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OPEN AND CLOSED INDUSTRY CLUSTERS: THE SOCIAL STRUCTURE OF INNOVATION

CLUSTERS INDUSTRIAIS ABERTOS E FECHADOS: A ESTRUTURA SOCIAL DA INOVAÇÃO

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ABSTRACT

In this theoretical essay we discuss knowledge and innovation in clusters and the benefits of clustering from a knowledge-based perspective. Knowledge-based resources and innovations are important sources of competitive advantage for firms. Aware of the importance of continuously seeking new knowledge, firms increasingly seek knowledge-rich locations such as specific industry clusters across the world. These locations are characterized by the concentration of firms operating in related and supporting activities, a specialized work force and a specialized institutional environment that nurtures the industry. However, it is not likely that these clusters are always locations from which the firms will be able to draw the intended knowledge benefits. The social structure of the relationships between individuals and firms determines the extent to which knowledge will be created, will flow between co-located firms and will bound the knowledge benefits firms may capture. We finish with a discussion of the need of further examination of the network dynamics involved in an industry cluster to obtain a clearer identification of the actual positive externalities that may accrue to co-locating firms.

Key words: strategy, industry clusters, innovation.

RESUMO

Este artigo discute o conhecimento e a inovação em *clusters* e os benefícios da clusterização a partir de uma perspectiva baseada no conhecimento. Recursos baseados em conhecimento e inovações são fontes importantes para a vantagem competitiva das firmas. Conscientes da importância de buscar continuamente conhecimento novo, as firmas buscam, cada vez mais, encontrar localizações ricas em conhecimento como "*cluster* industriais" específicos em todo o mundo. Essas localizações são caracterizadas pela concentração de firmas operando em atividades relacionadas e apoiadas por força de trabalho especializada e em um ambiente institucional especializado que nutre a indústria. Entretanto, não é possível que esses clusters sejam sempre localizações nas quais as firmas estarão habilitadas a conseguir os benefícios de conhecimento pretendidos. Ainda, a estrutura social dos relacionamentos entre indivíduos e firmas determinará a extensão em que o conhecimento é criado, flui entre firmas na mesma localização e limita os benefícios de conhecimento que a firma pode capturar. Finalmente, concluímos o artigo com a discussão da necessidade de investigação adicional sobre a dinâmica das redes de relacionamento envolvidas em um *cluster* industrial para a obtenção de uma identificação mais clara das externalidades positivas atuais que possam ser acumuladas em firmas co-localizadas.

Palavras-chave: estratégia, clusters industriais, inovação.

INTRODUCTION

Modern competition has placed the emphasis of competition between firms on knowledge (Grant, 1996; Teece, 1998, 2000) and innovation (Mcgrath *et al*., 1996). This is largely because the traditional shelters for supra-competitive returns such as information or trade barriers fell (Dunning, 1995; Teece, 1998), and the access to physical, capital, and knowledge assets is becoming easier (Bartlett and Ghoshal, 1989; Teece, 2000) as the production factors are becoming more internationally mobile. The ability to manage the knowledge exploitation and exploration (March, 1991) and possibly generate innovations, or some form of knowledge-based competitive advantage determines the firms' position in the market. Firms react in many different ways, namely by seeking knowledge-rich locations from which they may draw knowledge not yet held. Hence, the study of clusters and clustering is central to the traditional questions that strategy scholars address: 'why firms are different', and 'what accounts for firms' differential performance.

Rosenfeld (1997, p. 10) defined industry cluster as "a geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communications and dialogue, that share specialized infrastructure, labor markets and services, and that are faced with common opportunities and threats". This definition emphasizes the role of the social interaction and firms' cooperation in the nature of an industry cluster. The importance of the social interaction and functional relationships among clustered firms is also supported by the cluster definition and discussion developed by Jacobs and DeMan (1996), Porter (1998), Saxenian (1994), and Doeringer and Terkla (1995). Cantwell (1991) and Shaver (1998), for example, showed that there are significant benefits from the agglomeration of firms (both domestic and foreign), in a tradition that dates from Marshall's (1920) work on economic externalities.

Clusters favor the likelihood of knowledge spillovers (both intended and unintended spillovers) among co-located firms (Jaffe *et al*., 1993). It is based on this belief that several scholars and public officials have examined clusters for their potential for the generation of new knowledge and new innovations. The proximity among firms eases the coming into contact of firms and the sharing of resources, knowledge and capabilities. These knowledge spillovers, that the interaction entails, are also likely to promote the overall cluster competitive advantage and reinforce the attractiveness of the location inducing other leading firms and multinationals to search for these locations for their foreign investment (FDI) operations (Driffield and Munday, 2000).

Despite the existing research and debate on the role of clusters for knowledge accrual and innovations, it is yet to be uncovered whether all types of clusters actually generate knowledge benefits. It is likely that while in some clusters the social structure bounding individuals and firms promotes knowledge creation and sharing, in other clusters the social structure is less favorable for the exchanges and sharing of personnel, resources and information. The fact is that there is evidence that many firms that are not located in clusters are some of the most important innovators in their respective industries. These firms may have identified that clustering does not convey substantial benefits. For example, the Dutch Phillips and the US Xerox or Texas Instruments are not in a major cluster and yet they have come up with important knowledge and gestated important innovations.

In this paper we seek to theoretically extend on previous research focusing specifically on two major dimensions: the knowledge dynamics involved in a cluster, and the social structure of relationships in the clusters. These two aspects may, at least partly, drive whether there is actually an abnormal amount of valuable knowledge being generated in a cluster. These two aspects may also help us in understanding the kind of business and social relationships that we need to promote a cluster for it to truly contribute for a knowledge-based competitive advantage of co-located firms. Moreover, this paper may help us in shedding some light on the characteristics that industry clusters should hold to be environments of unusual innovative activity.

This paper is organized as follows: The first section discusses the current state of research on clusters and presents clusters as locations of rich innovation activity. The second section discusses de importance of innovation. The third section focuses on how the network (social) ties promote innovation in clusters and the fourth presents how different types of clusters may also have a different impact on the generation of knowledge and innovations. In each section we present theoretically-driven propositions. We conclude with an overall discussion, implications for theory and public policy and avenues for additional research.

CLUSTERS AND CLUSTERING

The study of industry clusters, or geographic agglomerations, has received the attention of many scholars in strategic management, international business, sociology, urban development, public policy, geography and other disciplines. Most of the extant research points to a limited set of consensus surrounding the importance of clusters. For our purpose in this paper, it is safe to state that there is wide consensus that clustering promotes knowledge creation and sharing among clustered firms. This evidence can be traced back to Marshall's (1920) original works and his statement that in a cluster "knowledge is in the air".

It is also reasonable to state that by locating in a cluster firms benefit from a wide set of positive externalities such as the access to a rich institutional environment, a qualified labor force, legitimacy (see, for example, the work by Meyer and Rowan, 1977; Dimaggio and Powell, 1983, in institutional

theory) reputation and status spillovers, and other externalities (Wheeler and Mody, 1992; Jaffe *et al*., 1993; Chang and Park, 2005). Porter (1998) noted that the potential benefits of clustering included: improving accessibility to specialized factors, easing access to market and technology information, promoting complementarities and cooperation among firms, access to infrastructure and increasing the competitive pressure.

In international business, Shaver (1998) has suggested that locating in a cluster attenuates the traditional liability of foreignness (Zaheer, 1995) that foreign multinationals may face when entering a country. The known risks and uncertainties of entering into an unfamiliar foreign country lead multinational firms to imitate other firms' actions and entry modes strategies (Knickerbocker, 1973; Guillen, 2002; Henisz and Delios, 2001). Partly this imitation may seek to overcome potential legitimacy hazards (DiMaggio and Powell, 1983). Clusters may attract many firms and seem a popular and perhaps rational location decision simply because other firms are already there and legitimize the location as the place to be in (Haveman, 1993; Haunschild and Miner, 1997).

Clustering benefits emerge from the concentration of competitive and cooperative firms in related activities, up and downward the value chain, in a certain location (Saxenian, 1994; Doeringer and Terkla, 1995; Porter, 1998). Krugman (1991) further highlighted that clustering benefits have elements of a self-perpetuating system due to the industry growth in that area that makes it even more attractive for other firms to co-locate. These are issues related to, for example, the access to specialized factors, supply of intermediate products, and access to infrastructures (see also Marshall, 1920; Porter, 1990).

Clustering is not always about cooperation and benefits. Indeed there may be a coexistence of substantial competition between rival firms in a cluster (Porter, 1998, 2000) and this competition pushes firms to be more innovative and generate new knowledge and technologies. It is possible that at least some clusters' unusually high entrepreneurial activity is what makes them "hot spots" (Pouder and John, 1996) for R&D. Competition may also emerge from the relatively free movement of the labor force among firms and the consequential difficulty in maintaining firm-specific resources and knowledge-base private. As people move among firms they transfer knowledge. It is thus probable that firms in a cluster become gradually isomorphic and holds similar (even if not identical) pools of knowledge (Tallman *et al*., 2004) that make any attempt at differentiation difficult. Moreover, clusters are not only about the positive externalities, there are potential negative effects such as the increased costs of labor and other factors as co-located firms compete for the same inputs and markets (Baum and Mezias, 1992; Chang and Park, 2005). For instance, Baum and Mezias (1992) noted that the co-location in Manhattan of hotels that were similar in terms of price and size and that competed with each other also reduced their chances of survival.

The negative externalities of clusters are also manifest in that while firms may benefit from the spill-over of other firms' knowledge, their own knowledge may spill-over to other firms. Hence, while Appold (1995) found that clustering was negatively related to performance in the US metalworking industry, Shaver and Flyer (2000) and Pouder and John (1996) noted that resource or knowledge-rich firms would avoid clustering because for these firms the potential costs of the knowledge spillovers overcome the potential advantages of clustering.

Hence, in the context of our study it is worth noting that clustering may hinder the innovation dynamism that is sought after in the first place. As firms in a cluster use each other as referents (Shah, 1998) and engage in groupthinking (Porter, 1998) they tend to search inside the cluster for models to follow, rejecting outside ideas and clues. One of the most remarkable examples of this rigidity is the inability of the US auto industry to adapt to a market demanding more fuel efficient cars. Note that, conversely, Phene *et al.* (2006) suggested that technologically distant knowledge will not be easy to assimilate, and that knowledge does not flow freely and immediately across geographic space.

In the European tradition the study of clusters has been largely supported by case studies of success (e.g., Saxenian, 1994; Appold, 1995; Cantwell and Iammarino, 1998; Henry and Pinch, 2002). Many of these studies show that the propensity to cluster produces industry concentration in certain locations, regions or cities. Generally, these clusters correspond broadly to old industries such as the knitwear industry in Carpi, pottery in Faenza, and sports cars in Modena, in Italy. In Switzerland, the luxury watches industry is concentrated in Geneva and the banking industry in Zurich. In Germany, the packaging machinery is in Dortmund and the shipbuilding industry in Hamburg and in Bremen. In the US we observe the concentration of the tire industry in Akron, Ohio, the automobile in the Detroit area, the well known motion pictures in Hollywood, and the minicomputer and electronic industry in Route 128, Boston and in Silicon Valley (see, for example, Porter, 1990; Saxenian, 1994). Some studies refer to newer industries such as the auto industry in the UK or the moulds for plastics in Portugal.

Regardless of whether these industries are high or low technology-based the predominant feature is the entrepreneurial dynamism revealed in these regions and the intertwining of firms through a network of social and professional ties that bound firms and individuals in the region (Saxenian, 1994). These studies are often descriptive and present the idiosyncrasies of these locations, some historical, other regulatory, that presided to the emergence of these clusters. Constant to these studies is the complex web of social relationships that seem to embody the advantages of these locations. Seldom, has research examined how the underlying social networks fail to provide guidance in periods of, for example, technological change and why some clusters

fail. Indeed, there are many cases of ultimate failure when firms and clusters are unable to readjust to the changing environment (see Maskell and Malmberg, 2001). However, the inability to adapt also presents us a clue as to the importance of the social networks and the isomorphic behaviors among co-located firms and is thus worthwhile studying.

The existence of clustering advantages is likely to be important in the context of innovation (Driffield and Munday, 2000). Received wisdom accepts that clusters promote innovation through technology and knowledge transfer, development of a skilled labor force in related industries, and the social infrastructure. Following this view and the majority of extant research we state the general proposition:

Proposition 1: *Innovation activity is higher among clustered firms than non-clustered firms.*

INNOVATION

According to Schumpeter (1950) innovation results when different combinations of assets' redeployment have superior benefits and come to replace prior dominant combinations. In other words, innovation is the mechanism through which firms gain access to resources with (superior) positive future value, and to valuable new resource combinations that are specific to the firm and that it alone may exploit (Mcgrath *et al.*, 1996). To the extent that these new combinations incorporate difficulty to imitate routines (Nelson and Winter, 1982) it will take more time for competitors to match the innovation (that is, to imitate). However, because the knowledge needed for innovations is increasingly distributed across firms, the innovation processes are becoming increasingly "interactive" and require simultaneous networking among independent firms (Breschi, 2000).

In the contemporary business landscape, firms' competitive position and advantage is supported on inimitable and idiosyncratic assets (Amit and Schoemaker, 1993; Cooke, 2001; Maskell and Malmberg, 2001), particularly their knowledge-based resources or capabilities (Grant, 1996; Tallman *et al.*, 2004). Innovations are important for the creation and maintenance of a sustainable competitive advantage, and impact on firms' performance (McGrath and Macmillan, 2000). Innovation is important for firms because they may generate future sources of revenues and the basis for a competitive advantage over the rivals. Any innovation is founded on novel knowledge or a novel recombination of existing bits of knowledge. Through knowledge exploring strategies firms renew their assets base (March, 1991). Hence, it is not surprising that the role of knowledge and how firms access and transfer knowledge has come to the forefront of the strategic management research as means to understand how firms create value and innovations (Nonaka, 1988; Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Conner and Prahalad, 1996; Grant, 1996).

A clearer approach to the problem of innovation requires the analysis of the extent to which the innovation is path-breaking, radical, or competence destroying or alternatively, incremental or competence-enhancing. Tushman and Anderson (1986) noted that when faced with radical competence destroying technological shifts established firms are at a disadvantage *vis-à-vis* new entrants. This is largely due to firms being stuck in their established 'core rigidities' and recurrently performed tasks (Cyert and March, 1963; Leonard-Barton, 1992) or routines (Nelson and Winter, 1982). It is likely, however, that if these firms are connected to other firms (with formal and/or informal ties) the reconfiguration of the firms' resources and capabilities may be eased. That is, firms that have more extensive ties are less likely to suffer from technological shifts insofar as these shifts do not destroy the value of the firms' networks of relationships. Moreover, the firms' social ties may bring in actionable information and business contacts that permit continuous learning and reconfiguring of the capabilities. Although it seems reasonable to suggest that when the technological shifts are less path-breaking and build on the firms' capabilities, the incumbents have an advantage over new entries, since any adjustment to an incremental innovation is far less complex. Notwithstanding, in any case, the social networks may be useful for a faster adaptation and upgrade.

A complementary approach to the problem of knowledge and innovation may be taken looking at the nature of knowledge. It seems reasonable to suggest that the degree to which the knowledge involved is explicit or tacit determines the ease and extent of imitation by competitors (Teece, 1997). Explicit knowledge is easily transferable and codifiable (Szulanski, 1996) and, therefore, more subject to unintended diffusion. Tacit knowledge, on the other hand, is less easily codified and is more difficult to transfer (Winter, 1987; Kogut and Zander, 1992; Zander and Kogut, 1995) and diffuse (intended or unintended) because it is frequently embedded in the individuals, routines, idiosyncratic resources and organizational skills (Nelson and Winter, 1982; Grant, 1996). Szulanski (1996) noted that causal ambiguity and different absorptive capacity between firms increases knowledge stickiness hindering inter-firms transfer. Hence, to access tacit knowledge, firms may hire away employees of a rival firm or, in alternative, they may co-locate because the geographic proximity eases the inter-firms flows of knowledge (Phene *et al.*, 2006). Giuliani (2005) notes that there are links between firm-level knowledge bases, the cluster absorptive capacity and the cluster potential for growth.

In sum, an overall review of the clustering literature that uses a knowledge-based lens leads us to formulate a general proposition:

Proposition 2: *Firms cluster in certain regions to benefit from the innovative potential.*

Verspagen (1999) noted that the most important element in innovations developed in regional innovation systems (i.e., clusters) is the social networks. Through networking with other firms with both different and complementary specializations the innovative potential increases and more innovations are likely to be generated. In general, clustering economies can also spur competition, which encourages information, knowledge, and technology transfer among related networked firms. The transfer of knowledge and technology among these interconnected firms can lead to new industry growth, innovations, and drive the overall growth of the cluster (Porter, 1998). That is, industry clusters seem to be areas of munificent innovation.

Rosenkopf and Tushman (1998) argued that firms take into consideration the actions of other competing firms when deciding which technological options to pursue, and hence that the technological evolution is generated by communities of organizations. That is, individuals imitate other individuals' choices. Institutional theory designates this as isomorphism (Meyer and Rowan, 1977). To imitate others, firms must be aware of what each is doing, and be somehow connected through business and social interaction. These relationships exist in clusters (Saxenian, 1990, 1994).

CLUSTERS: INNOVATION IN A SOCIAL MILIEUX

Industry clusters are largely characterized by their social networks that tie and bind firms and individuals together in a delimited geographic space. Clusters are often referred to as networks, even if bounded to a region. Much of the knowledge generated in a cluster is engendered through the exchange of knowledge among firms. However, to the best of our knowledge it is still unclear what, if any, is the relationship between the structure of the network and the distribution and variety of knowledge of the firms. Notwithstanding, at the individual level there is research and evidence that the composition and content of the networks of the managers matter (Podolny, 2001).

Although the knowledge-based of the firm view posits that knowledge exchange between firms is essential for the generation of knowledge and innovations (Kogut and Zander, 1992; Galunic and Rodan, 1998) it is unclear whether and how the type of network ties binding firms and the structure and content of the network matters (Uzzi, 1996). The type, content and configuration of the network ease or hinder the knowledge diversity held by the network members and how this knowledge is transferred among firms for future recombination. In the previous sections, we discussed the importance and impact of clusters and innovation for contemporary competitiveness. In this section we focus more specifically on the social networks. In the next section we suggest that the social structure or the specific characteristics of the cluster determines the configuration of the ties among firms, the flows of employees and who in fact drives the innovation process and outcomes altogether.

In understanding how the networks matter, we may take a structuralist perspective. The structuralist view focus on the benefits that individuals and firms may draw from specific structural characteristics of their networks. The studies of Burt (1992) and Coleman (1990) express this view on the variation in the connectedness of a person's contacts – this is the structural holes perspective. Burt's (1992) structural whole theory focuses on the brokering opportunities of a network full of disconnected contacts and the advantages of the diversity of information or knowledge that this position concedes. The disconnected contacts access non-redundant information that may be used or brokered between firms. Hence, the core idea is that a firm may have an advantage if it is in a brokerage position in a sparse network of disconnected contacts. That is, if the firm is in a position connecting two firms that are not otherwise connected (hence in a structural hole, according to Burt, 1992, 2000) it holds an advantage that may accrue on the form of added prestige, access to resources – namely knowledge-based resources and information, higher status and power, than if they were in a closed network. In a clusters setting we may search to identify those firms that are connected to firms in and outside the network, or cluster. These firms are likely to occupy structural holes and are thus more likely to be in the forefront of the innovations. In sum, a network of disconnected contacts is often associated with access to different information that increases the pool of opportunities.

The social networks research has used the network structure to discuss information and knowledge heterogeneity. Higher heterogeneity eases and speeds the discovery of new opportunities (Granovetter, 1985). That is, in essence, the access to more diverse knowledge allows the broker to be more fully informed. However, in an open network all firms will have easier access to novel knowledge, than in closed networks. Moreover, non-redundant ties bring about a larger knowledge diversity which will be instrumental in stimulating innovativeness. Notwithstanding, the causality herein implicit lacks empirical confirmation and warrants further theoretical development.

A major force into play connecting network and knowledge research is the novelty of the information and knowledge accessed. As Burt (1992) noted, strong ties usually convey similar and known – hence, redundant – information. Strong ties are not conveyors of novelty. Conversely, weak ties are assumed to be a source of non-redundant knowledge. Firms with open networks more often engage in disconnected (or weaker tie) contacts and are more likely to acquire a wider array of information. The access to heterogeneous knowledge should advance the innovative potential. Inferring to the industry clusters, it seems reasonable to suggest that clusters that are more open to a variety of external contacts will be exposed to more new information, knowledge and opportunities than closed industry clusters. Hence, we suggest that:

Proposition 3: *Open clusters are more likely to have higher levels of innovation activity than closed clusters.*

The degree to which a cluster is open or closed to outside contacts may be originated in several factors such as the role of a dominant firm, local policies, or even the cultural embeddedness of individual entrepreneurs and managers. In a complementary approach, the type of social structure of the cluster may influence the munificence of entrepreneurial activity. Entrepreneurial opportunities may be realized in some form of innovation, and the identification of the opportunity itself may be pointed out by an outside firm. Important, thus, is the ability to pursue those opportunities that were identified. Firms in open clusters are free to pursue opportunities outside their immediate market and technological landscape, thus promoting the pursuit and implementation of entrepreneurial opportunities. In this type of social structure deviant behaviours are not socially condemned or hindered by the other actors in the cluster. In a recent work Giuliani (2007) further suggests that innovation-related knowledge diffuses in selective and uneven ways in a cluster. The author related it to the heterogeneous and asymmetric distribution of knowledge bases inside the clusters. Moreover, novel ideas, opportunities and markets brought by outsiders are fertile ground for the gestation of new entrepreneurial firms. Hence, we suggest that:

Proposition 4: *Open clusters are likely to have higher levels of entrepreneurship than closed clusters.*

It is worth noting in this respect that at a lower level – at the level of the firm, rather than among firms – there is evidence (see Hansen, 1999) that weak ties among sub-units have a positive effect on innovation once each contributes with different pieces of knowledge for a certain innovation. The apparent paradox is that it is through strong ties that this knowledge is better transferred, particularly systemic, complex, tacit knowledge, as we discussed previously. In a cluster, the proximity among firms eases the transfer of knowledge given the strong ties connecting firms and the mobility of workers. Moreover, knowledge is more easily transferred among similar firms since there is a reduction in causal ambiguity and a higher absorptive capacity among these firms. However, it is the knowledge that is brought in from outside that is most likely unknown to the clustered firms, and the ties to outside firms are at best weak ties.

TYPES OF CLUSTERS AND SOCIAL STRUCTURE

Breschi (2000) noted that increasingly innovation is a joint effort and does not proceed by isolated firms. This means that alliances and different forms of partnerships are important but also that proximity to rivals, clients and suppliers may ease pooling together complementary knowledge and resources (Teece, 1987, 1997). In the latest and more sophisticated designs, clusters, alliances (Barney, 2001) and the various forms of partnerships increasingly appear not only as mutual competitive alternatives but as strategic complements (see Doz and Hamel, 1998, for a good reference in alliances application).

As Breschi (2000, p. 214) highlighted the "ability to innovate is affected by the spatial proximity to external sources of knowledge, one should then observe wide differences in the innovative capabilities among firms located in different geographical areas". In addition, it is possible that these geographical areas idiosyncratic features favor or impede the sharing and transfer of knowledge among firms. In other words, it seems likely that some characteristics may make some clusters more innovation abundant than others. In fact, it is our tenant in this paper that some clusters will promote innovations while others may not do so, and the social structure is one of the determining factors in explaining why innovation activity may vary sharply across industry clusters.

Different types of clusters have different underlying social structures. The task of identifying an exhaustive typology of clusters is beyond the scope of this paper. However, we may use Markusen's (1996) four types of industrial districts - or clusters - to illustrate briefly how different social structures and organizational configurations are likely to influence the generation of knowledge and of innovations. Markusen's (1996) descriptive typology of clusters is based on various criteria such as: (a) the firms' configuration; (b) internal or external orientation, or the embeddedness of firms within their cluster and with agents outside the cluster; (c) governance structures; (d) the role of the state; (e) the role of large firms; and (f) extent of cooperation and types of business relationships.

Following, we present a brief description of each of the four types based on Markusen's (1996) characterization. It is worth noting at the outset to state that in the context of our study, the relevant issue is to try to understand in which type of cluster the innovation potential is greater. Or, more broadly, the configuration of the firms and relationships that underlies to knowledge creation in clusters beyond the arguments on the appropriation of rents from innovation (Ferreira *et al.*, 2005). Perhaps, related to this broad question it is worth discussing who is likely to generate the innovations within each type of cluster. In sum, the types of firms, the models of outsourcing pursued and the strength of the business ties should matter, and these vary in open and closed industry clusters. Some important elements for each type of cluster are appointed here.

The *Marshallian industrial districts* are composed of multiple small, innovative and locally-owned firms that are deeply embedded in local and regional ties to other co-located firms in a broadly cooperative governance system, which favor their survival and adaptation. This type of clusters is frequent in Europe in the old industrial districts. The intra-cluster exchanges are dense and the employees move frequently across firms but within the cluster. There is a high degree of cooperation among competitor co-located firms that share risks, costs, and knowledge, while an idiosyncratic local culture is a major trait of this type of cluster.

These clusters are characterized by an overwhelming inward focus and a population of small to medium enterprises.

The employees are mobile but essentially to other incumbent firms inside the cluster and it seems plausible to advance that we will observe strong mimetism among firms. Although there may exist strong entrepreneurial drive, it is most likely to be from employees existing their previous employer to create their own firm and explore umbilical ties to the previous employer (Ferreira *et al*., 2006). While employee mobility eases the transfer of tacit knowledge, it becomes gradually less likely that these employees will be actually transferring knowledge not yet held.

The frequent shifts of employees from one firm to another inside the cluster make knowledge assume a 'local public good' character and is depicted by Markusen (1996, p. 299) as "the secrets of the industry are in the air" (see also, Arrow, 1962; Olson, 1965; Schelling, 1978). These clusters are relatively closed, are probably more resistant to change and less likely to search outside its boundaries. Moreover, since the purpose of innovation and R&D is to generate commercially viable knowledge and the small firms are less able to keep the knowledge from spilling over to the public domain they have a lower incentive to innovate. This feature allows the formulation of the following proposition:

Proposition 5.1: *Clusters composed of small firms seem to generate a low level of innovation activity.*

The *Hub-and-spoke districts* revolve around one or more dominant and externally oriented firms, typically vertically integrated, and surrounded by multiple smaller suppliers (both local and external). Two documented examples of this type of cluster include Seattle (Boeing) and Toyota City (Toyota). Although the specific morphology of this type of cluster may vary (see Markusen, 1996, for a discussion), the dominant firm(s) have extensive ties to suppliers, competitors and clients outside the cluster, the employees' mobility is substantially lower than in the *Marshallian* type, and the hub firm imposes the terms of the exchanges with the local spoke firms.

A major facet of these clusters is the presence of central hub firm(s) holding a dominating position and a large market power tying suppliers in long-term contracts. Probably these are clusters with low degree of cooperation among dominant firms in sharing the risks and the costs of knowledge creation. The dominant firm imposes the pace and objectives of innovation and it is reasonable to suggest that innovation objectives are outsourced modularly to small and specialized firms. Alternatively, the central, dominant, firm is more likely to develop in-house the knowledge innovation and then transfer it contractually through outsourcing ties. These clusters may be more open when the dominant firm is, for example, a large multinational firm or a large firm with clients worldwide, and in specific industries such as the airlines or automobile.

In these clusters, the large firms will likely generate the innovations and account for most outflows of knowledge spillovers to the clustered firms. They are thus aware that other firms will free-ride on their innovation efforts. The hazards of knowledge spillovers and difficulty in appropriating the rents from R&D may be the reason why some of the best firms prefer not to cluster (Pouder and John, 1996). Notwithstanding, it is reasonable to suggest that these firms will commit to some level of innovation activities with co-located firms to maintain the ability to assimilate and exploit new knowledge captured from external agents; that is to maintain some absorptive capacity (Cohen and Levinthal, 1990). This leads to formulate as follows:

Proposition 5.2: *Clusters dominated by a large outward looking firm generate a high level of innovation activity, mostly provided by the dominant firm.*

The *State-anchored industrial districts* are centered on one or more public institutions (e.g., university, military, and so forth) that anchor local economic activity. The nature and scope of the local economic activity is determined by and dependent on these anchors. A variety of suppliers may emerge around these large institutions, with which they establish short-term contracts. Given that these are state-funded institutions, decisions may be largely based outside the location or be dependent on political shifts. In addition, ties of these large institutions to clients and suppliers are not necessarily of a local nature.

Indeed, a similar situation may occur for the *state-anchored industrial districts* given that these are characterized by the presence of a large anchor firm such as anchor firm or legally contracted out, but in either case the anchor firm will probably retain the rights to the innovation and be able to protect it from unintended diffusion. This situation occurs for the military-driven research, for instance. Hence, we suggest that:

Proposition 5.3: *Clusters dominated by an inward looking firm generate a low level of innovation activity, and the innovations are addressed to the dominant firm's activity.*

Lastly, the *Satellite industrial platforms* consist of an assemblage of unconnected plants, mostly subsidiaries of multinational firms, embedded in external organizational links (Markusen, 1996, p. 293). These may be composed of high-technology firms or of firms that seek to exploit low cost of local resources but are generally large, foreign owned firms. Although the specific activities may vary substantially within this type, these firms must have the ability to stand alone and fairly detached from up and downward agents. The case of the agglomeration of unrelated research facilities of large multinational firms in the Research Triangle (in North Carolina, USA) is noted as a notable example of this type of cluster (Markusen, 1996). In addition, intra-cluster exchange

is minimal and business ties to co-located agents are minimal in favor of stronger ties to the parent headquarters and other non-local units.

In these clusters firms are fairly detached from local agents and any innovation is likely to be developed in relative isolation in-house. The scarce exchange flows with other co-located firms does not promote frequent locally bound innovations. Given that these firms are largely 'stand-alone' operations the diffusion of knowledge to potential imitators is more difficult and hence innovations through collaboration or the recombination of dispersed knowledge is not likely to be very frequent. The mobility of personnel among firms is limited and inter-firms exchanges are scarce. This type of clusters is also reasonably closed in terms of generating a social structure promoting knowledge creation.

But the complex characteristics of business units, in opposition to the sole formation of the three previous clusters, may take advantage of more sophisticated designs. Due to their condition of value generators for their corporations, they have also taken advantage of geographical proximity to develop their strategic alliances in the various levels of the productive channel (see Varadarajan and Ramanujam (1987) as a good reference for value generation in diversification, and Vyas *et al*. (1995) for how to do it by means of alliances). Therein, the principle is to promote frequent innovations by means of the preservation of their respective central competences and of the collaboration in their outlying competences (Hamel *et al*., 1989). Since the objective is precisely knowledge exchange, and the firms are bounded to a geographical cluster without necessarily characterizing their collaboration as so, major exchange appears among firms, increasing the imitation potential (Barney, 2001), the potential for the use of dispersed knowledge, and the generation of some mobility of the personnel as well. This broader understanding is a new window for the following proposition:

In sum, the analysis of the social structure across clusters and their impact on the innovation potential is a significant advancement over existing research. Although there are no general rules as to what the innovator firms are or as to what makes the most innovative regions – since they are likely to vary along multiple factors, such as the cluster configuration, the types of ties binding firms, the extent of employee mobility, and so forth – it is reasonable to suggest that we need to look deeper at the very heart of the clusters and their social structure.

DISCUSSION AND CONCLUSION

A major tenant of this paper is that we need further examination of the network dynamics involved in an industry cluster to obtain a clearer identification of the actual positive externalities that may accrue to co-locating firms. It is possible that some of these benefits are firms specific while others are location specific. It is further reasonable to state that not all firms in the cluster are alike, rather they are heterogeneous, even though there may exist a strong pressure towards assuming isomorphic behaviors through mimetism. The composition of the cluster drives the benefits firms may draw, namely the knowledge benefits.

Although we tend to focus on the positive effects of clustering, it is easy to infer negative effects. These are effects related to, for example, increased competition for the same resources, firms engaging in too much mimetism and groupthink thus failing to adapt to changing environments, and the unintended spillover of firms own knowledge or technologies. In fact, Porter and Stern (2001) had already stated that innovation in clusters is promoted when the cluster hold firms with different backgrounds. This paper intends to contribute to the debate on the type of social structure that is more beneficial for innovation and knowledge generation in a cluster.

Many of the clustering advantages focused upon in prior research highlight the essential role of the social networks in these regions (Porter, 1998) and the mobility of employees from one firm to another. That is, the flows of experience-based (or tacit and experiential) knowledge among firms are fuelled by the exchange of employees. This process permits the inter-firms transfer of knowledge that otherwise if relatively immobile (Kogut and Zander, 1992; Szulanski, 1996). It is further advanced that cooperation is a basic force tying firms in the cluster. Moreover there are other non-economic externalities that seemingly makes cluster a rational location decision, or even a knowledge-based strategy. These externalities are related to gains in legitimacy and reduction of uncertainty through imitation (Dimaggio and Powell, 1983; Henisz and Delios, 2001; Guillen, 2002).

Our discussion of the knowledge- and innovation-related benefits of clustering highlights the importance of maintaining an appropriate proportion of ties to firms outside the cluster. These ties bear novel knowledge. Ideally, a firm will be able to occupy a structural hole brokering with the other firms in the cluster. Hence, the network content matters, which means that we need to look at the type of cluster and the possibility to carry relationships to firms outsiders to the cluster. The network structure foundational to the cluster thus matters. Sparse networks permit the firm to access and possibly absorb heterogeneous knowledge. The structure of the network thus helps firms in either exposing the firm to varied knowledge, to opportunities and to the possibility of simply brokering the information.

Future research may evolve through multiple contiguous avenues. First, it is worth pursuing the empirical evaluation of the innovativeness of clusters compared to non-clustered firms. It is possible that innovation in clusters faces the serious issue of knowing who captures de rents from innovations (Ferreira *et al*., 2005). Second, researchers may look at how different governance models really impact on co-located firms' ability to innovate. That is, is innovation a phenomenon that occurs regardless of the structure and composition of the cluster or do

we find inter-cluster variations that are worth examining for both public policy and business strategy? This line of research may find in inter-industry studies a more prolific setting. Third, an evolutionary perspective on the relationships proposed is likely to be an interesting endeavor with theory building potential. That is, does the innovation activity evolve over the clusters' life cycle and the technologies and markets mature? Also, there is some evidence that short geographic distance is not enough for knowledge flow (Tallman and Phene, 2007) which lead to further investigation about social networks, open and closed industry clusters and other factors that may lead to knowledge flows among firms. Finally, it is worth assessing how industry's idiosyncrasies determine who is more innovative in a cluster - is it a small firm, a large firm, or a dominant firm?

Several implications result from our understanding of how knowledge and innovations are generated in clusters and the underlying social structure that is most favorable for this purpose. Every innovation requires at least the recombination of known bits of knowledge and every innovation warrants protection so that the future rents accruing from the innovation are captured by the innovator firm. Ultimately it is up to the manager to figure out where to locate to access knowledge and where to locate to impede the firm's own knowledge from dissipation to competitors (Teece, 2000).

In other words, managers need to decide in which kind of cluster to locate to benefit the most of knowledge spillovers. That is because clusters seem spots of particularly intense innovative activity, or hot spots (Pouder and John, 1996) but also rely on extensive inter-firm exchanges and collaboration. Rosenkopf and Nerkar (2001), for example, noted that innovations (specifically radical discontinuities) are likely to be at least partially based in knowledge and/or technology that reside outside the firm's boundaries. Nagarajan and Mitchell (1998) advanced that firms must rely on coordination among firms through strong interrelationships to generate innovations.

For public officials it is important to note that appropriate policies aimed at developing competitive clusters requires not only the expenditure in creating a high quality infrastructure and adequate institutional environment (schools, technology centers, R&D labs, and so forth) but also needs to take into account the human and cultural dimension that is foundational to the social structure of the region.

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