introduced by [Cohen and Levinthal \(1989\)](#). According to the authors, R&D investments not only serve to generate innovation, but also to develop and maintain the absorptive capacity. The absorptive capacity of an organization is its ability to recognize, understand, and exploit the flow of new information (or spillovers) from other organizations. As defined, the absorptive capacity defines some "productivity" of spillovers: the bigger it is, the higher the spillovers have effect on the organization's productivity. The development of the absorptive capacity is by learning. In the case of clusters, it depends on previous accumulated stock of knowledge, type of technological knowledge and structure of coordination and internal communication. However, the factors that encourage organizations to learning are the amount of knowledge to assimilate and exploit and the difficulty of learning ([Cohen and Levinthal, 1990](#)). Learning is difficult in an environment that has not accumulated prior knowledge and then becomes very expensive. However, we can safely state that two specificities of competitiveness clusters promote the strengthening of their absorptive capacity and so boost individual firms absorptive capacity. First, the dependency of technological trajectories (or path dependency) that allows learning at low cost and second, the large number of actors in interaction. Competitiveness clusters are therefore a "natural" environment conducive to learning, so the diffusion and adoption of innovations. They therefore need to densify the network and the interactions between firms.

Finally, competitiveness clusters need to diversify their knowledge base to increase the absorption capacity of individual firms and so limit the effect of uncertainty. Indeed, the ease of learning is also affected by the degree with which an innovation is related to existing knowledge base. To do this, the structure of coordination and communication should promote cooperation agreements with other clusters, other external actors and firms and allow opening outwards.

3.3 Collective appropriation of innovations

The problem of appropriation of research outputs remains a critical issue in innovation diffusion process. Indeed, the "public good" feature of the information produced generates opportunistic behavior and low appropriation of innovation. So to encourage private innovation, instruments of appropriation and privatization of gains were designed (i.e. patents and licenses). In addition to these instruments there are also other public mechanisms, so-called socialization of costs mechanisms, such as research laboratories and public funds. The new clusters-based industrial policy can be located halfway of the two previous mechanisms ([Crampes and Encaoua, 2005](#)). However the collective appropriation of innova-

tion in the framework defined by this cluster policy could pose many problems of governance and regulation. Indeed firms engage in R&D cooperation agreements because they expect to benefit from the results of research. The diffusion of innovation conditioned by R&D activities also depends on the degree of appropriation of innovation. If the actors are uncertain about the outcome of R&D cooperation agreements, they will be reluctant to cooperate. The structure of coordination and communication of competitiveness clusters will therefore facilitate and secure business profits especially for small and medium enterprises. To do this, competitiveness clusters can integrate outside expertise for training, supports for actors in negotiations and pre-contract, post-contract procedures, confidentiality of information, sharing of results procedures, etc.

4 Conclusion

In this paper, we tried to understand the conditions under which the policy of competitiveness clusters can actively participate to production and diffusion of technological innovations. Our critical analysis based on literature review highlights three non-exhaustive terms: (i) the ability of competitiveness clusters to coordinate and stimulate cooperation among stakeholders; here, we noted that the governance structure of clusters should be investigated and adequately model; it must reinforce collaboration and cooperation among firms; (ii) the ability of firms to generate and transfer technological knowledge; to do this, the firms' network of clusters can be seen as an installed base of innovations and a support of diffusion. Furthermore competitive clusters are "natural" environments to promote learning (and technology adoption) and strengthen the absorptive capacity of firms through technological trajectories. They will also densify the network of actors that they put in motion; (iii) the last condition is that the ability to promote and secure the appropriation of R&D outputs by firms who work around collaboratives projects. The clusters will assist for training and firms coaching to design intellectual property.

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