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INNOVATION CLUSTERS AND NETWORKS: A CRITICAL REVIEW OF THE RECENT LITERATURE

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Abstract:

The academic interest in innovation clusters and networks has given rise to a vast stream of works in recent years. Besides defining the notions of clusters and innovation clusters or networks, a core topic within the literature relates to the analysis of the logics underlying the emergence, the structuring and the evolution of innovative activities within various geographic areas. But despite the large amount of efforts deployed, there are no consensual views amongst academics on various conceptual and analytical key issues, especially as regarding the spatial/geographical boundaries of an innovation cluster and the nature and intensity of the actors interaction that characterize it. The whole picture is also blurred as a persistent “disciplinary segregation” prevent from integrating the most valuable and converging insights that could be drawn from various yet complementary social sciences perspectives. The paper offers a critical survey of the most visible pieces of the literature and suggests some possible pathways for a better analytical grounding of clustering and networking phenomena within innovative or creative fields.

Key words: Innovation Clusters and Networks; Spatial Scales; Emergence and Structuring Processes

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1. Introduction

Since the mid 90's, an increasing research effort has been devoted to the study of innovation clusters and networks. Scholars from various fields such as Economics (especially industrial economics and 'new' economic geography), as well as Economic Sociology and Strategic Management, have engaged in continuous investigations, either theoretical/conceptual, methodological or (mostly) empirical. One key common challenge of these research efforts has been to provide in-depth analyses of the spatial dimensions and mechanisms (mainly at the national or regional level) underlying the clustering and networking phenomena in prominent high-tech sectors, notably in biotechnology, ITC, nanotechnologies, new materials, and space and defence industries.

This academic interest in innovation clusters and networks analysis has been accompanied and encouraged by the growing conviction expressed since the late 90's by many governments and international organisations (notably the OECD and the EU) that national competitiveness in a global economy lie paradoxically, as Porter (1998) puts it, in "local things". Following this conviction, most governments in developed, emerging or developing countries have engaged in more or less active cluster policies, but with differentiated achievements and success. Along with these policies, national or regional governments and international organizations have supported and funded a large set of academic researches in order to enlighten their choices and actions in favour of innovative sectors and regional development and competitiveness.

Amongst the numerous research issues addressed in the literature, the analysis of the logics (scientific and technological, economic and financial, historical and institutional)¹ underlying the emergence, the structuring and the evolution of innovative activities within various geographic areas (metropolitan areas, regions, countries) appears to be a core topic. In most works, the emphasis is (explicitly or implicitly) put on one or both of two central issues. The first one relates to the nature and the intensity of the relationships between the key actors involved in innovative activities (especially in high-tech sectors): universities and research labs, firms, funding organisations and public/governmental institutions. The second (and partly related) issue concerns the relevant spatial/geographical scaling of innovation clusters and networks. Behind these issues lies of course also the conceptual challenge of defining what a "cluster" is in general, and what is an "innovation cluster" or an "innovation network" in particular.

But despite numerous research efforts and some valuable results yielded, all these issues are still sharply debated. In fact, when surveying carefully the large available literature, one can only but concludes that there are no consensual views amongst academics or even a few well documented 'stylized facts', either at the conceptual/theoretical or methodological/empirical level. Neither the definition of what is *really* a cluster (and specifically, an innovation cluster or network), nor what could be its spatial/geographical boundaries and its conditions of emergence and evolution are clearly and coherently established. By the same token, the literature displays a large variety of analytical/theoretical/methodological approaches and a persistent "disciplinary segregation" which all together blur even more the picture.

¹ This relates to the idea that these logics follow a co-evolutionary spatial and inter-temporal dynamics, as demonstrated for the case of pharmaceuticals and biotechnology during the 20th Century (Depret and Hamdouch, 2006, 2007; see also Gisling and Nooteboom, 2004). By the same token, the dynamics underlying innovation and knowledge creation/diffusion/accumulation processes take place within a multi-spatial framework (Hamdouch and Moulaert, 2006).

Through a critical survey of the most visible pieces of this literature, the aim of this paper is to highlight the various dimensions and implications of the issues at stake while providing at the same time some “reading keys” of the conceptual and analytical challenges that these issues raise. The paper is structured as follows: section 2 tries to disentangle the various definitions and conceptual approaches of the notion of “cluster” as stated on general grounds, and discusses the analytical and operational difficulties it entails. This discussion is crucial as it underlies some of the key analytical problems one encounters when turning specifically to the notions of “innovation clusters” and “innovation networks”. As shown in section 3, important indeterminacies remain as regarding these notions yet some useful insights and stimulating ideas can be drawn from several works. Building on the discussions developed in sections 2 and 3, section 4 is aimed at clarifying some key conceptual and analytical issues related to the dynamics underlying innovation clusters and networks formation and structuring. Here, I make also some suggestions on how these dynamics could be, potentially, better conceptualized through the notion of “multi-scaled networks”, though the notion is only “embryonic” and then requires further analytical elaboration. Section 5 concludes the paper by pointing out some important challenges that are still to be tackled if one wants truly to demonstrate that innovation clusters and networks are relevant phenomena for innovation dynamics analysis.

2. What is a cluster, *really*?

When one scans the literature dealing with “clusters” that has proliferated in recent years and tries to capture what could be the essence and the foundations of the notion, the result is quite frightening: there exists merely as much different definitions of what a “cluster” might be as there are authors or publications — even if, very often, the differences are only marginal or anecdotic.² Furthermore, whatever the definition encountered the notion of cluster remains rather fuzzy in its theoretical “contours” (Martin and Sunley, 2003, even talk of a “chaotic concept”). This lack of clarity and conceptualization turns even worse as the notion of cluster is frequently confused with many other supposed to be “neighbouring” notions or concepts — which are then used as equivalents or even synonyms of the term “cluster” without systematic and due clarification or justification. Notions such as “network”, “value chain”, “industrial district”, “local production system”, “innovative milieu”, “regional system of innovation”, “new industrial space”, “scientific/technological park”, “pôle de compétitivité” (the “French touch”) ... are “floating” together in the literature on clusters and cluster policies.³ Some distinctions are also frequently encountered, which add to the general confusion as the criteria used for such distinctions are rarely specified: “industrial district” vs. “innovation district”, “industrial cluster” vs. “innovation cluster” / “technological cluster” / “knowledge cluster”, “production network” vs. “innovation network”, “industrial region” vs. “learning region”, and so on.

² I will not enter here in a detailed (and somehow vain) listing exercise of all authors and definitions. Large samples of these notions and their various conceptions have already been compiled by others and can be found for example in Martin and Sunley (2003, pp. 10-13), and in Preissl and Solimene (2003, Ch. 3).

³ To take just an example, Nooteboom (2004, pp. 2-3) says straightforward that “Apparently, clusters and industrial districts are more or less synonymous” and that “Presumably, the notions of ‘innovation clusters’ and ‘regional innovation systems’ are close synonyms”. But as Moulaert and Sékia (2003) show, among others, these notions are quite distinct concepts as they relate each to a different theory of territorial development.

In fact, it is difficult even for specialized academics to swim within such troubled water. Yet, fortunately, a few but valuable syntheses and critical attempts have been proposed which contribute to conceptual and analytical clarification of the various notions and approaches in the literature (*cf.* den Hertog and Roelandt, 1999; Martin and Sunley, 2003; Moulaert and Sékia, 2003; Preissl and Solimene, 2003, ch. 3; Bekele and Jackson, 2006). These authors provide also a useful survey of old and recent theories of industrial location and regional/territorial development, ranging from the “canonical” theories (Marshall, Weber, Hoover, Lösch, Jacobs...) to contemporary approaches rooted either in economic geography (especially the “Californian School”), in economics (new geographical economics, endogenous growth theories, new industrial organization theories, evolutionary theories, regulation theories), in economic sociology (social networks theories) or in the managerial literature (especially in strategic management, with Porter as a prominent representative...).⁴

As my focus in this paper is only and explicitly on the “cluster literature”, narrowly speaking (i.e. only the literature using explicitly the term “cluster” and focusing on the study of “clusters”), and due to space limitations, I do not go into the analysis of these various approaches. I will rather go back to the notion of “cluster” *per se* and try to identify which content and features it is supposed to exhibit. Despite the wide variety of cluster definitions in the literature, it seems to me that the spectrum of the different conceptions could be considerably reduced if we are able to select only few relevant, discriminating criteria. By a matter of fact, after a careful screening of non-redundant features included in the various definitions proposed, two criteria appear to be particularly important. The first one is related to the *territorialized vs. non-territorialized* conception of the cluster notion. The second decisive criterion corresponds to *the focus vs. non-focus of the notion on activities or industries strongly based on innovation*.

On this basis, the full range of cluster definitions fall more or less under two main lines of conception. The first one turns around Porter’s works and the many authors that, broadly speaking, follow his approach. The second line, which is clearly more heterogeneous, is in tune with the OECD approach and/or follows “reticular” conceptions of clusters. Of course, a series of nuances, subtleties and incremental differences persists amongst the various definitions of clusters. Still, the two identified lines of cluster conception are quite likely to reflect most of the definitions of clusters encountered in the literature because they have also been the most influential (especially the Porter approach) in the academic field as well as in political circles (Martin and Sunley, 2003).

I examine successively these two conceptions and stress their shortcomings and the main conceptual and analytical problems they entail.

Porter’s approach and its various ‘contortions’

If the origins of the notion of “cluster” can hardly be traced back with precision, it is undoubtedly Michael Porter who popularized it from his 1990 book *The Competitive Advantage of Nations* (Porter, 1990), and then elaborated it later in a number of his publications (see especially Porter, 1995, 1998a, 1998b, 1998c, and 2000).

First, Porter (1998c, p. 78) defines in a very general manner what he means by “clusters”:

⁴ See also Scott (2004) for a useful discussion of the evolution pathways during the last decades of economic geography theories and their today increasing insemination by the so-called “new geographical economics”.

Clusters (are) critical masses - in one place - of unusual competitive success in particular fields. (...) Clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition.

Then he indicates the features that make, in his view, the cluster being an efficient form for the spatial organization of industrial activities:

Clusters promote both competition and cooperation (...). Competition can coexist with cooperation because they occur on different dimensions and among different players. Clusters represent a kind of new organizational form in between arm's-length markets on the one hand and hierarchies, or vertical integration, on the other. A cluster, then, is an alternative way of organizing the value-chain. Compared with market transactions among dispersed and random buyers and sellers, the proximity of companies and institutions in one location – and the repeated exchanges among them – fosters better coordination and trust. Thus clusters mitigate the problems inherent to arm's-length relationships without imposing the inflexibilities of vertical integration or the management challenges of creating formal linkages such as networks, alliances, and partnerships. A cluster of independent and informally linked companies and institutions represents a robust organizational form that offers advantages in efficiency, effectiveness, and flexibility (*ibid.* pp. 79-80).

In this conception, the cluster is meant as a *specific spatial industrial organization* based on two main dimensions: (a) The links between actors in terms of geographical proximity, of complementarities and of trustworthy relationships building; and (b) The existence of both competitive and co-operative interactions amongst the co-localized firms. It is the combination of these two dimensions that induces, according to Porter, a greater competitiveness of the firms and industries located within a cluster (comparatively to those operating in other organizational settings).⁵

This approach has been widely admitted and appropriated (with some nuances and variations) by many scholars and by national or regional policy-makers, probably due to its simplicity and an *a priori* convincing flavour. However, besides the fact that most Porter's assertions on the supposed direct links between industrial clustering and competitiveness are all but neither theoretically nor empirically demonstrated (see Martin and Sunley, 2003, for a detailed critical account), the notion of cluster as presented (and marketed) by Porter raises numerous key questions and analytical difficulties.

1) The first difficulty is related to the *identification of the relevant borders of the geographical space defining a cluster*. Here, Porter has varied significantly from one of his

⁵ As Porter admits it himself (Porter, 1998a), his conception has been initially to a large extent inspired by Alfred Marshall' "industrial districts" conception — but with no further explicit emphasis put on the key elements he picked up from his famous century ago or so predecessor... In fact, the two key dimensions of clusters emphasized by Porter overlap clearly and comprehensively with those stressed by Marshall, though in different wordings: "When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air (...) Good work is rightly appreciated; inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed; if one man starts a new idea it is taken up by others and combined with suggestions of their own, and thus it becomes the source of further new ideas" (Marshall, 1903, Book IV, Ch. X, pp. 152-153). For a renewed and enlightening presentation of industrial districts in the contemporary Italian context, see Beccatini (1990).

writings to another, but resting in the end on a very vague spatial bounding of the cluster. In a first approach, Porter (1998c, p. 79) defines these boundaries with no spatial reference at all:

A cluster's boundaries are defined by the linkages and complementarities across industries and institutions that are most important to competition.

In another article, two years later, Porter (2000, p. 16) provides a different definition including a spatial, though very permissive reference:

A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. The geographic scope of a cluster can range from a single city or state to a country or even a group of neighbouring countries.

As one can easily notice, this spatial bounding of the cluster is all but unclear. The first definition stresses *organizational and competitive borders rather than spatial borders*, whereas the second definition envisages *all geographical scopes* as being as relevant spatial cluster boundaries, including the entire country or even a group of geographically close countries... Thus, this conception departs from the Marshallian industrial districts' approach while at the same time moving towards more *reticular conceptions of the cluster* (see below). But then, what distinguishes the notion of *cluster* from the more general notion of *network*?

2) In his "territorialized" conception of clusters, Porter poses the existence of an *array of inter-related industries* (and other entities and institutions) that are important for competition (Porter, 1998c, p. 78). Yet this supposed interindustrial feature of the cluster remains also unclear. Does-it refer to *vertical industrial complementarities*? In this case, it would overlap with the "value chain" (an eminently Porterian notion, indeed...) conception of the cluster as proposed by the OECD definition (see below), or more simply with the concept of "filière de production" developed in France in the early 1980's (see Monfort, 1983). Or does-it relate to *horizontally different but co-localized industries*? This would then correspond to a conception of industrial location close to classical or more recent theories of urban and regional agglomeration in which co-localized firms and industries benefit from common markets of input factors and from the existence of a pooled basin of labour force and competences.

In both cases, the notion of "cluster" would lose much of its (alleged) specificity. Besides, the idea that the cluster's industrial diversification, and therefore that the diversity of activities and competences in the same place would augment the individual innovativeness of the firms located within the cluster is challenged by some authors. For example, Baptista and Swann (1998) show that if a firm is actually more likely to innovate if the labour resources linked to its sector are available within its regional location space, there is no robust relationship between the cluster industrial diversification degree and the total innovative propensity of the firms.

3) The third difficulty is related to the way Porter characterizes the links amongst the firms (and other organizations and institutions) within a cluster. For him, these links are *informal*, and this precisely for this reason that clusters are seen to be more efficient and flexible modes of industrial organization than pure market relationships, but also than vertical integration, alliances, partnerships and networks (see above the citation from Porter, 1998c, pp. 78-79). But, paradoxically, these latter *formal modes of industrial collaboration* (along with more informal inter-organizational and inter-personal relationships) appear to be precisely key building blocks of most industrial and innovation networks. This is especially the case when

the mobilization of strong complementarities between specialized firms (and between the latter and other kinds of actors like research centres, universities or funding organizations) is crucial for industrial and commercial operations and for innovation processes. Indeed, these formal collaborative forms are generally most needed when innovation processes entail access to funding resources and to new knowledge and competence fields, and when then collaborative R&D raises crucial issues regarding appropriation and patenting.⁶

4) By a matter of fact, Porter's approach doesn't make any distinction among clusters according to the nature of the sector or activities considered. Indeed, traditional and mature sectors on the one hand, and innovative or high-tech sectors — especially science-based sectors — are not differentiated at all in the Porterian cluster approach. Moreover, Porter (1998c, pp. 85-87) goes as far as denying any relevance for the distinction between high-tech and low-tech industries. The importance of R&D and innovation processes seem then to be clearly underscored by Porter, yet these processes are actually at the core of sectors which dynamics are intensively based on the development and the exploitation of new knowledge and competence bundles (like in biotechnology or nanotechnology).

The reticular conceptions of clusters

Following the line of the studies initiated by the OECD (1999, 2001), an *essentially reticular conception of clusters* has emerged and equally diffused within the academic sphere in recent years:

Clusters are characterised as networks of production of strongly interdependent firms (including specialised suppliers), knowledge producing agents (universities, research institutes, engineering companies), bridging institutions (brokers, consultants) and customers, linked to each other in a value-adding production chain (OECD, 1999, p. 5).

Within the OECD stream of works, den Hertog and Roelandt (1999) have enriched this approach by including the *possibility of strategic alliances* between firms, but also between the latter and universities and research institutions.

Here, *there are the strong institutional and inter-organisational links between interdependent actors that define the network within a value-chain*. But the links envisaged are apparently only of a formal form, which then leaves besides all more informal interactions between organizational or individual actors. Yet these more informal links require a certain *topologic proximity* of the actors (Dahl and Pedersen, 2004; Nooteboom, 2004). Contrary to Porter (and many others), the OECD approach is not very explicit on this issue even if it stresses the frequently localized, but “open”⁷ nature of clusters:

In a knowledge-based economy, these clusters of innovative firms form around sources of knowledge. They are based on a sophisticated infrastructure in which knowledge is developed, shared and exchanged, and are characterised by highly concentrated and effective links between entrepreneurs, investors and researchers. Clusters can take a variety of forms, depending on their main technological and commercial areas of specialisation. In most cases

⁶ This pattern is clearly demonstrated for most sectors where innovation is the key engine for firm competitiveness and market competition, as it is the case for pharmaceuticals and biotechnology for example (Hamdouch and Perrochon, 2000a, 2000b; Hamdouch and Depret, 2001).

⁷ Indeed, this spatial openness of the cluster is rightly emphasized here as I think it truly constitutes a key feature of clustering and networking dynamics within innovative industries (see below in the next paragraphs, and the detailed discussions in sections 3 and 4).

they operate within localised geographical areas and interact within larger innovation systems at the regional, national and international level. With globalisation, dynamic clusters are becoming key factors in a country's capacity to attract the international investment that generates new technological expertise, to interest investors in innovation (venture capital, etc.) and to benefit from the international mobility of skilled personnel (OECD, 1999, p. 5).

Another approach, with a purely reticular conception of the cluster, goes far beyond that of the OECD in two combined directions: first, because it merges all spatial possible scopes within a global undifferentiated framework; second, because it completely dematerialize the cluster through assimilating it with a virtual innovation network based on a cross-learning process among electronically connected actors. Hence, Passiante and Secundo (2002) talk of “global virtual learning environment” and defend the following hypothesis: in a global informational economy, learning, which is at the heart of innovation processes, take place increasingly within virtual networks.

On the one hand, one can easily agree that this dimension of dematerialized exchanges of information and (codified) knowledge between distant actors is nowadays of unquestionable importance. In particular, it introduces the potentially advantageous possibility of “open” clusters and networks and of valuable connections and exchanges with actors or partners located in various more or less distant spaces. This “openness” of the cluster or network is particularly crucial when innovation processes entail some logic of “exploration”, i.e. of searching for and capturing new knowledge pieces (Nooteboom, 2004).

But, on the other hand, one must stress that electronic networks are not really adapted to the exchange of tacit knowledge (Preissl and Solimene, 2003). To be effectively exchanged, tacit knowledge requires spatial proximity and physical, material interaction (Dahl and Pedersen, 2004). Besides, even the electronic exchange of *codified knowledge* (especially if not yet published or legally protected) between distant actors usually requires a *minimum of previous direct or physical contacts* which initiate mutual recognition and cross-identification of the potential “corresponding” actors, and permits also to establish some trustworthy basis for further relationships.

In any case, even an essentially reticular approach of (loose) clusters with distant actors exchanging goods, services, technologies, knowledge or whatever necessarily would call for some *spatial dimension* (though not identified by a specific, singular geographical area), i.e. for *geographical landmarks* allowing each of the interacting actors to know where are located his or her partners and what are the institutional, political, social... specificities (and potential consequences) of that location.⁸ In other words, *each actor has a specific geographical location that is all but not neutral*. Indeed, in a context of a capitalist-driven economy where profit-seeking behaviour is the rule, no person (or organization) will exchange anything of some economic value to somebody else if, as a minimum basis for possible exchange or economic transaction, he or she (a) doesn't know where the distant counterpart is located, and (b) is not confident with this location. This means that the “geographical identity” of the actors matters, especially when crucial knowledge or technologies are to be shared or exchanged.

However, this doesn't mean that the interacting actors need necessarily or systematically to be co-located in the same geographical area. Indeed, as Owen-Smith *et al.* (2002) have

⁸ This idea is in tune with that of the “institutional embedding” of the actors interacting within a cluster or network (Nooteboom, 2004); see section 3.

convincingly demonstrated through the case of the Boston biotech cluster, firms from this area have developed strong relationships with “external” partners in the Bay area of San Francisco, in New York City area and abroad. This case shows that the relevant spatial scale of a cluster may be variable and “multi-territorialized” over several regions or even countries. Furthermore, in the latter configuration of multi-national locations of various partners, some authors have come to talk of “*Global Innovation Networks*” (*GIN’s*) (Ernst, 2006) which reflect the effects of the increasing internationalization of R&D activities of large firms and the growing structural relationships among production and research centres (“clusters”, indeed) localized in different countries.⁹ I shall go back on this in sections 4.

To conclude this section, it seems to me clear that if the notion of “cluster” is to be recognized some usefulness for the analysis of the spatial organization of production and innovation activities, it still has to be clarified and refined. It is precisely the pathway opened by the concepts of “innovation clusters” or more generally of “innovation networks”, especially in high-tech sectors.

3. Conceptualizing innovation clusters and networks

The critical survey of “Territorial Innovation Models” provided by Moulaert and Sékia (2003) is particularly illuminating as they identify five main models (namely: ‘Local Production Systems’, ‘Innovative Milieux’, ‘Learning Regions’, ‘Regional Innovation Systems’, ‘New Industrial Spaces’, and ‘Spatial Clusters of Innovation’). But they qualify the latter model as being a “residual category, with little affinity to regional economics but close to Porters clusters of innovation...” (p. 291).

On the grounds of the various analytical difficulties that the cluster notion entails (see above), one can only but agree with this statement. But, on the other hand, it is hard to dismiss it purely and simply as a possible pathway for analyzing clustering and networking dynamics and the spatial organization of innovation activities. First of all, because the five other territorial innovation models present also several important (yet probably more limited) deficiencies and shortcomings as Moulaert and Sékia (2003, p. 295) clearly recognize it:

The conceptual superficiality of the TIM [Territorial Innovation Models] literature is a consequence of several factors such as the immediate links with regional economic competition policy (many TIM were written to legitimize it), the general trend in today’s scientific practice of ‘fast theory building’ and the confusion of analytical modelling with normative modelling (...).

To be sure, the cluster approach could not be well ranked amongst the TIM regarding this various criteria! But, and this is my second “defending” argument, the notion of cluster could become useful if clarified and refined on more robust analytical grounds, especially if explicitly articulated (together with the notion of network) with innovation issues. My final argument in defence of a cluster approach is maybe the simplest: the popularity and the

⁹ In the Chinese case, for example, Hamdouch and He (2007) and Liu and Buck (2007) show clearly how important are becoming “*international technology spillovers*” in high-tech sectors (especially in ICT) due primarily to the increasing direct investments engaged by multinational companies for building production and research facilities in China, but also thanks to the ongoing building of strong relationships between Chinese firms and research centres with North-American and European partners. These links are particularly strong and dense with the Silicon Valley thanks to the moving back to China (but the same holds for India and Taiwan) of Chinese (Indian, Taiwanese) students and migrants (see Saxenian, 1999, 2006).

widespread of the cluster reference amongst academics (most the empirical work on innovation spatial dynamics use explicitly the term¹⁰) and in policy-making arenas (the “sacred” terms here are “cluster policy” or “cluster initiative”) should push one to see how to render this loose and problematic notion of “cluster” analytically better grounded and empirically more “tractable” and meaningful.

This is the path I try to pave here, though the specific literature on innovation clusters is not as prolific as the more general literature on clusters in providing definitions of the notion. Indeed, only few useful definitions have been proposed (yet with various wordings and denominations), most of them rather overlapping or complementary one to each other. I discuss here several of these definitions in order to identify what could be the main features and dimensions which appear to be important components of an innovation cluster.

Strong collaboration and links are not enough...

A first, rather general (and somehow deficient) definition is used here as an *illustration of what should be avoided* if one wants really to identify what makes the specificity of innovation clusters and networks vis-à-vis clusters, broadly speaking. As a “negative” of a photograph, it serves also to point out to some key dimensions that should be checked for getting the “positive” of the picture. This definition is due to Simmie and Sennet (1999) in their attempt to analyse “innovation in the London metropolitan region” (sic):

We define an innovative cluster as a *large number* of interconnected industrial and/or service companies having a *high degree of collaboration*, typically through a *supply chain*, and operating under the *same market conditions* (p. 51; emphasis added).

This definition rests, as one can easily see, on very general features that could *a priori* define any kind of cluster. Indeed, if a “high degree of collaboration” may truly play a key role in innovation clusters (see below), the other features overlap with those highlighted by Porter or the OECD in their generic definitions of clusters (see above section 2). Even worse, besides the fact that there is no explicit reference to innovative activities at all, this definition suffers from several restrictions and deficiencies:

- It restricts collaboration to that amongst firms, and then excludes all other important organizations that are usually key players in innovative clusters, especially universities and research centres.
- It talks of a “large number” of companies as a key feature of these clusters, but with no precision on what the threshold for this “number” should be.
- It considers the “supply chain” as the central locus of inter-firm collaboration, which constitutes a double misleading: (a) Only vertical connections are considered, ignoring thus all horizontal relationships (including those between direct or potential rivals); (b) The supply chain relates to productive and commercial linked processes, not to innovation processes, which is not truly the right way to proceed if one wants to talk about “innovative clusters”...

¹⁰ This is especially the case for empirical works on biotechnology (which represents a large share of the literature), on ICT sectors and (more recently) on nanotechnology. It is impossible to cite here all the numerous empirical works on innovation clusters and networks. I just refer to some important works (other references will be signalled in the sequel of the text when relevant): Saxenian (1994, 1999, 2006); Swann and Prevezer (1996); Castilla *et al.* (2000); Ahuja (2000); Depret and Hamdouch (2000); Cooke (2001, 2002); Zeller (2001); Owen-Smith *et al.* (2002); Powell *et al.* (2002); Feldman (2003); Waluszewski (2004); Chiaroni and Chiesa (2006); Robnson, Rip and Mangematin (2007)...

- There is no explicit indication on the spatial scope or dimensions of the “innovative cluster”. Why then talk of a “cluster” at all?
- Finally, the reference to the expression “the same market conditions” is vague and even intriguing. Does-it refers to “institutional conditions” (laws, regulations, political and administrative settings...) or to “competitive conditions” of the ‘market’ in question? In both cases, a spatial or geographical relevant bounding of the market should be indicated, but is not (see above). Still, the expression is in any case misleading in two ways: First, the interconnected companies may well be operating in different but complementary activities, and then at least partly belong to different markets. Second, innovation processes take place for the most upstream or outside markets, and the collaborations between firms (and between the latter and other organizations) in these processes rely precisely on other modes of interaction and coordination (R&D agreements, licensing, alliances, partnerships, ... and informal relationships) than primarily on market mechanisms.

This critical discussion points out clearly to crucial dimensions that should be carefully considered in an accurate definitional exercise of “innovation clusters”.

Technological and functional links: is it the whole story?

A more interesting and analytically detailed approach — corresponding to what seems to me being a “*technological-functional*” conception of innovation clusters — has been proposed by Preissl and Solimene (2003). At a first glance, their definition (*Ibid*, p. 61) appears to be rather simple or even very general:

A cluster is a set of interdependent organisations that contribute to the realisation of innovations in an economic sector or industry.

According to the authors, this definition is based on two key principles: (a) Clusters represent a relevant phenomenon for the achievement of innovations; (a) Thus, the analysis of clusters constitutes a useful tool if one wants to capture the main features characterizing recent evolutions in innovation processes.

But things become much more interesting as the authors (*Ibid*, pp. 61-62) go on to detail what seem to them being the crucial features of innovation clusters involved in their definition. I summarize (and comment) their key ideas in the following terms:

- Clusters *are not* conceived as geographical agglomerations. This does not mean, however, that there are no potential benefits possibly stemming for geographical proximity. Rather, what is emphasized here is the fact that for some innovation processes or projects it is the quality of the technological expertise of the partners that matters (rather than a mere geographical closeness). Hence, thanks to the development of efficient electronic communication tools, innovative firms can possibly benefit from the competences of rather geographically distant partners that are the most valuable for their very specific projects.
- The definition proposed by Preissl and Solimene adopts an explicit *sectoral perspective* relating to the idea that each specific industry is characterized by complex and idiosyncratic processes of knowledge creation in technological fields that are relevant for this singular industry, and typically not for other industries.¹¹

¹¹ While clearly contrasting with approaches (such as the Porter one, or Scott, 2006 one; see below) which assume a rather industrial diversification of a cluster, Preissl and Solimene are in tune with a number of studies

- The cluster is defined as an entity that contributes to *innovation outcomes at the collective or aggregate level* — and not only for some specific firms that belong to it. Thus, an innovation cluster must be interpreted as a *bundle of resources that constitutes a potential base (a “reservoir”) for innovative projects and activities*. These resources can then be activated or mobilized by *certain* innovative firms belonging to the clusters, typically through cooperative arrangements. From this point of view, an innovation cluster within a given industry comprises *sub-sets of inter-related firms (and organizations) within specific innovation projects or processes*. Hence, these sub-sets of firms and organizations can assimilate to *innovation networks* that form and operate within the innovation cluster.¹²
- Finally, this definition comprises *all the actors* that contribute to the innovation dynamics within a cluster. This concerns universities and public or private research organizations, but also industrial firms or service providers whose activities are not necessarily R&D intensive.

As such, this approach appears well “calibrated” for innovation clusters analysis, and above all in high-tech or science-based sectors. Still, it rests on somehow *excessive technological and functional grounds* as it surprisingly lacks a clear integration of some key dimensions highlighted by Nooteboom (2004) and Scott (2006) (see below) along with many others (including Porter, the OECD and the various general approaches of clusters; see above). Indeed, the social and institutional dimensions of actors’ interactions and embedding and the role of *informal interactions* and of *interpersonal relationships* are roughly underscored or even ignored. By the same token, the roles of various institutions that usually impact the formation, the functioning and the development patterns of an innovation cluster are not clearly stressed in this approach. Such institutions are typically funding organizations (banks, venture capital companies, business angels, public funding agencies...), law companies (especially those specialized in property rights’ issues), regulation entities (standardization committees, ethical commissions...), and so on. Yet these institutions are greatly differentiated across countries, across regions and across cities. Their impact on innovation dynamics is therefore likely to be quite variable from one location to another.¹³ This stresses again the necessity to take explicitly into account the geographical specific locations of the actors involved in a clustering dynamics.

Exploration networks

A third approach, which I could qualify as a “*socio-cognitive*” *conception* of clusters and innovation clusters, is much more analytically grounded than the previous one and offers truly

on innovation clusters/networks in high-tech sectors like biotechnology (see e.g. Owen-Smith *et al.*, 2002) or nanotechnology (see Robinson, Rip and Mangematin, 2007) where clustering dynamics are essentially sector-driven. Yet, as these studies also show, co-location and geographical proximity are often crucial in the initial phases of cluster/network formation and development.

¹² This idea is very important: an innovation cluster is not a whole homogeneous, undifferentiated ensemble of actors, but rather a systemic and structured entity. It also points out to the fact that clusters and networks of innovation are obviously overlapping phenomena, at least in the specific way Preissl and Solimene put it. I shall elaborate more on this in the next section and show that this overlap is of a more general essence and operates at various organizational and spatial inter-related scales.

¹³ See among others: Castilla *et al.* (2000); Cooke (2001); Zeller (2001); Owen-Smith *et al.* (2002); Powell *et al.* (2002); Eto (2005); Feldman and Martin (2005); Autant-Bernard *et al.* (2006); Depret and Hamdouch (2006, 2007); Hamdouch and Moulaert (2006); Lynskey (2006); Scott (2006). Feldman and Martin (2005) even talk of a “jurisdictional advantage” of certain countries, regions or cities which explain their attractiveness for firm location and their positive role in initiating and sustaining spatial clustering dynamics of innovative industries.

an interesting angle for the specification of innovation clusters (and networks). This approach, due to Nooteboom (2004), combines three sets of “ingredients”:

- (a) *The notion of “embedding”*. Here, Nooteboom (2004, p. 3) distinguishes between “three kinds of embedding: *institutional embedding*, *structural embedding* and *relational embedding*. Institutional embedding regards the impact of regulation and norms of conduct, taxes, subsidies, legal system, infrastructure, schooling, research, labour market, etc. Structural embedding derives from the social network literature. Structural features of networks are size (...), density (...), centrality (...), and stability (...). Relational embedding appears in the social network literature in the notion of ‘strength of ties’, but is developed in more detail in the literature on alliances or inter-organizational relations (...). In other words, I propose that *an adequate understanding of clusters requires a combination of geography, social networks and inter-organizational relations*” (my italics here).
- (b) *The notion of “cognitive distance”*. This notion “(...) derives from a social constructivist view of knowledge, according to which perception, interpretation, understanding and value judgment entail mental constructions on the basis of mental categories that are developed in interaction with the physical and social world. As a result, *different people, and different organizations, that have developed their cognition along different paths of development, in different conditions, will perceive, interpret and evaluate the world differently*” (*Ibid*, emphasis added).
- (c) *The distinction between “exploitation” and “exploration”* as derived from James March (1991) work. Exploitation corresponds to “the efficient employment of current assets and capabilities”, while exploration means “the development of novel capabilities” (Nooteboom, 2004, p. 5).

Although Nooteboom states that “(t)he economic success of regions and clusters requires success in both exploitation and exploration (...)”, he recognizes straightforward that this double condition “is a paradoxical task” as exploitation “often requires the maintenance of a stable organizational structure (...) in unambiguous terms of clear standards, in a narrow organizational focus, while exploration requires the reverse: loosening of structure for novel reconfigurations, shifting meanings and deviation from existing standards, in a wide focus” (*Ibid*).

Nooteboom then goes on building a detailed analytical approach describing the conditions and features of a “cycle of discovery” process through which the exploitation logic and the exploration logic can combine in time and space depending on “how exploration may be based on experience in exploitation, and how to ensure that the outcome of exploration will be exploitable” (*Ibid*).

I do not enter here in the discussion of this idea of “cycle of discovery”. It suffices to say that it is quite questionable as it seems to me that:

- (a) Alternatives to this model exist, e.g. *multi-scaled clusters and networks* where, at the same time, the logic of exploitation may prevail at some spatial scale whereas the logic of exploration may entail the commitment of some actors in open-ended

(exploratory) and innovation-oriented relationships with partners delineated by different geographical locations (see below)¹⁴;

(b) It is not sure at all that the two logics should *necessarily* be combined and timely articulated in a cyclical way: the exploitation logic may well be continued and sustained for a very long period of time through incremental changes, and then maybe change radically when new structural conditions arise.¹⁵ By the same token, the exploration logic may be continually renewed through “edge investments” towards sustaining scientific and applied knowledge pioneer development and innovation, while exploitation activities may be off-shored to a certain extent to other “partner” locations. This is exactly what has been depicted by Saxenian (1999, 2006) for the Silicon Valley (SV) in recent years, where the SV, California, remains at the front-edge of ICT while at the same time being strongly related to “New Silicon Valleys” in China, Taiwan and India for manufacturing (but also, and increasingly, design and development) operations (see also Bresnahan, Gambardella and Saxenian, 2002; Poon *et al.*, 2006; Hamdouch and He, 2007).

Following these remarks, it seems to me that the exploitation vs. exploration logics could be a fruitful analytical tool for characterizing innovation clusters and networks where the dominant logic should be that of exploration, and industrial clusters and networks corresponding to a rather exploitation main guiding principle. Admittedly, this somehow simplified assimilation is susceptible of deserved criticism that I easily anticipate and assume. Yet, Nooteboom himself distinguishes between “networks for exploration” and “networks for exploitation”. And when looking at the way Nooteboom develops his analytical framework and specifies the main features for each of the two categories of networks (see table 1), the differentiation between the two logics of networking (or clustering) is so clear that the simplification operated here appears rather acceptable.

Indeed, as to *network structure parameters*, “networks for exploration” show a high density of connections, a low centrality of actors and a low stability of the network. “*Strength of ties*” parameters are also clearly discriminating. In particular, one must notice that networks for exploration entail a wide scope of open ties based on a priori trustworthiness. The “values” attributed to the other parameters are more questionable. For example, it is not sure that the “frequency of interaction” should be high when exploration is at stake vs. low when in an exploitation configuration of network. It may well be exactly the reverse: frequency of interaction with the same actors when exploring for new knowledge (if, for example, some “knowledge providers” appear to be less promising than expected, or if they “defect”), whereas the frequency of interactions may well prove high if exploitation entails recurrent

¹⁴ Nooteboom (2004, p. 5) himself recognizes that “clusters, to the extent that they entail stable relations, need outside ties for ongoing innovation”.

¹⁵ See for example the remarkable essay by Edward Glaeser (2005) showing how Boston have been able to “reinvent” itself only three times in its long history between 1630 and today: in the early 19th century; in the late 19th century; and in the late 20th century. According to Glaeser, the “secret” resides in *human capital* and its capacity to adapt to new, radical circumstances: “(...) in all of its period of reinvention, *Boston’s human capital has been critical*. Skills with sailing ships enabled the city to reinvent itself as a global maritime center in the early 19th century. Yankee technology and Irish labor together fuelled industrialization. And today more than ever, Boston’s skills provide the impetus for economic success in technology, professional services, and higher education. Boston’s experience certainly suggests that *human capital is most valuable to a city during transition periods when skills create flexibility and the ability to reorient towards a new urban focus*” (Glaeser, 2005, p. 122; my emphasis). For a more general enlightening discussion on economic regional evolution and the possibility to escape path dependency and lock-in through a “regional path creation”, see Martin and Sunley (2006).

transactions with the same partners. The same assessment holds for the “duration” of ties: they can obviously be high if collaborating actors are for example working together on basic research in new technological areas or in new scientific fields, which usually demand time and perseverance (like in biotechnology and in nanotechnology). By a matter of fact, some parameters are probably more sensitive to the exact nature of the activities at stake and to the specific configuration of interaction (precisely according to the types of actors’ embedding and to the prevailing “cognitive distance” between the interacting actors) than to the mere broad nature of the network.

Table 1: Key distinctive features of ‘Networks for exploration’ vs. ‘Networks for exploitation’

Network features	Exploration	Exploitation
<i>Network structure:</i> Density Stability Centrality	High Low High	Low High Often high
<i>Strength of ties:</i> Scope Investment in mutual understanding Duration Frequency of interaction Trust/openness	Wide High Limited* High High	Narrow Low Often long Low Generally low

* “Especially when technology is systemic”

Source: Adapted from Nooteboom (2004), table 2, p. 24

In any case, the approach proposed by Nooteboom is really interesting and useful as it opens a genuine route for the characterization of innovation clusters and networks.

Creative fields

Finally, a fourth interesting and truly useful approach, which I qualify as a “*socio-institutional-evolutionary*” *conception* of innovation clusters, is that of “creative fields” proposed by Scott (2006). To begin, the author provides (p. 3) three differentiated, but complementary definitions of what he means by “creative field”:

Definition 1: “The notion of a field of creative forces can be used to describe any system of social relationships that shapes or influences human ingenuity and inventiveness and that is the site of concomitant innovations. An adjunct idea is that this field will rarely be frozen in time and space, but that the very innovations it triggers will also act back upon it, thereby causing changes in its organization and operational logic”.

Definition 2: “A more specific identification of the creative field (...) is that is comprises all those instances of economic effort and organization whose *spatial and*

locational attributes, at whatever scale they may occur, promote development – and growth-inducing change”.

Definition 3: “To narrow the focus yet more, the creative field (...) is represented by sets of industrial activities and related social phenomena forming geographically-differentiated webs of interaction giving rise to diverse entrepreneurial and innovative outcomes. An intrinsic element of this definition is that both the field on the one side and its effects on entrepreneurship and innovation on the other are reflexively intertwined with one another”.

Then Scott recognizes that this concept overlaps partly with notions such as “innovative milieu”, “learning region”, “regional innovation systems”, but declares that his main focus is on “agglomerated economic structures such as industrial districts, regional productive complexes, and urban economic systems. Phenomena like this, he continues, are almost always characterized by dense networks of firms and multifaceted local labor markets, and (...) these are the settings within which entrepreneurial and innovative energies flourish *par excellence* in the new economy (...)” (Scott, 2006, p. 3).¹⁶

Finally, for Scott, a distinctive feature of his concept of is that “the idea of the creative field goes far beyond specific applications in the domain of the economy”. He continues: “Developments in the spheres of culture and science, too, can in part be understood in terms of arguments that are essentially variations of the notion of the creative field” (*Ibid*).

All by large, one can only but widely agree with most or nearly all of Scott’s statements cited above.¹⁷ In particular, the notion of “creative field” seem to me really fruitful as it potentially embraces the key idea that any domain of human activity (including the social, artistic and aesthetic fields) is susceptible of novelty, inventiveness and innovation within and across various spatial scales — as has already been emphasized by different authors (see e.g. Moulaert and Sékia, 2003, and Moulaert *et al.*, 2005).

Yet, the various definitions provided by Scott deserve some analysis and discussion. First of all, each of the three definitions offers a distinctive angle of analysis or a specific emphasis, though all valuable. The first definition highlights, amongst other traits, the idea that the creative field “is the site of *concomitant innovations*”, which stresses the *systemic nature of innovativeness within the ‘field’*, and then rightly departs from a mere firm-centred approach of innovation in the vein of most of the literature promoting the idealized figure of the individual entrepreneur or innovator. It also emphasizes the *dynamic intrinsic nature of the innovative field* as it insists on its spatial and temporal coordinates and on the *feedbacks* that innovation outcomes are likely to entail for the field itself in terms of structure and organization. Here again, this approach throws discredit on frequent static and poor innovation clusters conceptions made of simplistic “success stories”.

¹⁶ In his mind, this focus on agglomeration phenomena doesn’t mean that “wider spatial frameworks of industrial activity and their implications for entrepreneurship and innovation, including, in the limit, the global” (*Ibid*, p. 3) are not important, as he claims it in several parts of his article (for example in p. 7). But this recognition seems to me rather superficial as Scott is clearly focusing on the socio-institutional creative dynamics as they are territorialized within specific geographical locations, notably cities and regions for him.

¹⁷ Yet, of course, I do not really adhere to all the ideas developed in Scott’s paper. In particular, the evolutionary process he describes for network formation and development seem to me rather mechanical and simplistic.

The second definition insist on the *variety of actors involved in creative activities*, which then disqualifies severely narrow conceptions of the “innovative engine” as being solely fuelled by (mostly) private companies, such as the one discussed in the beginning of this section.

Finally, the third definition points out to the *spatially, institutionally and socially embedding characteristics of the actors involved* (see also above the approach developed by Nooteboom) and insists on the *diverse but intrinsically related or connected* nature of the activities concerned (Scott talks of “sets of industrial activities). This approach sheds a crude light on the vacuity of all marketed (and usually “moneyed”; see Martin and Sunley, 2003) “friendly” advices that there may be “recipes” for initiating and/or promoting innovative or competitive cluster policies on the (false) grounds of presumably previous successful cases or experiences (on this, see also Bresnahan, Gambardella and Saxenian, 2002).

Another positive assessment of Scott’s approach is that *it truly focuses on innovation dynamics* as it takes place within *specific fields and spaces*, whatever the wordings and spatial spaces that may be envisaged (fields, networks, clusters, districts, cities, metropolitan areas, regions or even countries or the global arena). In this sense, the approach proposed by Scott distinguishes clearly with a-spatial and non-specifically oriented conceptions of the clustering and networking conceptions (see above).

If I should express only one, yet important regret regarding Scott’s approach, it would be the following: while the author alludes to possible multiple spatial scales and to “multiscalar interdependencies” (Scott, 2006, p. 17) as key features of creative fields, his analysis rests on quite allusive settlements. As we shall see in the next section, these “multi-scaled” organizational and spatial attributes of innovation clusters and networks could be rather general features of innovative (creative) interacting actors, and only not contextual, occasional or specific ingredients, especially when genuine innovative activities are at stake.

To conclude, it seems to me that while the various definitions and approaches discussed in this section (and also in the previous one) provide quite valuable insights on what may be the key features of clusters and especially of innovation clusters, the whole picture remains rather dispersed and thus appeal for some synthesizing effort. Besides, several crucial issues regarding the analytical grounds of the notion and its empirical investigation are still pending, and therefore deserve some clarification.

4. Some crucial pending issues

The idea I defend here is that innovation clusters and networks are not “conceptual illusions” or “panacea” (Martin and Sunley, 2003) as they truly display concrete, detectable features and dynamics. Indeed, I think that these notions could genuinely prove to be helpful (and potentially relevant) for our comprehension of the spatial and organizational dynamics underlying innovation processes, but at the (affordable) price of a serious effort towards a better conceptual and methodological grounding of the analysis.

Of course, given the limited space allowed, it is impossible here to go on an extensive account of all the facets that this analytical improvement entails. Rather, I shall focus only on some selected, yet key issues one can derive from the works surveyed in the previous sections and from other important pieces of the literature.

I will therefore organize the discussion under four main headings:

1. Fixing the notion of innovation cluster in a synthetic way
2. Outlining the debate about the originating dynamics and the initiating/impeding “forces” that drive innovation cluster formation and sustainability
3. Clarifying key issues related to the spatial scaling, the nature and the strength of the ties among the actors, and the structure of the innovation cluster/network
4. Deriving and outlining the hypothesis of “multi-scaled networks” as potentially being the foundational principle of innovation clusters.

Fixing the notion

Building on the previous discussion of the varied definitions examined in sections 2 and 3, it seems to me possible and useful to outline a synthetic definition that captures the key features of innovation clusters (more generally, of innovation networks):

An innovation cluster comprises an ensemble of various organizations and institutions (a) that are defined by respective geographic localizations occurring at variable spatial scales and within specific institutional environments, (b) that interact formally and/or informally through inter-organizational and/or interpersonal regular or more occasional relationships and networks, (c) and that contribute collectively to the achievement of all kind of innovations within a given industry or domain of activity, i.e. within a domain defined by specific fields of knowledge, competences and technologies.

This definition is rather flexible, as it entails only that the three sets of conditions are being simultaneously verified. It could then correspond to a large variety of spatial, institutional and organizational concrete configurations of innovative dynamics. Moreover, it does not prejudge of the spatial topography of the interacting actors, nor does it impose any constraint on the way they may interact (i.e. cooperate or compete). Finally, it does not stipulate any specific paths of cluster emergence, structuring, evolution and performance.

Indeed, as we shall now see, the way innovation clusters (and networks) are susceptible to emerge, get structured and potentially evolve is rather complex, varied and quite uncertain.

Neither miracles nor chimera

One of the most vigorous debates in the literature turns around the originating dynamics and the initiating/impeding “forces” that drive innovation cluster formation and sustainability. For the most, the views expressed turn around the opposition between “top-down” and “bottom-up” processes (see e.g. Bresnahan, Gambardella and Saxenian, 2002; Fromhold and Fromhold-Eisebith, 2005), or in even more crude terms, between “spontaneous clusters” and “political clusters” (Chiaroni and Chiesa, 2006).

What I want to stress here is that these binary views are misleading. Indeed, innovation clusters are neither “chimera” — in the sense of a purely, artificially designed creations by the means of a *deus ex machina* concretising some strong strategic or political will — nor “miracles” stemming from a deterministic chaos, or alternatively yielded by some mysterious forces or even by pure chance. Indeed, the very processes underlying clustering and networking phenomena within and across innovative fields often operate in *hybrid forms that combine an array of various mechanisms*. These mechanisms range in a continuum from rather decentralized and somehow self-organizing dynamics to more collective and

institutionalized actions and policies. They comprise, among various other possibilities, *science and technology driven logics* (like in biotech clusters (Owen-Smith *et al.*, 2002; Powell *et al.*, 2002) or *technology and manufacturing driven logics* like in ICT (Saxenian, 1994; Bresnahan, Gambardella and Saxenian, 2002), “*genealogical*” *chains of spin-offs* (like in the historical development of the Silicon Valley; see Castilla *et al.*, 2000), “*historical accidents or path-dependent processes* (for an in-depth presentation and discussion, as well as many examples, of these processes, see Martin and Sunley, 2006¹⁸), the catalytic role of “returnees” and of “Argonauts” (as in the case of the “New Silicon Valleys” in Asia and elsewhere; Saxenian, 1999, 2006), the *initiating role of an “institutional entrepreneur”* (like in the case of the development of a nanotechnology cluster in Grenoble; see Robinson, Rip and Mangematin, 2007) and, of course, yet at different degrees of political or institutional “voluntarism”, the very *large range of local, regional or national actions, policies and initiatives* (for accounts of these initiatives and policies, see for example Sölvell, Lindqvist and Ketels, 2003; Ketels and Sölvell, 2006; OECD, 2007).

I will not go further on this discussion, as the topic is truly endless. Yet, one additional remark seem to me important: if on the one hand — as now widely agreed in the literature — no one policy-maker can simply decide “by fiat” to create an innovation cluster from scratch or so (or at the risk of experiencing afterwards a likely painful failure...¹⁹), on the other hand, one cannot hastily conclude that every voluntarism or policy measures towards helping the start or the development of an innovation clustering process should be banished (see, among others: Luukkunainen, 2001; Bresnahan, Gambardella and Saxenian, 2002; Fromhold and Fromhold-Eisebith, 2005; Scott, 2006). Therefore, the central issue should be of which relevant incentive and coordination mechanisms could be designed and implemented by the various public and institutional actors interested in the development of an innovation cluster²⁰ — granted that other important conditions are met, such as a critical mass of competences, strong inter-organizational complementarities and a diversity of actors, an entrepreneurial culture, and so on (for extended accounts of these conditions and various sectoral illustrations of their impact, see e.g.: Saxenian, 1994, 2006; Audretsch, 2001; Fromhold and Fromhold-Eisebith, 2005; Gordon and MacCann, 2005; Martin and Sunley, 2006; Scott, 2006; Robinson, Rip and Mangematin, 2007).

Scales, ties and network structure

The brief discussion above shows clearly that clustering and networking processes are by no means simple as they follow no clear “fairways”: they are likely to be driven *both* by “invisible hands” and by “visible hands”; and they may develop as a “legacy of the past” or emerge as an attempt towards exploring a new and promising “creative field”, or both through following some transitional dynamics.

¹⁸ Other examples are the case of Uppsala in Sweden (Waluszewski, 2004) or again the case of Boston (Glaeser, 2005).

¹⁹ An interesting illustrative case, analyzed by Orsenigo (2001), is the failure of the development of a biotech cluster in Lombardy. The failure of the Multimedia Corridor Project in Malaysia (see Bunnell, 2002) is another, yet more striking example.

²⁰ In this respect, the original and successful case of the BioReggio contest, launched in the nineties by the German Federal Government in order to encourage the formation/development of biotech clusters, is quite interesting in that it clearly illustrates how adapted incentives and balanced coordination schemes between and across the federal/regional levels can yield positive outcomes (see Dohse, 2000, and Zeller, 2001). By contrast, the policies engaged in Japan and France for the creation of clusters in high-tech sectors display a rather mitigated an uncertain results, probably because they have been mainly designed at the central level, yet in different forms (see respectively Eto, 2005, and Gaffard, 2005).

I shall now discuss the way these processes are also likely to display different spatial/geographical scaling and configuration patterns as well as various actors' tying and relational paths.

Although (and admittedly) the localization of activities within a geographically-bounded space (a city, a metropolitan area or a region) is neither a sufficient ground nor a systematic condition for the existence of an innovative cluster, one should nevertheless recognize the fact that the firms and other actors involved in interacting in innovation processes or common projects are, on their part, necessarily located somewhere. It is then the *spatial configuration* of the various individual respective localizations of the interacting actors within innovation activities that matters rather than their mere spatial co-location or their geographical proximity. Besides, if the geographical proximity of actors can certainly play a key role in many innovation processes, in most situations it must also be combined with other forms of proximity if it is to generate location spillovers and agglomeration positive externalities. Therefore, as many works have repeatedly shown, organizational, cognitive and institutional dimensions of proximity are usually at least as (and sometimes even more) crucial features for innovation networking and collaboration as geographical proximity (see among others: Rallet and Torre, 1995, 2001, 2007; Audretsch and Feldman, 1996; Feldman, 1999, 2003; Depret and Hamdouch, 2006, 2007).

Moreover, the sole geographic proximity (though more or less possibly supplemented with other dimensions) of truly innovative firms and “knowledge organizations” (such as universities and research centres) is by no means indicating the very existence of an innovation cluster. Indeed, as clearly demonstrated in a detailed comparative study of eight high-tech regional agglomerations in the United-States, the impact of these organizations for the development of innovating firms depend crucially on the “alignment” between the research competence fields of the universities and the industrial specializations of the firms yet located in the same area (see Paytas, Gradeck and Andrews, 2004).²¹ Equally important are the availability of efficient systems for the coordination and the cooperation of the various “actors of innovation” and the reach of balanced compromises between centralized and decentralized levels for decision-making processes (*Ibid*). Once again, this analysis shows that the existence (or the sustainability) of an innovation cluster requires both an institutional and organizational proximity and what I may call a “cognitive impedance” of the actors (see also Nooteboom, 2004, and Depret and Hamdouch, 2006, 2007).

By contrast, more or less geographically distant actors can engage in “strong links” and manage sustained interactions within a productive and/or innovation process that requires continued collaborations or exchanges with close-complementary partners in terms of knowledge, competences or expertise (Ernst, 2006; see also Preissl and Solimene, 2003, as already pointed out in section 3).

By the same token, as stressed by Bresnahan, Gambardella and Saxenian (2002), if the local availability of a university and of high-skilled human capital (both technical and managerial) may truly help for the emergence and the development of an innovation cluster, it is neither a

²¹ In line with this idea, see also the concept of “regional industrial identity” proposed by Romanelli and Khessina (2005). This approach highlights the importance of the way the internal or external actors of the cluster build on specific representations of the capacity of a region to promote the development of certain activities, and on the way these representations can influence the actors' decisions about the nature and the localization of their investments.

sufficient nor a compulsory condition as “the supply of skills can come from outside the region” (p. 15). This may be the case when “there can be different sources of skills in different regions” (*Ibid*) within a country, or even when regional innovative firms can attract high-skilled labour from abroad (as it has happened for the Silicon Valley in the eighties and nineties). Finally, as the authors show, most of the “nascent clusters” (“New Silicon Valleys”) in China, Taiwan and India have greatly benefited from the technical and managerial skills of US-educated returnees.

In sum, beyond mere geographical proximity, it is the actors’ ability to engage in valuable relationships with specific partners that matters, whatever distant from one each other they may be. Yet, as that has been already stressed above, the geographical origin and localization of each of the interacting actors is also crucial in one’s actor decision to engage or not in a relationship with a certain potential partner. Hence, if the spatial distance (or closeness) between actors is not *per se* as crucial in all circumstances, the *topography* of the actors according to their respective geographical localizations should constitute a key dimension of our understanding of how an innovative cluster (or network) specific dynamics of emergence, structuring and evolution operate, and on how the prevailing governance modalities of the cluster came out and may have fostered (or, conversely, impeded) its very development and achievements.

This is precisely here that the discussion around the nature and the strength of the ties between the actors should shed some light on how various forms of “proximities” amongst the actors could be more or less decisive.

Let me briefly synthesise some of the key issues at stake. First of all, besides *formal inter-organizational links* between interacting actors within and/or across innovation clusters and networks — which may prove crucial when appropriation and patenting issues are at stake; see above section 2 —, many network analysts (economists, but for the most sociologists) have stressed the decisive role of both *informal links* (at either inter-organizational or inter-individual levels) and *inter-personal ties* (see among others: Granovetter, 1973; Saxenian, 1994; Walker *et al.*, 1997; Castilla *et al.*, 2000; McKelvey *et al.*, 2003; Dahl and Pedersen, 2004; Owen-Smith and Powell, 2004; Casper and Murray, 2005; Cassi and Zirulia, 2005; Goyal, 2005; Casper, 2007). These links or ties play a double decisive role: (a) they create what I may call the “cement” (in terms of trust and mutual understanding; see also above the discussions in sections 2 and 3) that is required for a flexible and adaptive coordination of the actors within an innovation cluster or within the various networks it generally comprises; (b) these ties are the very foundations of innovation clusters and networks as “opportunity creators” (Preissl and Solimene, 2003; Dahl and Pedersen, 2004; Paytas, Gradeck and Andrews, 2004; Cassi and Zirulia, 2005).

This discussion points immediately to another lively debate amongst the sociologists of networks around what should the “strength” of the ties between the actors that could most favour novelty and innovation. Briefly speaking, three main arguments have been proposed. I outline them for the specific context of innovation networks:

- (a) *The “social capital” or the “network closure” argument* (Coleman, 1988, 1990): here, the idea is that the social capital of an actor (for example a start-up) builds on the high connectivity and cohesion of the network (which facilitate trust and the exchange of knowledge, and therefore collective learning). Hence, the actors who enjoy the highest social capital are also the most likely to create new ties, i.e. to benefit

potentially from a new knowledge or a new source of economic advantage (or, more broadly speaking in sociological and political terms, of an enhanced “power” position) through new partnerships.

(b) *The “structural holes” argument* (Burt, 1992, 2001, 2005): here, the idea is that the actors that are the most structurally constrained (i.e. which have dense and “closed” networks, with only few or indirect ties) are also the less likely to attract new partners — either because they display lower returns due to their constrained strong relationships with eventually powerful actors or because they are seen as engaged in routine rather than innovative activities. In any case, Burt’s argument, on general grounds of network analysis, is that actors who are “brokers” between rather loosely connected actors (here lay the “structural holes”) enjoy a powerful position. In an innovation context, the idea is that diversified and “open networks” stimulate the creativity of the actors as they give access to more varied information while at the same time are less constraining for their members, which is also favourable for innovation.

(c) *The “strength of weak ties” argument* (Granovetter, 1973): yet compatible with Burt’s view, the argument here is somehow different because the “weak ties” in question relate essentially to informal or occasional relationships. Therefore, as I interpret it in an innovation network context, the idea is that weak ties may be crucial when uncertainty is at stake as it could reveal new unforeseen opportunities, new knowledge and cut-edge innovation fields, or more simply new potentially fruitful relationships.

The first vs. the two latter arguments are apparently opposite. Yet Burt (2001) offers a somehow “operational” compromise between his view and the Coleman’s one: closure and social capital are then meant to be important for network consolidation and functioning, and for “absorbing” eventual opportunities yielded by structural holes, while the latter could build further potential, valuable new ties (as sources for new knowledge insights or innovation possibilities).²² This smells much as the “exploitation” -“exploration” articulated pathway logics proposed by Nooteboom (2004), yet in very different terms as the Burt’s approach is relating mainly to inter-personal networking analysis whereas Nooteboom’s one is mainly dealing with broader socio-economic inter-organizational interactions — notwithstanding the fact that sociological analysis of networks has preceded by more than a decade the interest of economists or management specialists in these topics. As regarding the Granovetter’s “strength of weak ties” argument, it seems to me that it may potentially be the most stimulating notion for the analysis of innovation clustering and networking dynamics in such science-based fields like biotechnology or nanotechnology in which the future paths for technological achievements are at best “promising” (for the first one) or embryonic (for the latter field).

Here again, this controversy around the network openness vs. closeness respective merits regarding innovation echoes (and introduces to) another inquiry topic emanating from a different, yet surprisingly “distant” scientific field, namely statistical physics. Building on the

²² Indeed, no conclusive assessments have been provided on general grounds in favour or, conversely, in negative support of these opponent theses. In the specific case of networks in biotechnology, Shan, Walker and Kogut (1994) find rather supportive results in favour of the structural holes argument, while Walker, Kogut and Shan (1997) find results that support the social capital and network closure argument...

sociological work on social networks that developed in the Granovetter and White tradition²³, scientists like Watts, Strogatz, Girvan, Newman and several others (see especially Watts and Strogatz, 1998; Albert and Barabasi, 2002) have build what Watts (2004) have labelled as a “New Science of Networks”(NSN). This NSN consists in developing powerful algorithms in order to detect *topological regularities within digital as well as social real networks*. It is here that this approach connects to the previous discussion as four main categories of networks are distinguished. The two first categories relate to the traditional polarized hypotheses or “Random Networks” vs. “Regular networks”, whereas the two latter are genuine new (intermediary) configurations highlighted by the NSN drawing from the analysis of “real networks”:

- *Random Networks*: here, the distribution of the links between the nodes (actors) and the path lengths connecting them are completely random (which corresponds somehow to the image of the “pure competitive market” in economics, or to that of a generalized “anarchy” in organization and political science);

- *Regular Networks*: All the nodes (actors, organisations, institutions) are connected with neighbour or more distant nodes in a similar way (all nodes have the same “degree”, i.e. the same number of connections, and the same path length, i.e. the same average distance with other nodes) with certainty (absence of any randomness), at the image of a totally integrated community or team amongst “equals”;

- *Small World Networks (SWN)*: Most of the nodes are interconnected trough short paths with a high coefficient of connectivity (transitivity). This is a dense, rather homogeneous network, yet some nodes may have fewer/more, and/or closer/longer connections. This means that SWN allow both for some (small) dose of randomness for the connections and some degree of topological differentiation amongst the actors;

- *Scale Free Networks (SFN)*: As for SWN, SFN emphasize the importance of short path lengths and the weight of the transitivity coefficient between nodes (actors) as displayed by most real networks. But here the role of these parameters derives from a hypothetical dynamics of entries/exits of nodes (actors) within/from the network (evolutionary properties of a graph according to its “demography”); SFN are usually “heterogeneous”.

Clearly, the first form of networks is an extreme, rather hypothetical situation as it has few to do with the social world. Regular networks are more likely to illustrate some specific, though not so spread real social situations. They reflect, in my opinion, an extreme, specific case of “cohesive networks” (according to Coleman terms).

Our interest here is rather with the two other networking structures highlighted by Watts and Strogatz (1998). It seems to me then that “small world networks” (SWN) are somehow analogues to Coleman’s “cohesive networks”, while “scale free networks” (SFN) are obviously echoing Burt’s idea of “structural holes”. As to Granovetter’s idea of “strength of weak ties”, I think that it lies in between of the two network configurations as it doesn’t disqualify strong ties (as those in SWN) yet stressing at the same time the key role of more remote and/or occasional/random ties (as those in SFN).

²³ See: Granovetter (1973, 1979, 1985, 1992); White (1981a, 2001); White and Harary (2001). For useful surveys of this literature, cf. Swedberg (1994), Flap (2002), and Borgatti and Foster (2003).

This debate around the openness/closeness of innovation networks is not merely a technical or theoretical issue. It is at the very heart of the understanding of how the “morphogenesis” (Cohendet, Kirman and Zimmerman, 2003) of networks and clusters — i.e. their emergence, structuring and evolution processes — may impact innovation dynamics within a given industry. The pending question is then how various forms of ties and network structures combine with specific spatial/geographical scales to form particular networking and clustering configurations within and across given creative fields.

Multi-scaled networks as key foundations of innovation clustering dynamics?

The notion of *multi-scaled networks* I propose here builds on the previous discussions in the paper. It is aimed at designing an alternative way of conceiving innovation clusters which attempts to go beyond the various splits and distinctions regarding both the spatial/geographical scaling of an innovation cluster and the nature and strength of ties between the interacting actors it comprises. But I do not proceed from scratch. Rather, my idea is to put together the various insights gathered into an enlarged analytical framework.

The point I want to emphasize is that multi-scaled networks may well constitute a crucial key for our understanding of how innovation clusters come to form, and how they may structure and evolve. As this approach stands for the moment only as an exploratory research hypothesis within my ongoing work on innovation clusters and networks, I will just briefly outline it here.

My idea is that innovation clusters build on the development of variously scaled and structured networks that dynamically combine, superpose or overlap in various configurations. Put in other words, innovation clusters are meant as the result of the dynamic articulation of various “circles” of relationships between the actors.

Either formal or informal, some of these relationships could be rather dense, close and recurrent producing therefore “strong ties”, “local cohesiveness” and “social capital” (as in Coleman’s analysis) in a “small-world network” (Watts and Strogatz, 1998). This configuration fits also with what Nooteboom (2004) calls a “network for exploitation” of already identified and concretely technological or market opportunities. Yet, the exploitation logic can go along with a continuous stream of incremental innovations (either technological, organizational, commercial, institutional or social) stemming from collective learning processes in actors’ close and regular interactions.

By contrast, other relationships could be more occasional, smoother and more distant through “weak ties” that can potentially turn to be useful or even decisive (Granovetter, 1973) in providing advantages (in terms of new knowledge flows, new technologies or new market opportunities). This tying logic is much in tune with the idea of “Networks for exploration” highlighted again by Nooteboom (2004).

Yet other different relationships can come out from unforeseen events or build on rather random processes following therefore a somehow “scale-free” networking dynamics (Watts and Strogatz, 1998; Albert and Barabasi, 2002). These relationships could then concern only certain “privileged” actors (benefiting of “structural holes” or brokerage positions; see Burt, 1992, 2000). The latter category could correspond to several different paths. First, the scale-free networking logics may simply and generally fit in with the idea of genuine discovery, chance or “nice surprise” (for example in a neo-Austrian perspective of entrepreneurship; see

Kirzner, 1997) in meeting some new valuable contact person or a new technological or market opportunity. The second possible path is related to “genealogical effects” through chains of spin-offs from existing firms (Saxenian, 1994; Castilla *et al.*, 2000; Feldman, 2003; Feldman and Romanelli, 2006). A final possibility is what Castilla *et al.* (2000, pp. 220-221) call “Networks of Access and Opportunity” which build through chains of direct and indirect acquaintances rather than on close relationships (as illustrated by the Silicon Valley very “fluid” labour market).

Of course, all these possibly networking paths can occur at any spatial scale. Indeed, the openness of some innovation networks and clusters towards interregional, national or international relationships clearly illustrates this idea of multiple “circles” of relationships (see among others: OECD, 1999; Bresnahan, Gambardella and Saxenian, 2002; Owen-Smith *et al.*, 2002; Gay and Dousset, 2005; Ernst, 2006; Roijakkers and Hagedoorn, 2006; Saxenian, 2006). This openness may be necessary not only for the access by the actors to some key resources, knowledge or competences, but also because it may be useful both for benchmarking purposes and for the detection of new possible “futures”.

The idea of multi-scaled networks still requires due formalization on stronger analytical grounds. Yet, the hypothesis that the actors could potentially connect one to each other and interact in rather different but complementary ways in innovative or creative fields appears rather plausible, as echoed by a number of works surveyed in the paper. Therefore, the very variety of possible networking forms through concomitant but differentiated relationships may truly be a fruitful pathway for conceptualizing clustering dynamics.

5. Conclusion: The challenges ahead

The aim of this paper was to survey the vast literature devoted to the study of the clustering/networking dynamics in innovation or creative fields and to see if this literature has been able to capture the essentials of the phenomenon. I have then showed that if some useful insights and analytical results can be derived from a number of works, the picture is not as positive as one may have expected. The notions of “clusters” and “innovation clusters” (or “innovation networks”) are far from being unified and grounded in solid analytical frameworks. Also, some key issues related to the clusters’ spatial/geographical scaling and to the nature and the forms of actors’ interaction within innovation clusters (and networks) are still pending though widely debated in the literature.

Moreover, one can only but recognizes that, all by large, our comprehension of the mechanisms underlying the dynamics of emergence, structuring and evolution of innovation clustering and networking phenomena rests on partial, fragmented and rather fragile theoretical and analytical grounds. Yet, as I have tried to show along with others, there are obviously some promising pathways for improving these grounds but at the price of departing from (explicit or implicit) normative postures and “fast theory building” (Moulaert and Sékia, 2003, p. 295). Therefore, strong efforts towards better conceptualization and sound analytical work are required. The challenge is also to be able to overcome cross-disciplinary boundaries, which are often rather artificial and counterproductive. Indeed, if economists, sociologists, economic geographers, organization scientists and probably others have followed different paths for the analysis of innovation clusters and networks, their (partial) respective achievements appear to me rather complementary or even converging.

This observation holds particularly for the way actors' relationships and network structures are conceptualized and analyzed by various social scientists. As my discussion of this key topic in section 4 shows, there are obviously substantial overlaps and "bridges" between the remarkable intuitions and insights provided the sociological work on social networks, the in-depth work of economists and organization scientists on knowledge creation/diffusion and learning processes, the emphasis put by economic geographers and other social scientists on the key role of institutions and the institutional embedding of the actors within specific geographical spaces, and the network structuring and change features highlighted by the "New Science of Networks". Building on this and on my discussion of the spatial/geographical scaling and configuration of innovation clusters and networks, I have suggested the idea of "multi-scaled networks" as a potential (yet embryonic) analytical tool for understanding how innovation clusters' dynamics of emergence and structuring operate and lead to spatial, institutional and organizational specific configurations in a given creative field.

My conviction is that it is only through these efforts towards better analytical grounding and strong interdisciplinary integration that social scientists may be able to prove that clustering and networking processes are neither illusions nor mysterious phenomena, but rather constitute real structuring forces of innovation dynamics within and across creative spaces.

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