CIRCLE

LUND UNIVERSITY

Paper no. 2006/11

The uneven and selective nature of cluster knowledge networks: evidence from the wine industry

Giuliani, Elisa (Eg20@sussex.ac.uk)
University of Pisa and SPRU Univity. of Sussex

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications
ISSN 1654-3149

WP 2006/11

The uneven and selective nature of cluster knowledge networks: evidence from the wine industry

Giuliani, Elisa

Abstract

Most of the studies about industrial clusters and innovation stress the importance of firms' geographical proximity and their embeddedness in local business networks, as factors that positively affect their learning and innovation processes. More recently, scholars have started to claim that firm-specific characteristics should be considered to be central in the process of learning and innovation in clusters. This paper contributes to this latter direction of research. It applies social network analysis to explore the structural properties of knowledge networks in three wine clusters in Italy and Chile. The results show that in spite of firms' geographical proximity and the pervasiveness of local business networks, innovation-related knowledge is diffused in clusters in a highly selective and uneven way. This pattern is found to be related to the heterogeneous and asymmetric distribution of firm knowledge bases in the clusters.

Keywords: Clusters, firm knowledge base, knowledge network, business network, wine industry.

The uneven and selective nature of cluster knowledge networks:

evidence from the wine industry

Elisa Giuliani
SPRU, The Freeman Centre
University of Sussex, Brighton
East Sussex, BN1 9QE, UK
Eg20@sussex.ac.uk

DEA, Facoltà di Economia
University of Pisa
Via Ridolfi 10
56124 Pisa, Italy

(A previous version of this paper can be downloaded from http://www.druid.dk/wp/pdf_files/05-11.pdf)

Acknowledgements

The author would like express her gratitude to Martin Bell, Nick von Tunzelmann, Angelo Secchi and Lionel Nesta for their helpful suggestions during the elaboration of this paper. Thanks go also to Cristian Diaz Bravo, Marcelo Lorca Navarro, Erica Nardi and Elena Bartoli for their support in data gathering. This paper has also benefited from comments and insights given by Hubert Schmitz, Stefano Breschi, Mari Sako, Michael Storper and three anonymous referees. Encouragement received by Peter Maskell and the scientific committee of the DRUID Summer Conference 2005 has been greatly appreciated. Funding provided by the EU Marie Curie Fellowship Program (HPMT-GH-00-00158-01) and the UK Economic Social Research Council (ESRC) (PTA- 030200201739 and PTA- 026270644) is gratefully acknowledged. Usual disclaimers apply.

The uneven and selective nature of cluster knowledge networks: evidence from the wine industry

Abstract

Most of the studies about industrial clusters and innovation stress the importance of firms' geographical proximity and their embeddedness in local business networks, as factors that positively affect their learning and innovation processes. More recently, scholars have started to claim that firm-specific characteristics should be considered to be central in the process of learning and innovation in clusters. This paper contributes to this latter direction of research. It applies social network analysis to explore the structural properties of knowledge networks in three wine clusters in Italy and Chile. The results show that in spite of firms' geographical proximity and the pervasiveness of local business networks, innovation-related knowledge is diffused in clusters in a highly selective and uneven way. This pattern is found to be related to the heterogeneous and asymmetric distribution of firm knowledge bases in the clusters.

Key-words: Clusters, firm knowledge base, knowledge network, business network, wine industry.

JEL Codes: O1, O18, O30, R11

1 Introduction

Studies of industrial clustering date back to at least Alfred Marshall's contribution on economies of localisation (1920). However, interest in spatially agglomerated industrial firms has risen mainly during the past thirty years, when the dominant model of the Fordist firm came to be questioned (Piore and Sabel, 1984) and geographical clusters of firms were seen as drivers of national competitiveness and growth (e.g. Porter, 1990; Krugman, 1991). [1] Among the directions of research in this field, the relationship between industrial clustering, localised learning and innovation has received rising consideration (e.g. Maskell, 2001a; Pinch et al. 2003). A vast majority of the empirical studies have found that clustered firms show a higher innovative capacity than isolated firms (Porter, 1990; Baptista and Swann, 1998; Baptista, 2000), with only a few exceptions questioning this view (e.g. Beaudry and Breschi, 2003) .

The interpretation that is often given to the higher innovativeness of clustered firms is twofold: on the one hand, economists stress the public nature of knowledge (Arrow, 1962; Jaffe, 1989) and argue that geographical proximity is conducive to innovation because of localised knowledge spillovers (e.g. Jaffe et al., 1993). On the other, scholars of economic geography emphasise that it is not geography *per se* that matters for innovation, but it is the embeddedness of firms in localised networks that facilitate the diffusion of knowledge and enhance collective learning in clusters (Maskell and Malmberg, 1999; Capello and Faggian, 2005). In particular, the presence of local business networks is often associated with the capability of a cluster to promote localised learning (Keeble and Wilkinson, 1999) both vertically, between clients and suppliers, and horizontally, among rival firms. In spite of their differences, both views promote the idea that innovation-related

[1] An industrial cluster is defined here as a geographical agglomeration of firms operating in the same industry, in line with the definition given by Humphrey and Schmitz (1996). Sometimes scholars have defined this type of industrial agglomeration as industrial district. Throughout the paper terms like clusters and districts will be used interchangeably.

knowledge is diffused in clusters in a pervasive and unstructured way, very much consistent with the Marshallian idea of 'industrial atmosphere'.

More recently, however, scholars have started to highlight the need to understand the process of localised learning and innovation, looking at the role played by firms, considered as private profit-maximising agents, rather than at the institutional, meso-level characteristics of territories (e.g. Lazerson and Lorenzoni, 1999; Maskell, 2001b; Martin and Sunley, 2003). This paper contributes to this stream of studies; it considers a specific micro-level dimension, the knowledge base of firms, and explores the relationship that exists between this dimension and the structural characteristics of cluster knowledge networks. Drawing on the evolutionary economists' view of the firm, this paper explores whether and how the heterogeneous and asymmetric distribution of firm knowledge bases (Nelson and Winter, 1982; Dosi, 1988) in clusters influences the way innovation-related knowledge is transferred and absorbed at the local level (Cohen and Levinthal, 1990). The paper raises questions about the widespread view that the diffusion of knowledge in clusters is pervasive and tied to local meso-level conditions, such as the geographical proximity of firms and the presence of business networks.

These issues are explored here using empirical evidence collected in the specific context of the wine industry. The study is based on firm-level data for three wine clusters in Italy (Colline Pisane and Bolgheri/Val di Cornia) and Chile (Valle de Colchagua) and it uses a combination of social network analysis and econometric methods. In line with a number of studies that have begun to emphasise the role of firms in cluster innovation processes (e.g. Bell and Albu, 199; Lazerson and Lorenzoni, 1999; Beaudry and Breschi, 2003; Maskell, 2001b; Markusen, 2003), this paper shows that innovation-related knowledge is diffused in the three clusters in a selective and uneven way, a property that reflects the different internal capabilities of firms to transfer and absorb knowledge at the local level. Moreover, this study finds no empirical support for views that describe the process of diffusion of knowledge in clusters as pervasive and driven mainly by the geographical proximity of cluster firms and their participation in local business networks.

The paper is structured as follows. Section 2 provides a review of the literature. Section 3 outlines the conceptual framework and defines the research hypotheses of this paper. Section 4 explains the methodology applied in this research and the operationalisation of concepts. Section 5 presents the empirical evidence and Section 6 discusses the results and the limitations of this study, providing suggestions for future research.

2 Knowledge diffusion in industrial clusters

The description of the process of knowledge diffusion and generation in clusters of firms has traditionally been based on several re-interpretations of the Marshallian, externality-driven world of industrial districts. Empirical studies have elaborated on the Marshallian notion of knowledge spillovers;[2] this paper considers two widely influential views: the economists' perspective on localised knowledge spillovers and the economic geographers' view of learning in clusters.

2.1 The economists' view of localised knowledge spillovers

A view maintained by many economists is that knowledge spillovers, which are by definition a public good (Arrow, 1962; Jaffe, 1989), tend to be highly localised (Jaffe et al., 1993), a property that links conceptually geography and innovation. Within this stream of studies, robust empirical evidence has shown that a relationship exists between spatial clustering, knowledge spillovers, and firms' innovative output. Audretsch and Feldman (1996) use US micro-level data and find that, in

[2] Marshall (1920) described the industrial district as a place where "mysteries of trade become no mysteries; but are as it were in the air." (p. 225)

knowledge-intensive industries, innovative activities tend to cluster spatially even after controlling for the agglomeration of productive activities. This is considered to be due to the fact that, in such industries, the transmission of tacit knowledge is important to foster innovation, so that “innovative activity is more likely to occur within close geographic proximity to the source of that knowledge, be it a university research laboratory, the research and development of a corporation, or the exposure to the knowledge embodied in a skilled worker” (Audretsch and Feldman, 1996, p. 638).

Quite in line with this, using UK data, Baptista and Swann (1998) find that a firm is more likely to innovate if it is located in a region where the presence of firms in its own industry is strong, which is to say that the geographic proximity of firms operating *within* the same industry positively affects their innovation. One of the interpretations given for this is related to “the pervasiveness of knowledge externalities or spillovers. It seems likely that spillovers, particularly those associated with new technological knowledge, tend to be geographically localised. Certain regions accumulate sources of spillovers, which in turn attract or support innovators” (p. 538). Similarly, Baptista (2000), still using UK data, finds evidence that the geographic proximity of previous adopters of a given technology facilitates the probability of adoption by other firms. This result thus provides support for “the existence of a significant positive regional learning effect influencing diffusion” (Baptista, 2000, p. 530).

Finally, Feldman (1999) suggests that the several economic approaches used to investigate the relationship between geography and innovation “demonstrate the existence of geographically-mediated knowledge spillovers, [and] the persistence and importance of localized knowledge” (p. 13). Within the economics literature, however, the mechanisms by which geographic proximity is likely to generate innovation are not directly explored (Jaffe et al., 1993; Feldman, 1999; Anselin et al., 2000) and what tends to predominate is the conception of knowledge as a public good, which spreads pervasively within a spatially-bounded area, as in the case of a cluster.

2.2 Economic geographers' view of learning in clusters

Over the past two decades, economic geographers have increasingly acknowledged the fact that geographic proximity *per se* is not sufficient to explain processes of localised learning and innovation (Boschma, 2005). They have undertaken what Boggs and Rantisi (2003) call a 'relational turn,' an expression used to indicate the fact that the relational dimension among economic actors has progressively become the unit of analysis in the study of economic geography. In this vein, the emergence of successful clusters or districts has become increasingly associated with the presence of localised networks, based on market and socio-institutional relationships among cluster firms. As Storper (1997) put it: "the status of the region is now not merely a locus of true pecuniary externalities, but – for the lucky regions – as a site of important stocks or relational assets." (p. 44) Several authors have emphasised that industrial clusters are places where market-based relationships, which Storper (1995) calls "traded interdependencies" among cluster firms, are strongly intertwined with socio-institutional ties (see e.g. Scott, 1988; Maillat, 1990; Becattini, 1990; Camagni, 1991; Saxenian, 1994; Storper, 1995; Porter, 1998; Morgan, 1999).

Both market and socio-institutional relationships are then considered to be important vehicles for the diffusion of knowledge at the intra-cluster level. First, the presence of stable and intense client-supplier linkages are considered to be "essential to information exchange" (Morgan, 1999, p. 495). Moreover, the existence of a local labour market and the mobility of skilled workers, including spin-off initiatives, is considered to be among the important vehicles for the transfer of knowledge and local know-how (Camagni, 1991; Capello, 1999; Capello and Faggian, 2005).

Second, the process of knowledge transfer is considered to be smoothed when firms are embedded in a similar socio-institutional context. As an example, Scott (1988) stresses that districts may host a community of life, characterised by "tangled informal networks of useful knowledge about production methods, business conditions, and employment practices [which] are an intrinsic element of community consciousness and help to keep the whole system functioning smoothly" (Scott, 1988, p. 39). As Keeble and Wilkinson (1999) remark contemporary analysis of industrial districts places emphasis on the influence of the local community, defined as family and other social relationships, and rules of behaviour embedded in those relationships, "in guaranteeing standards of behaviour which engender trust and cooperation and thereby strengthen inter-firm networks." (Keeble-Wilkinson, 1999, p. 289). As said, these social linkages are often associated with the transfer of knowledge. For example, Saxenian (1994) describes the formation of a technical community in Silicon Valley, formed by technician entrepreneurs with high collective identity, as a critical element to generate an environment of informal socialisation that boosts innovation. By the same token, formal institutions, such as business associations, consortia and similar cooperative initiatives, are considered to be another important element, which contributes to generate an intra-cluster "institutional thickness" (Amin and Thrift, 1994, p. 102), which favours inter-firm networking and the diffusion of knowledge.

In industrial clusters, market-based and socio-institutional relationships of the types described above are often considered to be highly overlapping. Scholars have considered that the coexistence of these different relationships leads to the formation of intra-cluster business networks, defined by Keeble and Wilkinson (1999), quoting Yeung (1994), as "an integrated and co-ordinated set of ongoing economic and non-economic relations embedded within, among and outside business firms" (p. 299). In turn, business networks are seen to favour collective learning (among many others: Capello, 1999; Keeble and Wilkinson, 1999; Lawson and Lorenz, 1999; Capello and Faggian, 2005).

Furthermore, a view maintained by many economic geographers is that business networks are able to generate a learning environment in which knowledge is diffused pervasively, as a club good within the boundaries of the cluster. This comes as the result of the fact that the formation of intra-cluster networks is often guided by unstructured decision processes, and by the fact that geographical proximity leads entrepreneurs and professionals to meet and interact almost by chance. The so called "cafeteria effects" are a nice metaphor for this (Camagni, 1991). In this vein, Malmberg (2003) defines intra-cluster interactions as being "not just…unstructured and unplanned, but also relatively broad and diffuse, sometimes unwanted and often seemingly of little immediate use" (p. 157). Similarly, Saxenian (1994) describes the informal conversations among engineers in Silicon Valley as "pervasive" (p. 33) and states that "this decentralised and fluid environment accelerated the diffusion of technological capabilities and know-how within the region" (p. 37). These views have promoted the idea that both firms' geographical proximity and their embeddedness in business networks are important factors that lead cluster firms to innovate.

More recently, a number of economic geographers have begun to question a part of this story. They have started to claim that *firms* should be considered central actors in the process of economic development since their individual behaviour influences the meso-level conditions that eventually lead to innovation. In this direction Lazerson and Lorenzoni (1999) suggest that:

> Throughout most of the literature there is a tacit assumption that all district firms are relatively homogeneous and that they do not merit attention in their own right. While local institutions and broader social-structural features undoubtedly shape and constrain economic behaviour within industrial districts, we want to emphasise that industrial districts continue to be very much shaped by individual agency (pp. 237-238).

Likewise, Ann Markusen (2003) claims that it is not the space that "self-organizes" following meso-level rules, but it is the decision-making of firms, as private, profit-maximising agents, that shapes the territory and its development process. In line with these studies, others have suggested that to understand the process of localised learning and innovation there is a need to place firm-level learning at the centre of cluster analyses with the objective of understanding how firm-level and cluster-level learning processes interact (Bell and Albu, 1999; Maskell, 2001b; Taylor and Asheim, 2001; Martin and Sunley, 2003; Bathelt and Glückler, 2003; Asheim and Coenen, 2005; Boschma and Frenken, 2006). In this direction, Martin and Sunley (2003) argue that:

> 'The cluster literature' lacks any serious analysis or theory of the internal organization of business enterprises (Best and Forrant, 1996). Instead it emphasizes the importance of factors external to firms and somehow residing in the local environment. In too many accounts local 'territorial learning' is privileged, yet what this process actually is remains ambiguous and its interactions with firm-based learning are left completely unexamined (Hudson, 1999). (p. 17)

Using the expression 'territorial learning', Martin and Sunley clearly refer here to the 'collective learning' process occurring at the cluster level (see Martin and Sunley, 2003, p. 17) and stress the need to understand how such a process interacts with firm-level learning. This paper builds on this literature, proposing a conceptual framework that allows this interaction to be explored, as discussed in Section 3.

3 A firm-level interpretation of cluster learning and innovation

3.1 Heterogeneous firm knowledge bases and cluster knowledge networks

Drawing on Nelson and Winter's (1982) evolutionary theory of the firm, the view maintained here is that firms in industrial clusters are likely to be characterised by heterogeneous and asymmetrically distributed knowledge bases, a fact that has also been observed empirically by several cluster scholars (Schmitz, 1995; Rabellotti and Schmitz, 1999; Lazerson and Lorenzoni, 1999; Camison, 2004). A firm's knowledge base is defined here as the "set of information inputs, knowledge and capabilities that inventors draw on when looking for innovative solutions" (Dosi, 1988, p. 1126). Knowledge is seen as residing in skilled knowledge workers in the firms and it is accrued and generated through their experimentation effort, both to exploit and to explore new ways to solve problems (Nelson and Winter, 1982; March, 1991).The process of accumulation of knowledge at the intra-firm level is, moreover, inherently imperfect, complex and path-dependent, resulting in persistent firm heterogeneity (Dosi, 1997).

The question here is whether and how this heterogeneity influences the structural characteristics of a cluster knowledge network, defined as the network that links firms through the transfer of innovation-related knowledge, aiming at the solution of complex technical problems. The claim here is that the intra-cluster knowledge network has structural properties that are shaped by the relative strength of firm knowledge bases in the cluster.[3] This is related to the fact that, since networking is a time-consuming and costly process, firms looking for an informal technical advice will deliberately *target* and *select* the firms, which are the most likely to offer a better solution to a problem (Schrader, 1991). The formation of innovation-related knowledge linkages will therefore be the result of a purposeful behaviour rather than a random leakage of knowledge. This is in line with Coe and Bunnel (2003), who state that "innovation should not be considered in the context of an anarchic, placeless 'space of flows' (Castells, 1996), but rather in terms of situated social relations between appropriate actors, in turn embedded in particular places" (p. 439).

An implication of this is that firms with particularly strong knowledge bases will be likely to be perceived by other cluster firms as 'technological leaders' in the local area, leading to them being sought out as sources of advice and knowledge more often than firms with weaker knowledge bases

[3] The structure of networks in districts has also been previously explored by other scholars. A pioneering study is that of Markusen (1996), who focused on the division of labour and on the organisation of production in industrial districts. This paper focuses on a different dimension, that of knowledge transfer, and it is novel in applying methods of network analysis (Wasserman and Faust, 1994), still poorly utilised in economic geography, as remarked by Boggs and Rantisi (2003).

(Giuliani and Bell, 2005). In contrast, the knowledge base of some other firms may be so weak that neither do they offer anything of value to other firms nor do they have the internal capacity to absorb the stock of knowledge that is available in other cluster firms (Cohen and Levinthal, 1990). In view of this, some firms will be more central than others in the intra-cluster knowledge network.

Moreover, firms with stronger knowledge bases will be more likely targeted by those cluster firms that are able to decode and absorb the knowledge that is potentially transferred (Lane and Lubatkin, 1998), and whose 'cognitive distance' from the technological leaders is not too high to inhibit communication (Boschma, 2005). A consequence of this is that firms with similarly strong knowledge bases will exchange knowledge more intensively. From an economic viewpoint, firms with stronger knowledge bases have incentives to *transfer* knowledge to other organisations when these have equally advanced knowledge bases and are therefore in a condition to reciprocate with valuable knowledge. In line with von Hippel (1987) and Schrader, (1991), reciprocation constitutes the expected pay-off for the transferred knowledge.[4] These considerations lead to the formulation of the following hypothesis:

> **Hypothesis 1** Firms with stronger knowledge bases are likely to be more central in the cluster knowledge network.

3.2 Business networks and the diffusion of knowledge in clusters

This section explores the extent to which the knowledge networks formed within clusters are entangled with local business networks. As already noted in Section 2, business networks are "an integrated and co-ordinated set of ongoing economic and non-economic relations embedded within,

[4] In Giuliani and Bell (2005), the authors find that knowledge transfer needs not to be reciprocated to occur, as firms may transfer knowledge also in an unbalanced way (on this, see also Bouty, 2000). However, they also illustrate the emergence of knowledge communities in the cluster, formed by actors with similarly advanced knowledge bases, which have an interest in exchanging knowledge in a balanced way.

among and outside business firms" (Keeble and Wilkinson, 1999, p. 299). Accordingly, the formation of business networks is based on the coexistence of market, social and institutional relationships, which occur almost routinely in a cluster context. In contrast to the knowledge network, the business network is more likely to be shaped by pervasive and unplanned local interactions. This is in line with Becattini (1990), Pyke at al. (1990), and Malmberg (2003), among many others, who suggest that professionals or entrepreneurs who work within the same cluster meet by chance and interact on issues related to their jobs, from market transactions to other informal professional interactions. Obviously, business networks may be channels for the transfer of several assets, among which knowledge and information. What follows is that, if business networks were a relevant channel for the diffusion of innovation-related knowledge among cluster firms, then this knowledge would become distributed quite pervasively in the cluster, consistent with the views of economists and economic geographers discussed in Section 2.

However, the argument of this paper is that it is the heterogeneity and the asymmetric distribution of cluster firms' knowledge bases that shapes the way innovation-related knowledge is diffused in clusters, as described in Section 3.1. Accordingly, when looking for technical advice, firms deliberately *target* and *select* the firms that are the most likely to offer better solutions to problems, no matter whether they are connected to the local business network. In other terms, firms with weak knowledge bases, because they neither offer anything of value to other firms nor have the internal capacity to absorb external knowledge, will have at best a marginal position in the knowledge network, even if they are centrally positioned in the business network. In effect, the two networks are formed by differing underlying motivations, so that it is reasonable to believe that their structural characteristics will differ widely. This leads to the formulation of the following hypothesis:

Hypothesis 2: The structure of the knowledge network differs significantly from that of the business network.

Exploring the difference between the business and the knowledge network is relevant as it may help to understand the extent to which innovation in clusters is related to meso-level factors (e.g. firms' geographical and sectoral proximity and firms' connectedness to the local business network) or to firm-specific factors (e.g. their knowledge bases), an issue that has been recently debated by scholars in economic geography (Section 2.2). This in turn could illuminate on the nature of the innovative process at the intra-cluster level. In effect, whereas business networks are likely to be formed by the pervasive and unstructured interactions occurring almost by chance between cluster firms, as cited above, the knowledge network is structured by the heterogeneity of firm knowledge bases and it may be formed on a more selective basis. In the presence of an asymmetric distribution of firms' knowledge bases, the diffusion of innovation-related knowledge among cluster firms will occur in a rather uneven way, with some firms evidently central in the cluster knowledge network and others completely isolated. This leads innovation-related knowledge in clusters to be diffused more unevenly than one would expect if it were to flow through the business network. Accordingly, the following hypothesis is formulated:

Hypothesis 3: The diffusion of innovation-related knowledge among firms with heterogeneous knowledge bases will be more uneven than would be expected if this knowledge were to flow primarily through the business network.

4 Methodology

4.1 The context

This empirical study is contextualised in the wine industry. Known for being a traditional industry, wine production has recently emerged as a dynamic and fairly knowledge-intensive activity (Loubere, 1990; Paul, 1996). In the last two decades, wine consumption has dramatically changed, shifting market preferences from quantity, non-premium wines to quality, premium wines. On the side of production, technology and techniques of grape-growing and wine making have undergone processes of increased codification of knowledge. As suggested by Paul (1996): “Instrumentation, statistical analysis, and comparisons of various methods of analysis have become much more important than they were in the old oenology.… Oenology is done with high-tech research tools” (p. 338). Technical change has been strong in the industry and the key competitive asset of wine producers is now the capacity to absorb and manage new techniques of production. In this context, the presence of qualified oenologists and agronomists have become necessary to produce high quality wines, and many firms have hired external consultants (the ‘flying winemakers’) to cope with the continuous upgrading in wine production techniques.

The codification of knowledge in this industry has allowed countries which were not traditional ‘old world’ wine producers to catch up and emerge as exporters of fine wines. Hence, during the past two decades, particularly in the 1990s, countries like Australia, New Zealand, South Africa, Chile and Argentina have become competitive in the international market of premium wines, challenging old producers. Subsequently, the shares of world wine total exports for traditional producing countries like France, Italy, Spain and Portugal have been eroded over time in favour of new world exporters, such as Chile and Argentina (Anderson and Norman, 2001).

This study has been carried out in two countries, Italy and Chile, which differ historically but have recently undergone a similar process of wine industry growth and modernisation. In both cases, what has sparked growth is a process of technological change aimed at improving the quality of wines. Based on this, new and successful wine clusters have developed in both countries since the 1980s. This study considers two clusters in Italy (Colline Pisane and Bolgheri/Val di Cornia) and one in Chile (Valle de Colchagua). The boundaries of these wine clusters are given by their natural conditions. These types of clusters are therefore easily identifiable economic entities, whose boundaries are nowadays set by the Denomination of Origin regulations applied internationally by wine producing countries. All three clusters are territories densely populated by fine wine producers and by grape growers. The degree of vertical division of labour is rather low, with no other relevant suppliers located within the cluster territory.[5] A business association is also present in each cluster. On a global scale, these clusters can be classified as 'followers,' with Bolgheri/Val di Cornia and Valle de Colchagua being more dynamic than Colline Pisane.

4.2 Data collection

This study is based on micro level data, collected at the firm level in the three wine clusters on the basis of interviews, carried out with the firms' skilled workers (i.e. oenologists or agronomists) in charge of the production process at the firm level. The survey was carried out between September 2002 and July 2003 and was directed to producers of fine wines in each of the three clusters. The survey was not based on a sample. Instead data were gathered on the *universe* of fine wine

[5] The three wine clusters studied here are rural territories with a specialisation in wine production and grape-growing. With the exception of other crops or agricultural activities not connected to wine, no other industries are located within the clusters' boundaries, as input producers, e.g. of chemicals, machinery, or other materials, are located elsewhere. The shift from quantity- to quality-oriented wine production, moreover, has recently changed the yet limited division of labour between grape-growers and wine producers. The latter, in fact, have vertically integrated the phase of grape-growing, in order to have direct control over the quality of grapes. As a result, grape-growers have shrunk in number and have progressively become marginal actors in the production of fine wines.

producers populating the three clusters, which is 32 in Colline Pisane, 41 in Bolgheri/Val di Cornia and 32 in Valle de Colchagua, summing up to a total of 105 firms.[6]

Table 1 reports descriptive statistics on firm-level characteristics, such as their size, the ownership (i.e. whether they are foreign or domestic), and the decade of localisation in the cluster. Finally, the table includes information about the organisational structure, distinguishing between four types. The first are independent, vertically integrated firms, comprising firms that are not part of a larger corporation and that perform all the phases of the productive chain within the cluster. This type, which constitutes the vast majority of firms in the sample, differs from the cases in which local firms or plants are part of a group or a larger corporation and are either vertically integrated locally, thus performing all the phases of the productive chain within the cluster, or they are vertically disintegrated, in which case only a part of the production process is undertaken locally (e.g. grape-growing). Finally, a fourth type includes residual forms of organizational structure (e.g. firms forming part of a cooperative).

[Table 1here]

4.3 Operationalisation of variables and analysis

Apart from general background and contextual information, the interviews were designed to obtain information that would permit the development of quantitative indicators in three key areas: (i) the knowledge base of firms, (ii) the knowledge network and (iii) the business network.

[6] The lists of firms are drawn from official sources: the S.A.G. (Servicio Agricola y Ganadero) for Chile and the Provinces and Chambers of Commerce in Pisa and Livorno for Italy. Further screening by key informants has also been performed. The collection of data on the universe of fine wine producers in each cluster is desirable to achieve a robust network analysis (Wasserman and Faust, 1994).

(i) The knowledge base of firms (KB)

In the literature, the knowledge base of the firm is often associated with training, human resources and R&D. Correspondingly, the structured interviews sought detailed information about: (i) the number of technically qualified personnel in the firm and their level of education and training (Human resources), (ii) the experience of technically qualified personnel – in terms of months in the industry (Months of experience); and (iii) the intensity and nature of the firms' experimentation activities (Experimentation intensity). Experimentation intensity is a proxy for knowledge creation efforts. This has been measured on a scale ranging from 0 to 4, according to the number of areas in which the experimentation is carried out by a firm: for example, if a firm experiments in all the production phases, from the introduction of different clones or varieties in the vineyard 'terroir', the management of the irrigation and vine training systems, and the fermentation techniques and enzyme and yeast analysis, to, finally, the ageing period analysis, this firm will get a score of four in its experimentation intensity. In contrast, a firm with no in-house experimentation will have a zero. The three variables were transformed into a scalar value via Principal Component Analysis.

(ii) The knowledge network (KN)

In the questionnaire-based interview, this kind of relational data was collected through a roster recall method (Wasserman and Faust, 1994), which means each firm was presented with a complete list (roster) of the other wine producing firms in the cluster, and was asked questions related to the transfer of innovation-related knowledge. The questions are reported below:

Q1 If you are in a critical situation and need technical advice, to which of the local firms mentioned in the roster do you turn?

[Please rate the importance you attach to the knowledge linkage established with each of the firms according to its persistence and quality, on the basis of the following scale: 0= none; 1= low; 2= medium; 3= high].

Q2 Which of the following firms do you think have benefited from technical support from this firm?

[Please rate the importance you attach to the knowledge linkage established with each of the firms according to its persistence and quality, on the basis of the following scale: 0= none; 1= low; 2= medium; 3= high].

These network data are expressed in matrix form. A matrix is composed by *n* rows and *n* columns, corresponding to the number *n* of firms in each cluster. Each cell in the matrix reports the existence of knowledge being transferred from firm *i* in the row to firm *j* in the column. Since the relational questions (questions Q1 and Q2 above) allowed for the collection of valued data about the importance of innovation-related knowledge linkages ('valued data'), it was possible to construct a valued matrix for each cluster knowledge network.

The matrices resulting from these data have specific important characteristics. Firstly, they only include knowledge linkages, which are internal to the cluster. Other questions in the survey identified linkages that connected cluster firms with extra-cluster sources of knowledge (e.g. clients, suppliers, public organisations, etc.). However, given the focus here on intra-cluster knowledge networks, these types of external linkages are not explored in this paper, although they are obviously important in explaining cluster learning and innovation processes (Amin and Thrift, 1992; Bell and Albu, 1999; Coe and Bunnel, 2003). Secondly, the transfer of inter-firm knowledge that is analysed in this study is specifically directed to the solution of technical problems or to the transfer of technical know-how *a la* von Hippel (1987). [7] This is because the paper focuses on technological innovation, which is a key asset to compete in high-end international markets, as highlighted in Section 4.1. Thirdly, as a consequence of the limited division of labour within the clusters, discussed in Section 4.1, only horizontal linkages among fine wine producers are mapped by this survey. Wine producers reported to have established vertical linkages, e.g. with suppliers of machineries, enzymes, chemicals, etc., but all these run outside the cluster. Moreover, vertical linkages with grape-growers within the clusters were not relevant channels of knowledge, as grape-growers appeared not to play a critical role in the process of innovation in the three clusters. For this reason, they are not included in this present study. The same applies to the local business associations, which do not play a relevant role in the process of technological innovation. This focus on horizontal knowledge linkages is consistent with numerous other studies that have highlighted their importance in innovation (e.g. von Hippel, 1987; Carter, 1989; Schrader, 1991; Powell et al., 1996; Porter, 1998; Bouty, 2000; Lissoni, 2001; Maskell, 2001a; Amin and Cohendet, 2004; Dahl and Pedersen, 2004; Håkanson, 2005).

(iii) The business network (BN)

The concept of business networks has been operationalised in terms of the set of relationships established by the technical professionals, when they interact with other firms on a wide range of business issues. Examples of such interactions that give rise to the formation of a business network are the trade of inputs or services, the membership in the same local consortium, or the meeting at local industry events, which imply a personal direct interaction about, for example, their productive activities, the local labour market, international markets, etc. A business interaction occurs also when two firms borrow each other's machinery or tools for production, or their technical employees

[7] The questionnaire included questions on inter-firm joint experimentation and on the mobility of skilled workers. However, none of these two channels of knowledge transfer resulted to occur at a significant level in any of the three clusters.

meet and discuss their appropriate use or, finally, when firms buy each other's grapes or bulk wine or when entrepreneurs gather together to fund a new oenotourism initiative in the area.

Consequently, they include market-based transactions as well as many other types of interactions that are done on a cooperative basis among local professionals or, on the basis of a common institutional affiliation. Relational data of this type have been collected through a roster recall method, so that each respondent was presented with a complete list (roster) of the other firms in the cluster. The wide ranging nature of the relationship was explained as a basis for the question below:

Q3 With which of the cluster firms mentioned in the roster do you interact for business matters?

[Please indicate the frequency of interaction according to the following scale: 0= none; 1= low; 2= medium; 3= high]

When asked this question, professionals were requested to mention only firms with which any linkage was formed for a business-related matter, independent of the underlying reasons that led to the formation of that linkage – e.g. whether it was based on the existence of a solid friendship among the parties or on a pure arms' length relations. This measure of business network thus captures the existence of inter-firm business relationships, which can be built both through market and socio-institutional motivations. For the sake of simplicity in data collection, this question does not allow market-based relationships to be disentangled from socio-institutional relationships. Business relationships are expressed in matrix form. Each cell in the matrix reports the existence of a business relationship between firm *i* and firm *j*. Also in this case, a valued matrix could be constructed.

The methods of analysis applied to test the hypotheses of research are reported in Table 2 and briefly summarised in the rest of this section. Table 2 (A) reports the measures and methods of analysis used to test Hypothesis 1 about the relationship between the strength of a firm's knowledge base and its centrality in the cluster knowledge network. This hypothesis is tested adopting a negative binomial regression model with cluster fixed effects (Cameron and Trivedi, 1986). As dependent variable it uses an indicator of centrality of each wine producing firm in the knowledge network, which measures the number of direct knowledge linkages established with other firms in the network. As independent variable, it uses a measure of the knowledge base, which is an index derived from the application of the Principal Component Analysis of the three indicators Human resources, Months of experience and Experimentation intensity, discussed previously. Table 2 (A) also lists the regression control variables. The test of Hypothesis 1 is accompanied by a descriptive analysis of the structural characteristics of the knowledge networks, based on several measures of network cohesion (i.e. clique, *n*-clique, core-periphery models, factions), explained in the table. These measures are used to identify the presence of densely connected subgroups of firms within the network and to explore whether firms that are more densely connected have stronger knowledge bases.

Table 2 (B) reports the measures and methods used to test Hypothesis 2 about the existence of a structural difference between the knowledge and the business networks. The structure of the two networks is measured by a simple graph-theoretical indicator, the network density (*ND*), that measures the intensity of inter-firm networking in the clusters. The statistical significance of the differences among the knowledge and business networks' densities is analysed using the bootstrap *t*-test developed by Snijders and Borgatti (1999).

Finally, Table 2 (C) reports the measures and methods used to test Hypothesis 3 about the unevenness in the distribution of business and knowledge linkages. This analysis is carried out in two steps. First, business and knowledge networks are compared with respect to the concentration indexes (Gini and Hirschman/Herfindahl) of 'actor coreness', a measure of network centrality, explained in Table 2 (C). Second, the statistical distribution of firms' degree centrality of the two networks are compared for the pooled data of all the three clusters.

[Table 2 about here]

5 Empirical results

5.1 Knowledge networks and the knowledge base of firms

This section tests Hypothesis 1, which predicts that firms with stronger knowledge bases will be more central in the knowledge network. Table 3 reports the descriptive statistics and the correlation matrix between the relevant variables and Table 4 reports the results of the estimations.

[Table 3 here]

[Table 4 here]

The results are discussed into two steps. First, column 1 in Table 4 reports the estimations for the pooled dataset, showing that the firm knowledge base (*KB*) influences the extent to which a firm is central in the cluster knowledge network (the normalised degree centrality indicator - *KN_nDC*). The coefficient is positive and significant at 5%, controlling for all the firm-level variables (*SIZE, OWNER, ORG1-4, YEAR70-00*). This result provides support to Hypothesis 1. It clearly indicates that firms with stronger knowledge bases tend to be more centrally positioned in the cluster knowledge network. This follows the argument raised in Section 3 that firms with strong internal capabilities are likely to (a) be perceived by other cluster firms as 'technological leaders' and sought out as sources of knowledge, and (b) have high absorptive capacity, to search for and exploit relevant knowledge in other cluster firms.

The rest of the section explores this relationship in greater detail at the level of the three separate clusters. As shown in columns 2-4 in Table 4, the relationship differs between them. As for the pooled data, significant and positive results are found for both Bolgheri/Val di Cornia and Valle de Colchagua. In contrast, however, the results for Colline Pisane show that the *KB* does not significantly influence the centrality of firms in the cluster knowledge network. In order to understand what underpins this difference, a descriptive analysis of the knowledge networks of the three clusters is offered here.

(i) Colline Pisane

The visualisation of the knowledge network in Figure 1 shows that Colline Pisane has a strikingly high number of isolated firms that are cognitively disconnected from the rest of the firms in the cluster. Even the number that are linked to other firms (16) are in only a weakly connected network structure (formed by five *weak cliques*[8] and one *2-clique*). In other words, there is very little difference between firms with absent or very weak knowledge links. At the same time, as Table 5 indicates, most of the firms have similarly weak knowledge bases across the isolates and weakly linked cliques (0.03 and -0.09 respectively) (see also Table 3 for statistics on the means' value of firm knowledge bases across the cluster). These values mean that firms do not employ skilled knowledge workers and that they carry out barely any in-house experimentation. As suggested in Section 3, firms with such weak internal knowledge bases are unlikely to seek external advice. In other words, the weak knowledge bases of the firms in this cluster are likely to be associated with weak knowledge links – hence the absence of any significant association between differences in firms' knowledge bases and differences in the centrality of firms in the network as reported in Table 4.

[8] Scott (2000) defines weak cliques as those in which all ties are not reciprocated. The presence of weak cliques is particularly common in directed graphs as in this specific case of knowledge transfer.

A further interesting feature of this cluster is shown by the major exception to the general pattern of weak knowledge bases among the firms. The firm with strongest knowledge base, indicated by the largest node size in Figure 1, is entirely disconnected from the knowledge network. The interviews suggested that the methods of production adopted by this firm are very different than those commonly adopted by the other cluster firms. This is likely to result in a wide cognitive distance from other cluster firms that constitutes a barrier to knowledge exchange (Boschma, 2005). This firm is however strongly connected with sources of knowledge which are external to the cluster (Giuliani, 2004), a condition that allows the firm's internal knowledge stock to be rejuvenated and improved over time.

[Figure 1 here]

[Table 5 here]

(b) Bolgheri/Val di Cornia

Bolgheri/Val di Cornia is characterised by a faction-shaped knowledge network, visualised in Figure 2. This means that there are two non-overlapping sub-groups of firms (factions), which differ in many respects. As indicated by Table 6, one of the two factions (the 'advanced faction'), is characterised by densely inter-connected firms, whose knowledge base is higher than that of the rest of the cluster firms, reaching an average value of 0.61. In contrast, the other faction, indicated in Figure 2 as the 'laggard faction', is composed of firms which are both poorly connected and characterised by weak knowledge bases (-0.53). Finally, the average knowledge base of firms which are entirely disconnected from the cluster knowledge network is -0.34. This result is consistent with the fact firms with stronger knowledge bases are more capable of generating a densely connected knowledge network at the local level.

[Figure 2 here]

[Table 6 here]

(c) Valle de Colchagua

The knowledge network in the Valle de Colchagua is characterised by a core-periphery structure (Figure 3). This means that it is possible to identify a 'core' of firms that are densely interconnected among themselves and a 'periphery' of firms that tend to establish loose linkages with the core firms and virtually no interconnections with other peripheral firms. As reported by Table 7, the density of knowledge linkages within the 'core' is higher than the density of knowledge linkages observed among 'peripheral' firms, both considering dichotomous and valued linkages. More importantly, firms in the 'core' have, on average, stronger knowledge bases (0.58) than firms in the 'periphery' (-0.45). This result is in line with the one for Bolgheri/Val di Cornia indicating that firms with stronger knowledge bases tend to connect more intensively to each other, potentially leading to the formation of a local community of knowledge.

[Figure 3 here]

[Table 7 here]

These data about the three clusters allow two considerations to be raised. Firstly, a general tendency, observed in both Valle de Colchagua and Bolgheri/Val di Cornia as well as the pooled dataset, indicates that firms with stronger knowledge bases tend to be more central in the knowledge network, thus validating Hypothesis 1. Where a significant result was not found – i.e. in Colline Pisane – this was due to the fact that the majority of firms are characterised by very weak knowledge bases, an aspect that hinders inter-firm knowledge flows altogether. More interestingly, the only firm with a relatively strong knowledge base, although strongly linked to extra-cluster sources of knowledge, is entirely disconnected from the local network, because of the cognitive distance existing with other cluster firms. This feature clearly contributes to the overall fragmentation of the knowledge network in Colline Pisane.

Secondly, in the clusters where knowledge was diffused more intensively, it appeared to be transferred in a highly polarised and uneven fashion. Knowledge is diffused primarily within the boundaries of one or more cohesive subgroups of firms, such as the 'advanced faction' in Bolgheri/Val di Cornia and the 'core' in the Valle de Colchagua. The presence of these subgroups is likely to be influenced by the formation of local communities of knowledge, formed by technical professionals who share common language and technical background, and seek advice from other peers of the same community and in so doing may boost processes of knowledge exchange and generation (von Hippel, 1987; Lissoni, 2001; Dahl and Pedersen, 2004; Giuliani and Bell, 2005). These communities, however, let very limited knowledge spill over to the rest of the cluster firms, to the 'laggard faction' in Bolgheri/Val di Cornia and the 'periphery' in Valle de Colchagua, while no knowledge spills over to isolated firms. This results is interesting since it indicates that, in the three clusters studied here, innovation-related knowledge is certainly not diffused pervasively among cluster firms. This aspect is explored in more detail in the section that follows.

5.2 The differences between business networks and knowledge networks

The argument here is that business and knowledge networks are formed by differing underlying motivations, as discussed in Section 3. This section tests Hypotheses 2 and 3, which are directed to explore the differences existing between the structural properties of knowledge networks and those of the business networks. The visualisation of the business networks and the knowledge networks for the three clusters is presented in Figures 4 to 6. These figures show two striking features: first, that the shape of the business networks are visibly very similar across the three clusters and, second, that a much smaller number of firms are connected through the knowledge network, as also visualised in Figures 1 to 3.

[Figures 4-6 here]

These properties are reflected more precisely in the networks' density values reported in Table 8, showing significantly higher density values in the business networks than in the knowledge networks: in Colline Pisane the density of the business network is 0.32, it is 0.20 in Bolgheri/Val di Cornia and 0.30 in Valle de Colchagua. In contrast, the density of knowledge networks is significantly lower in all cases, ranging from 0.04 in Colline Pisane to 0.05 in Bolgheri/Val di Cornia and to 0.09 in Valle de Colchagua. This result thus supports Hypothesis 2.

[Table 8 here]

The test of Hypothesis 3 explores whether knowledge linkages are formed in a more uneven way than business linkages. This comparison is carried out looking at two inequality indexes of actor 'coreness' (Borgatti and Everett, 1999) for both the business and the knowledge networks. Results are shown in Table 9, which reports significant higher values for both indexes (higher concentration of linkages) of the knowledge network. In the knowledge network the distribution of linkages is thus more uneven than in the business network.

[Table 9 here]

This aspect is further explored by analysing the distribution of the normalised degree centrality of firms using the pooled dataset for both knowledge and business networks. A first test is performed to see whether the normalised degree centrality of firms, for each of the two networks, follows a

Normal distribution. In the case of the business network, the Kolmogorov-Smirnov test for Normality gives a *p*-value of 0.158, thus not rejecting the null hypothesis of normality. In contrast, the distribution of the knowledge network's normalised degree centrality is statistically different from the Normal (*p*-value=0.002). A narrower inspection of the structural characteristics of the knowledge network (Figure 7) finds that the distribution of the knowledge network's degree centrality is highly skewed. This skewed distribution suggests that the network is characterised by few nodes with extraordinarily high connectivity, whereas the majority of nodes have poor interconnection. This means that only a small number of firms are 'hubs' of knowledge in the network, whereas the rest tend to play more marginal roles in the diffusion and absorption of innovation-related knowledge. This leads to accept Hypothesis 3.

[Figure 7 here]

To conclude, this section has shown that the business and the knowledge networks are structurally different, as the former is more densely connected than the latter (Hypothesis 2) and, also, that business linkages are more homogeneously distributed than knowledge linkages (Hypothesis 3). More broadly, the empirical results presented in this section suggest a clear contrast. On the one hand, the geographical co-localisation of firms in a cluster may generate similar chances for firms to interact on business matters, as indicated by the higher density of business linkages and the Normal distribution of the business networks' degree centrality. This behaviour may thus be associated with a pervasive pattern of business interaction in the cluster, in line with most of the cluster literature. On the other hand, the skewed distribution observed in the case of the innovation-related knowledge network could be considered the result of a selective process over time, which reinforces the position of some firms, while progressively weakening that of others. This is observable by the emergence of largely interconnected 'hub' firms in the knowledge network.

These results raise an important issue about the process of innovation in clusters. If, as suggested by part of the cluster literature (discussed in Section 2), innovation-related knowledge is transferred in a pervasive way in the cluster, similarly to the pattern observed in the formation of business linkages, then it would be reasonable to expect the innovation process to be the result of the effort of the *whole collectivity* of firms in the cluster. Accordingly, both the geographical proximity of firms and the presence of inter-firm business linkages could be considered to contribute to such a collective effort. This in turn would imply that "factors external to firms" (Martin and Sunley, 2003, p. 17) residing in the local clusters, such as the geographical, sectoral and relational proximity of firms, matter for firm innovation. In line with certain other studies (Lazerson and Lorenzoni, 1999; Bell and Albu, 1999; Taylor and Asheim, 2001; Maskell, 2001b; Martin and Sunley, 2003; Bathelt and Glückler, 2003; Markusen, 2003; Boschma and Frenken, 2006), this empirical work has instead illustrated that innovation-related knowledge is transferred in clusters in a strikingly uneven and selective way, and that indeed this property differs from the Marshallian idea of 'industrial atmosphere'. In effect, the evidence presented here is consistent with the view that it is the firm's internal accumulation of knowledge that shapes the local knowledge network and the potential for generating innovation at the local level.

6 Conclusion

Cluster studies have become very popular. Among the different directions of research on clusters, increasing consideration has been given to the relationship between industrial clustering, localised learning and innovation (e.g. Maskell, 2001a; Pinch et al., 2003). In particular, several empirical studies have found clustered firms to be more innovative than isolated firms (Porter, 1990; Baptista and Swann, 1998; Baptista, 2000), while a few have recently debated this view (e.g. Beaudry and Breschi, 2003). A view maintained by many economists is that the higher innovativeness of clustered firms is due to firms' geographical proximity, which generates localised knowledge spillovers (e.g. Jaffe et al., 1993); while economic geographers emphasise the importance of a wide range of relational proximities, commonly defined as 'business networks' in the industrial cluster literature, for the promotion of localised learning and innovation. According to these views, the transfer of knowledge in clusters is often described as being diffused pervasively and almost randomly in the cluster, thus enhancing the likelihood of firms to learn and innovate.

More recently, economic geographers have advanced a different view. The have started to claim that firms should be considered central actors in the process of economic development and they influence the meso-level conditions that eventually lead to innovation (e.g. Lazerson and Lorenzoni, 1999; Maskell, 2001b; Martin and Sunley, 2003). This paper has contributed to this latter direction of research and has argued that knowledge is diffused in clusters on the basis of a purposeful and highly selective search process, rather than pervasively or randomly.

The conceptual framework developed in this paper considers the structural properties of knowledge networks in clusters to be related to the heterogeneous and asymmetric distribution of cluster firms' knowledge bases (Dosi, 1988; Rabellotti and Schmitz, 1999). Using micro-level data on fine wine producers in three wine clusters located in Italy and Chile and a combination of social network analysis and econometrics, this paper has illustrated that firms with stronger knowledge bases are indeed more likely to exchange innovation-related knowledge with other firms in the cluster. This is because these firms may be perceived by other cluster firms as 'technological leaders' in the local area, leading to their being sought out as sources of innovation-related advice and knowledge more often than firms with weaker knowledge bases. However, this is likely to occur only among firms whose cognitive distance is not too high, which are therefore characterised by similarly strong knowledge bases and find beneficial a reciprocal knowledge exchange. This may explain the formation of densely connected cohesive subgroups and the emergence of local knowledge communities.

In contrast, when a cluster is populated almost exclusively by firms with particularly weak knowledge bases, which have poor capabilities to both transfer and absorb knowledge, there is a high chance that the intra-cluster knowledge network will be poorly connected. In this case, moreover, the most advanced firms may have no interest in forming knowledge linkages with the rest of the cluster firms and may therefore entirely disconnect from the intra-cluster knowledge network, possibly strengthening their connection to sources of knowledge external to the cluster, as shown in Giuliani and Bell (2005).

The interesting result here is that this is likely to occur even when firms are connected to the local business network. The structural differences, observed in this paper, between the knowledge and the business networks, indicate that the formation of these two networks may be driven by differing underlying motivations. This empirical evidence has shown that, in spite of the presence of pervasive business interactions, innovation-related knowledge is exchanged in a rather uneven and selective way. As a result, a question arises about the importance of both the geographical proximity of firms and their embeddedness in local business networks, as factors that drive the diffusion of knowledge and positively affects firms' innovation processes.

This analysis was set within specific empirical and methodological limits. The first is that this is a single industry study. The generalisation of its results is therefore bounded by the specificities of the wine industry. In particular, this industry is characterised by rather incremental innovation by cluster firms, which allow proprietary knowledge to be diffused without problematic competitive backlash effects (Carter, 1989). It is conceivable that in industries where the pace of innovation is higher and the relevant knowledge is protected by patents or other appropriability devices, the horizontal transfer of knowledge will be even more limited, or subject to even higher selectivity among equally advanced firms (Appleyard, 1996).

The second limitation refers to the operationalisation of the network variables. The underlying motivations for the selection of the measures for knowledge and business networks have been discussed in Section 4. It is probable that the focus on innovation-related knowledge networks has been biased toward the more technological forms of innovation and other studies might want to pursue innovation-related knowledge in other areas (e.g. financial, markets, or clients, etc.) and also include other channels of intra-cluster knowledge diffusion (e.g. mobility of skilled workers, imitation, etc.).

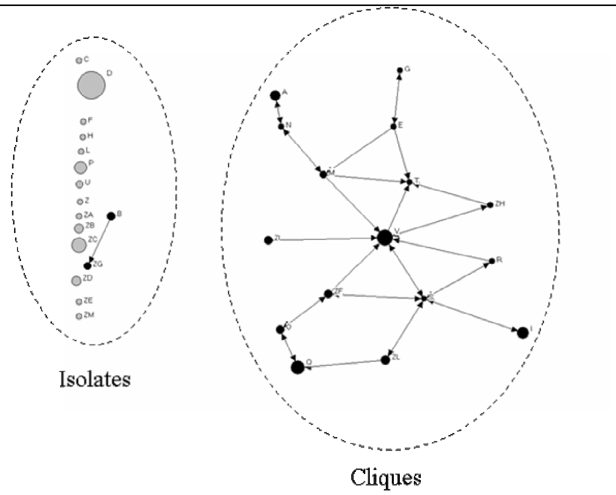
Two further limitations are particularly important and raise interesting questions: first, the cross-sectional nature of this analysis and, second, its focus on intra-cluster linkages only. Relaxing these limitations prompts interesting speculation, particularly in relation to the central conclusion about selectivity in the knowledge network formation process. In more detail, although, in the context of this analysis, the patterns observed in the formation of knowledge networks are strictly cross-sectional, their characteristics may tell an interesting underlying dynamics. The distribution of firms' degree centrality may be associated with the idea of 'preferential attachment' (Barabasi and Albert, 1999), which suggests that knowledge networks grow by way of a reinforcing mechanisms that leads the more central firms to become progressively more central over time (also known as the "rich-get-richer" phenomenon). This condition helps to explain the formation of largely interconnected 'hub' firms, characterised by extraordinarily high degree centrality values (Barabasi and Bonabeau, 2003). In this analysis, such 'hub' firms correspond to firms with stronger knowledge bases, which, over time, may have endogenously reinforced their position in the knowledge network, even at the detriment of other more marginal firms.

Furthermore, this selectivity may, on the one hand, guarantee a certain degree of quality in the *content* of the knowledge transferred, since most of the firms involved in the transfer of knowledge will be characterised by strong knowledge bases and, therefore, they may be more able to boost local processes of innovation. On the other hand, selectivity exposes the local knowledge network to a certain degree of vulnerability to disruption (Barabasi, 2003). This is because, as noted in Section 5, it is only a minority of 'hub' firms that keep the whole intra-cluster knowledge network connected, an aspect that, in line with Lazerson and Lorenzoni (1999), may render the cluster development process dependent on the behaviour of a few individual firms.

It is at this point that the limitation of this study to intra-cluster linkages becomes particularly important. From the previous discussion, it is reasonable to believe that 'hub' firms will keep the intra-cluster knowledge network connected as long as they have an interest to tap into local knowledge (Cantwell and Iammarino, 2003), an interest that is conditioned by the strength of other cluster firms' knowledge bases. Thus, if none of the local firms is able to offer good technical advice, 'hub' firms will look for solutions to their internal problems outside the cluster. This aspect raises but leaves open interesting questions about the role of intra-cluster linkages in a globalising economy, where knowledge is becoming increasingly codified, and where firms in clusters have easy access also to geographically distant national or international sources of learning (Coe and Bunnel, 2003).

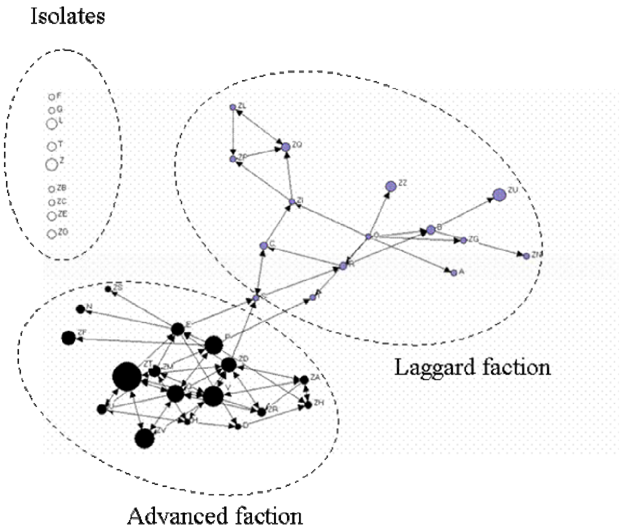
Figures

Figure 1 Structure of knowledge network in Colline Pisane



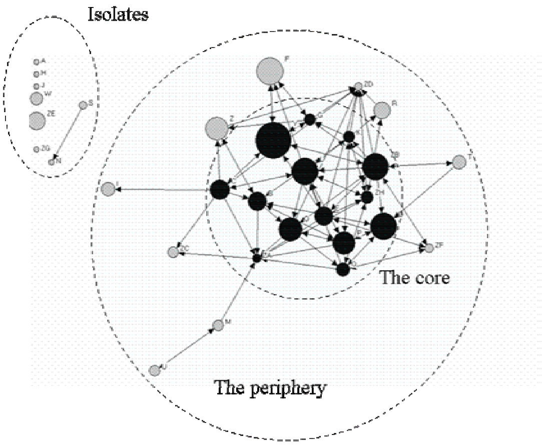
Note: The size of the nodes is proportional to the measure of their knowledge base.

Figure 2 Structure of knowledge network in Bolgheri/Val di Cornia



Note: The size of the nodes is proportional to the measure of their knowledge base.

Figure 3 Structure of knowledge network in Valle de Colchagua



Note: The size of the nodes is proportional to the measure of their knowledge base.

Figure 4(a) Business network in Colline Pisane

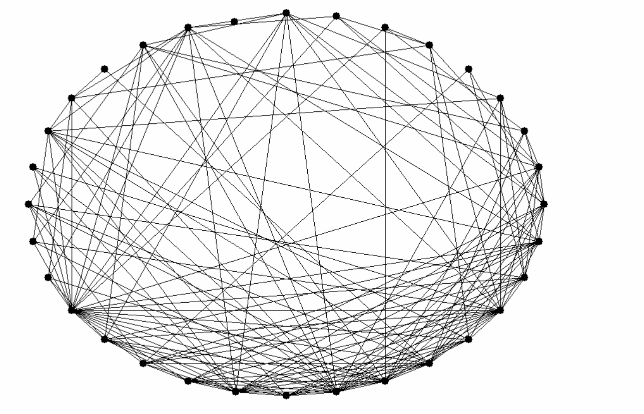


Figure 4(b) Knowledge network in Colline Pisane

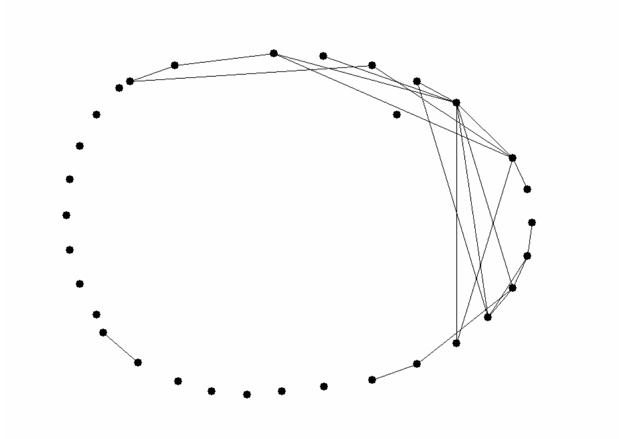


Figure 5(a) Business network in Bolgheri/Val di Cornia

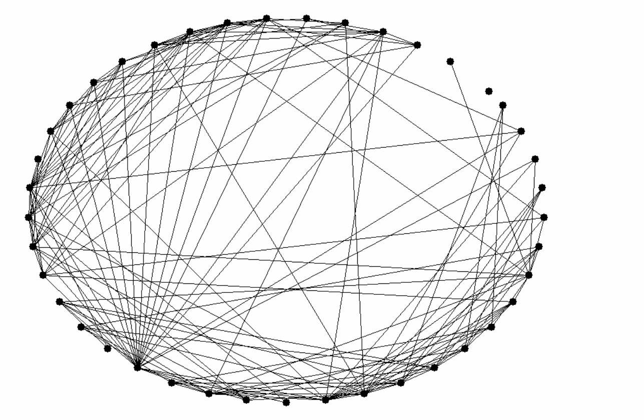


Figure 5(b) Knowledge network in Bolgheri/Val di Cornia

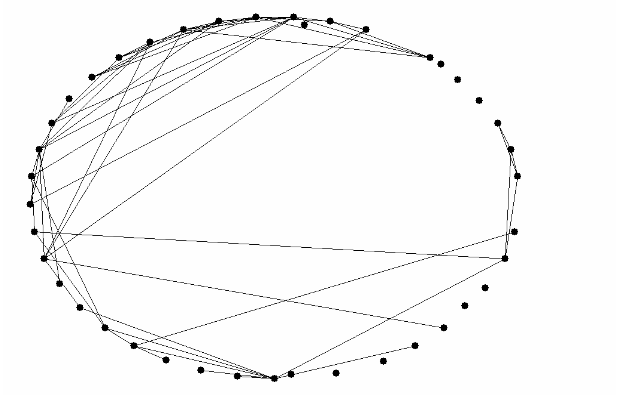


Figure 6(a) Business network in Valle de Colchagua

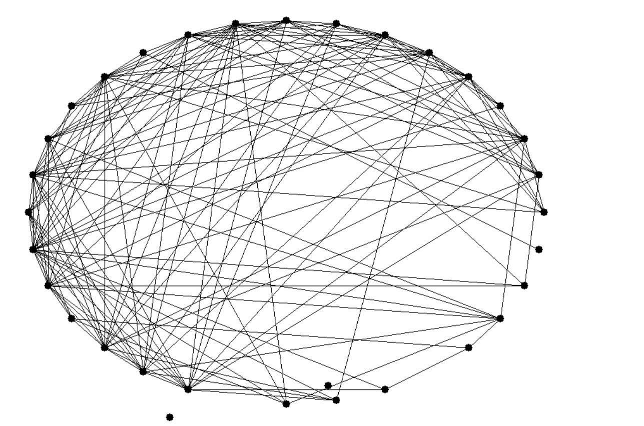


Figure 6(b) Knowledge network in Valle de Colchagua

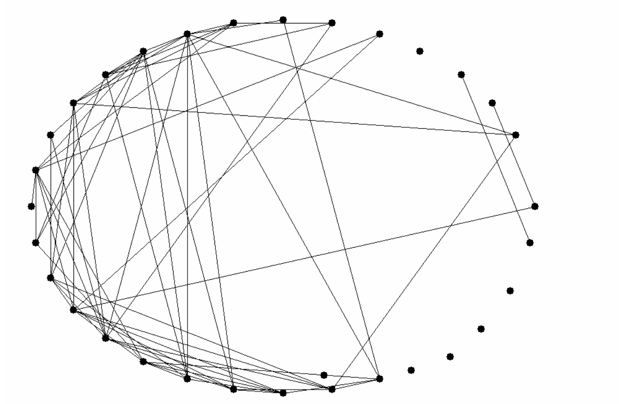
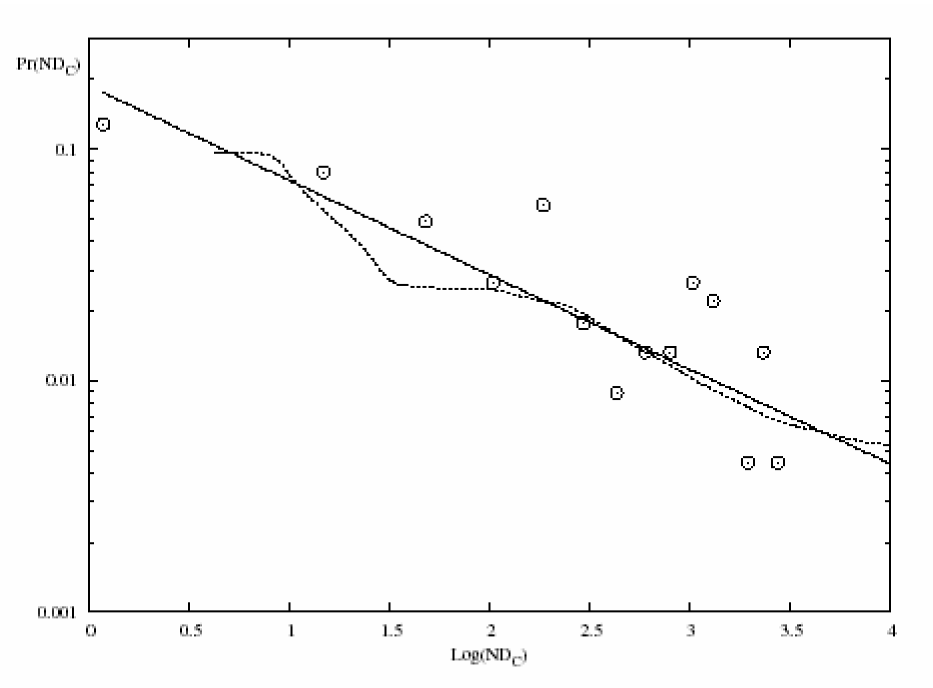


Figure 7 Distribution of firm degree centrality in the knowledge network



Note: Empirical density of the knowledge network's degree centrality together with a linear fit and a non-parametric local estimate, obtained with a smoothing kernel method (Pagan and Ullah, 1999). The kernel function used is the Epanenchnikov density with 0.371 as bandwidth. The estimate has been performed by a software package called gbutils developed by G. Bottazzi and available at www.sssup.it/\simbottazzi/. A strongly significant slope is obtained (*beta*=-0.94), with a standard error of 0.12.

Tables

Table 1 Firm characteristics by cluster

	Cluster		
Characteristics of firms by:	**Colline Pisane** (N= 32)	**Valle de Colchagua** (N= 32)	**Bolgheri/Val di Cornia** (N= 41)
(a) Size (no. employees)			
Small (1-19)	91	28	90
Medium (20-99)	9	66	4
Large (≥100)	0	6	6
(b) Ownership			
Domestic	100	81	95
Foreign	0	19	5
(c) Year of localisation			
Up to 1970s	53	24	24
1980s	9	16	22
1990s	31	38	23
2000s	6	19	15
(d) Organisational Structure			
1 Independent, vertically integrated	88	66	93
2 Part of a group, vertically integrated firms	3	22	7
3 Part of a group, vertically disintegrated firms	-	13	-
4 Other (e.g. cooperatives)	9	-	-

Note: The numbers refer to percentages within the respective cluster.

Table 2: Method of analysis and measures

A. Hypothesis 1

Firms with stronger knowledge bases are likely to be more central in the cluster knowledge network.

(i) Negative binomial regression model with fixed effects. The baseline specification assumes that the dependent variable follows a Poisson distribution. The choice of the negative binomial specification is due to overdispersion in the dependent variable.

Dependent variable: Normalised degree centrality (KN_nDC_i): measures the extent to which a firm is connected to the knowledge network. Due to the different size of the networks across clusters, an actor-level normalised degree centrality is used here. This is measured as the sum of linkages of firm *i* with other *j* actors of the network (degree centrality, DC_i) and standardised by *g,* with *g* being the number of nodes in the network:

$KN\_nDC_i = DC_i / (g - 1)$

The indicator is computed on dichotomous undirected data.

Independent variable: the knowledge base of the firms (*KB*), derived from the application of Principal Component Analysis of Human resources, Months of experience and Experimentation intensity.

Control variables:

- Size (*SIZE*): measured by the log of the number of employees.
- Ownership (*OWNER*): Foreign (1), Domestic (0).
- Organisation structure (*ORG 1-4*): corresponding to the four types indicated by Table 1 (d).
- Year range of a firm's localisation in the cluster (*YEAR70-00*): corresponding to the four decades indicated by Table 1 (c).

(ii) Descriptive analysis of cohesive subgroups of the knowledge networks based on the following measures:

(a) Clique: a maximal subgraph of three or more nodes. It represents a subgroup of firms all connected to each other.

(b) *n*-clique: a maximal subgraph in which the largest geodesic distance between any two nodes is no greater than n. Formally, an *n*-clique is a subgraph with node set *N* such that $d(i, j) <= n$ for all n(*i*) and n(*j*) belongs to *N*. This is considered to be a loosely defined clique.

(c) Core-periphery models: core-periphery analysis allows the identification of a cohesive subgroup of core firms and a set of peripheral firms that are loosely interconnected with the core (Borgatti and Everett, 1999).

(d) Factions: partitions of the network done by grouping together actors on the basis of similarity to whom they are tied (Hanneman, 2001).

B. Hypothesis 2

The structure of the knowledge network differs significantly from that of the business network.

(i) Test of density. It uses Snijders and Borgatti's (1999) bootstrap-assisted paired sample *t*-test to test whether the density of the knowledge and business networks are statistically different.

Network density (*ND*) is defined as the proportion of possible linkages that are actually present in a graph. *ND* is calculated as the ratio of the number of linkages present, *L*, to its theoretical maximum, $g(g\text{-}1)/2$, with *g* being the number of nodes in the network (Wasserman and Faust, 1994):

$ND = L / [g(g-1)/2]$

C. Hypothesis 3

The diffusion of innovation-related knowledge among firms with heterogeneous knowledge bases will be more uneven than would be expected if this knowledge were to flow primarily through the business network.

(i) Comparison of business and knowledge centrality with respect to two indexes of heterogeneity, Gini (G) and Hirschman/Herfindahl (HH), applied to actor 'coreness', a measure of centrality, defined as the degree of closeness of each node to a core of densely connected nodes observable in the network, as described by Borgatti and Everett (1999).

(ii) Comparison of the statistical properties of the distribution of both knowledge network and business network's normalised degree centrality (KN_nDC_i and BN_nDC_i), a measure described above.

Note: Network measures are computed using UCINET 6.51 (Borgatti et al., 2002).

Table 3 Descriptive statistics and correlation matrix

	Descriptive statistics by cluster Mean (SD)			**Correlation matrix**											
	Colline Pisane	**Bolgheri/ Val di Cornia**	**Valle de Colchagua**	***KN_nDC***	***KB***	***SIZE***	***OWNER***	***ORG1***	***ORG2***	***ORG3***	***ORG4***	***YEAR70***	***YEAR80***	***YEAR90***	***YEAR00***
KN_nDC	4.43 (5.60)	7.11 (6.24)	12.59 (10.24)	1											
KB	-0.42 (0.58)	-0.16 (0.80)	0.67 (1.26)	0.304***	1										
SIZE	1.25 (0.92)	1.38 (0.92)	3.44 (1.13)	0.429***	0.420***	1									
OWNER	-	-	0.19 (0.40)	0.216**	0.023	0.183	1								
ORG1	0.03 (0.177)	0.08 (0.27)	0.23 (0.42)	0.170	0.413***	0.340***	0.407***	1							
ORG2	-	-	0.10 (0.30)	0.349***	0.000	0.226***	-0.053	-0.068	1						
ORG3	0.88 (0.33)	0.92 (0.27)	0.68 (0.47)	-0.260***	-0.340***	-0.424***	-0.284***	-0.752***	-0.438***	1					
ORG4	0.09 (0.29)	-	-	-0.124	0.009	0.075	-0.046	-0.059	-0.034	-0.377***	1				
YEAR70	0.53 (0.50)	0.28 (0.20)	0.26 (0.44)	0.018	0.091	0.045	-0.185	-0.124	-0.007	0.055	0.114	1			
YEAR80	0.09 (0.29)	0.23 (0.42)	0.16 (0.37)	0.020	-0.044	-0.043	0.000	0.099	0.078	-0.082	-0.078	-0.330***	1		
YEAR90	0.31 (0.47)	0.33 (0.47)	0.31 (0.47)	-0.021	-0.133	-0.015	0.170	0.015	-0.004	-0.009	-0.004	-0.534***	-0.323***	1	
YEAR00	0.06 (0.24)	0.15 (0.36)	0.19 (0.40)	-0.017	0.105	0.005	0.021	0.045	-0.069	0.025	-0.069	-0.295***	-0.178	-0.288***	1

Note: *** Correlation is significant at 1%. ** Correlation is significant at 5%.

Table 4 Relationship between centrality in the cluster knowledge network and firm knowledge bases

Model	(1) Pooled dataset	Results by cluster: (2) Colline Pisane	(3) Bolgheri/VdiCornia	(4) Valle de Colchagua
Intercept	1.33 (0.63)**	-2.73 (1.64)*	0.76 (0.40)*	1.55 (0.64)**
KB	0.33 (0.12)**	-0.10 (0.46)	0.35 (0.17)**	0.57 (0.18)***
SIZE	0.02 (0.12)	0.49 (0.35)	-0.04 (0.18)	-0.08 (0.15)
OWNER	0.44 (0.43)	-	-	0.44 (0.43)
ORG1	-0,66 (0.58)	-	0.38 (0.47)	-0.80 (0.59)
ORG3	-0.41 (0.51)	1.53 (0.95)	-	-0.45 (0.45)
ORG4	-1.29 (0.99)	-	-	-
YEAR70	0.35 (0.31)	1.62 (1.17)	0.46 (0.41)	0.43 (0.50)
YEAR80	0.24 (0.34)	0.88 (1.34)	0.52 (0.45)	-
YEAR90	0.20 (0.31)	1.14 (1.19)	-0.13 (0.47)	0.42 (0.46)
YEAR00	-	-	-	0.27 (0.51)
CLUSTER- BVC	0.67 (0.25)**			
CLUSTER-CV	0.83 (0.40)**			
Log-likelihood	-206.09	- 48.54	-79.18	-70.06
LR Chi Square	28.38	6.36	11.80	12.41
Pseudo R2	0.06	0.06	0.06	0.08

Note: *** The coefficient is significant at 1%. ** The coefficient is significant at 5%. * Correlation is significant at 10%.

Table 5 Density of linkages and firm knowledge bases in Colline Pisane

	Density of linkages		Average firm knowledge base
	Dichotomous	Valued	by subgroup
Cliques	0.10/	0.12	-0.09
Isolates	0.00	0.00	0.03

Table 6 Density of linkages and firm knowledge bases in Bolgheri/Val di Cornia

	Density of linkages		Average firm knowledge base
	Dichotomous	Valued	by subgroup
Advanced faction	0.17	0.53	0.61
Laggard faction	0.07	0.20	-0.53
Isolates	0.00	0.00	-0.34

Table 7 Density of linkages and firm knowledge bases in Valle de Colchagua

	Density of linkages		**Average firm knowledge base by subgroup**
	Dichotomous	Valued	
Core	0.32	0.57	0.58
Periphery	0.02	0.26	-0.45
Isolates	0.00	0.00	-0.76

Table 8 Differences in the density of business and knowledge networks

	Colline Pisane	**Bolgheri /Val di Cornia**	**Valle de Colchagua**
Density of:			
Business network	0.32	0.20	0.30
Knowledge network	0.04	0.051	0.09
Significance of the differences between densities:			
Bootstrap paired sample *t*-test	7.77**	5.57**	4.48**

Note: ** The coefficient is significant at 5%.

Table 9 The distribution of business and knowledge linkages

	Colline Pisane	**Bolgheri /Val di Cornia**	**Valle de Colchagua**
Business Network:			
Gini	0.324	0.410	0.345
Hirschman/Herfindahl	0.010	0.014	0.012
Knowledge network:			
Gini	0.871	0.806	0.609
Hirschman/Herfindahl	0.311	0.091	0.046

Note: The unevenness in the distribution of linkages in the business and knowledge networks is measured by two concentration indexes: the Gini and the Hirschman/Herfindahl.

References

Amin A, Cohendet P. 2004. *Architectures of Knowledge. Firms, Capabilities and Communities*. Oxford: Oxford University Press.

Amin, A., N. Thrift. 1992. Neo-marshallian nodes in global networks. *International Journal of Urban and Regional Research* 16:571-587.

Amin, A., Thrift, N. 1994. *Globalization, Institutions and Regional Development in Europe*. Oxford: Oxford University Press.

Anderson, K., Norman, D. 2001. Global Wine Production, Consumption and Trade, 1961 to 1999: A Statistical Compendium. Adelaide: Centre for International Economic Studies.

Anselin, L, Varga, A., Zoltan, A. 2000. Geographical spillovers and university research: a spatial econometric perspective. *Growth and Change* 31(Fall): 501-515.

Appleyard, M.M. 1996. How does knowledge flow? Interfirm patterns in the semiconductor industry. *Strategic Management Journal* 17:137-154.

Arrow K J. 1962. Economic welfare and the allocation of resources for invention. In *The Rate and Direction of Inventive Activity*, ed. R.R. Nelson, pp. 609-26. Princeton: Princeton University.

Asheim, B. T., Coenen L. 2005. Knowledge bases and regional innovation systems: Comparing Nordic clusters. *Research Policy*, 34(8): 1173-1190.

Audretsch D, Feldman M P. 1996. R&D spillovers and the geography of innovation and production. *American Economic Review* 86: 630-40.

Baptista R. 2000. Do innovations diffuse faster within geographical clusters? *International Journal of Industrial Organization* 18: 515-35.

Baptista, R., Swann, P. 1998. Do firms in clusters innovate more? *Research Policy* 27:525-540.

Barabasi A-L, Albert R. 1999. Emergence of scaling in real networks. *Science* 286: 509-512.

Barabasi A-L, Bonabeau A. 2003. Scale-free networks. *Scientific American* 288: 50-9.

Barabasi A-L. 2003. *Linked: How everything is connected to everything else and what it means for business, science and everyday life*. New York: Plume, Penguin Group.

Bathelt, H., Glucker, J. 2003. Toward a relational economic geography. *Journal of Economic Geography*, 3: 117-144.

Beaudry, C., Breschi S. 2003. Are firms in clusters really more innovative? *Economics of Innovation and New Technology* 12:325-342.

Becattini, G. 1990. The Marshallian industrial district as a socio-economic notion. Pp. 37-51 in *Industrial districts and inter-firm co-operation in Italy*, eds. F. Pyke, G. Becattini, W. Sengenberger. Geneva: International Institute for Labour Studies.

Bell M, Albu, M. 1999. Knowledge systems and technological dynamism in industrial clusters in developing countries. *World Development* 27: 1715-34.

Best M, Forrant R. 1996. Creating industrial capacity: Pentagon-led versus production-led industrial policies. In *Creating Industrial Capacity: Towards Full Employment*, eds. J. Michie, J. Grieve Smith. Oxford: Oxford University Press.

Boggs, J. S., & Rantisi, N.M. 2003. The 'relational turn' in economic geography. *Journal of Economic Geography*, 3: 109-116.

Borgatti S P, Everett M G, Freeman, L C. 2002. Ucinet 6 for Windows, Harvard: Analytic Technologies.

Borgatti S P, Everett M G. 1999. Models of core/periphery structures. *Social Networks*, 21: 375-395.

Boschma R A. 2005. Proximity and innovation: A critical assessment. *Regional Studies*. 39 (1): 61-74.

Boschma, R. A., Frenken, K. 2006. Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *Journal of Economic Geography* (forthcoming).

Bouty, I. 2000. Interpersonal and Interaction Influences on Informal Resource Exchanges Between R&D Researchers Across Organizational Boundaries. *Academy of Management Journal* 43:50-65.

Breschi, S., Malerba, F. 2001. The Geography of Innovation and Economic Clustering: Some Introductory Notes. *Industrial and Corporate Change* 10:817-833.

Camagni, R. 1991. *Innovation networks: Spatial perspectives*. London, New York: Belhaven Press.

Cameron A C, Trivedi P K. 1986. Econometric models based on count data: comparison and applications of some estimators and tests. *Journal of Applied Econometrics* 18 (1): 29-53.

Camison, C. 2004. Shared, Competitive, and Comparative Advantages: a Competence-Based View of Industrial-District Competitiveness. *Environment and Planning a* 36:2227-2256.

Cantwell, J., Iammarino, S. (2003) *Multinational corporations and European regional systems of innovation*, London, New York: Routledge,.

Capello R, Faggian A. 2005. Collective learning and relational capital in local innovation processes. *Regional Studies* 39 (1): 75-87.

Capello R. 1999. Spatial transfer of knowledge in high technology milieux: Learning versus collective learning processes. *Regional Studies* 33: 353-65.

Carter A P. 1989. Know-how trading as economic exchange. *Research Policy* 18: 155-63.

Castilla, E. J., Hwang, H., Granovetter, M., Granovetter, E. 2000. Social Networks in Silicon Vallery. In *The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship,* eds. L. Chong-Moon, H. Rowen, M. Hancock M. Stanford: Stanford University Press.

Coe, N. M., Bunnell, T.G. 2003. Spatialising knowledge communities: towards a conceptualisation of transnational innovation networks. *Global Networks*, 3(4): 437-456.

Cohen W, Levinthal D. 1990. Absorptive Capacity - a new perspective on learning and innovation. *Administrative Science Quarterly* 35: 128-52.

Dahl, M.S., Pedersen, C.Ø.R. 2004. Knowledge flows through informal contacts in industrial clusters: myth or reality? *Research Policy* 33:1673-1686.

Dosi G. 1988. Sources, procedures and microeconomic effects of innovation. *Journal of Economic Literature* 26: 1120-71.

Dosi G. 1997. Opportunities, incentives and the collective patterns of technological change. *Economic Journal* 107: 1530-47.

Feldman M P. 1999. The new economics of innovation, spillovers and agglomeration: a review of empirical studies. *Economics of Innovation and New Technology* 8: 5-25.

Giuliani E, Bell M. 2005. The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. *Research Policy*, 34(1): 47-68.

Giuliani, E. 2004. Laggard clusters as slow learners, emerging clusters as locus of knowledge cohesion (and exclusion): a comparative study in the wine industry. in LEM Working Paper. Pisa: Sant'Anna School of Advanced Studies.

Håkanson L. 2005. Epistemic Communities and Cluster Dynamics: On the Role of Knowledge in Industrial Districts, *Industry and Innovation*. 12 (4), 433-450.

Hanneman RA. 2001. Social Network Methods: an online handbook. University of California, Riverside, http://faculty.ucr.edu/~hanneman/networks/nettext.pdf.

Hudson R. 1999. The learning economy, the learning firm and the learning region: a sympathetic critique of the limits to learning. *European Urban and Regional Studies*, 6: 59-72.

Humphrey J, Schmitz H. 1996. The triple C approach to local industrial policy. *World Development* 24: 1859-77.

Jaffe A B, Trajtenberg M, Henderson R. 1993. Geographic localization of knowledge spillovers as evidence from patent citations. *Quarterly Journal of Economics* 188: 577-98.

Jaffe A.B. 1989. Real effects of academic research. *American Economic Review* 79: 984-99.

Keeble D, Wilkinson F. 1999. Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe. *Regional Studies* 33 (4): 295-303.

Krugman P. 1991. *Geography and Trade*. Cambridge: MIT Press.

Lane P J, Lubatkin M. 1998. Relative absorptive capacity and interorganizational learning. *Strategic Management Journal* 19: 461-77.

Lawson C, Lorenz E. 1999. Collective learning, tacit knowledge and regional innovative capacity. *Regional Studies* 33 (4): 305-317.

Lazerson, M.H., and G. Lorenzoni. 1999. The firms that feed industrial districts: a return to the Italian source. *Industrial and Corporate Change* 8:235-266.

Lissoni, F. 2001. Knowledge codification and the geography of innovation: the case of Brescia mechanical cluster. *Research Policy* 30:1479-1500.

Loubere, L.A. 1990. *The Wine Revolution in France*. Princeton, New Jersey: Princeton University Press.

Maillat D. 1990. SMEs, innovation and territorial development. In *The Spatial Context of Technological Development*, ed. R Cappellin, Nijkamp, P, pp. 331-51 Avebury.

Malmberg A. 2003. Beyond the cluster - Local milieus and global economic connections. In *Remaking the Global Economy*, ed. J Peck, H.W.C. Yeung, pp. 145-59. London: Sage Publications.

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science* 2:71-87.

Markusen, A. 1996. Sticky places in slippery space: A typology of industrial districts. *Economic Geography*, 72(3): 293-313.

Markusen, A. 2003. An actor-centered approach to regional economic change. *Annals of the Association of Japanese Geographers* 49:395-408. Available from: http://www.hhh.umn.edu/img/assets/6158/262_actor-centered_503.pdf.

Marshall A. 1920. *Principles of Economics*. London: MacMillan.

Martin R, Sunley P. 2003. Deconstructing clusters: chaotic concept or policy panacea? *Journal of Economic Geography*, 3 (1): 5-35.

Maskell P, Malmberg A. 1999. Localised learning and industrial competitiveness. *Cambridge Journal of Economics* 23 (2), 167-186.

Maskell P. 2001a. Towards a knowledge-based theory of the geographical cluster. *Industrial and Corporate Change* 10: 921-943.

Maskell P. 2001b. The firm in economic geography. *Economic Geography*, 77 (4), 329-344.

Morgan, K. 1999. The learning region: institutions, innovation and regional renewal. *Regional Studies*, 31(5): 491-503.

Nelson R R, Winter S G. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, Mass: Belknap Press of Harvard University Press.

Pagan A, Ullah A. 1999. *Nonparametric Econometrics*, Cambridge: Cambridge University Press.

Paul, H. W. 1996. *Science, Vine and Wine in Modern France*. Cambridge: Cambridge University Press.

Pinch S, Henry N, Jenkins M, Tallman S. 2003 From 'industrial districts' to 'knowledge clusters': a model of knowledge dissemination and competitive advantage in industrial agglomerations, *Journal of Economic Geography* 3: 373-388.

Piore M J, Sabel, C F. 1984. *The Second Industrial Divide: Possibility for Prosperity*. New York: Basic Books Inc.

Porter M E. 1990. *The Competitive Advantage of Nations*. London: Macmillan.

Porter ME. 1998. Clusters and the New Economics of Competition. *Harvard Business Review* November-December.

Powell, W.W., K.W. Koput, and L. Smith-Doerr. 1996. Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. *Administrative Science Quarterly* 41:106-145.

Pyke F, Becattini G, Sengenberger W. 1990. *Industrial Districts and Inter-firm Co-operation in Italy*. Geneva: International Institute for Labour Studies.

Rabellotti, R., Schmitz, H. 1999. The Internal Heterogeneity of Industrial Districts in Italy, Brazil, and Mexico. *Regional Studies* 33:97-108.

Saxenian, A. 1994. *Regional advantage culture and competition in Silicon Valley and Route 128*. Cambridge, Mass: Harvard University Press.

Schmitz, H. 1995. Small schoemakers and Fordist giants: tale of a supercluster. *World Development* 23:9-28.

Schrader S. 1991. Informal technology transfer between firms: cooperation through informal trading. *Research Policy* 20: 153-70.

Scott J. 2000. Social Network Analysis. A Handbook. London: SAGE Publications.

Scott, A.J. 1988. *New Industrial Spaces. Flexible Production Organization and Regional Development in North America and Western Europe*. London: Pion Limited.

Snijders TAB, Borgatti S P. 1999. Non-parametric standard errors and tests for network statistics. *Connections* 22: 61-70.

Storper, M. 1995. The resurgence of regional economics, ten years later: the region as a nexus of untraded interdependencies. *European Urban and Regional Studies*, 2: 191-122.

Storper, M. 1997. *The regional world territorial development in a global economy*. New York: Guilford Press.

Taylor M., Asheim, B. (2001) The concept of the firm in economic geography. *Economic Geography* 77(4), 315-328.

Von Hippel E. 1987. Cooperation between rivals: informal know-how trading. *Research Policy* 16: 291-302.

Wasserman S, Faust K. 1994. *Social Network Analysis. Methods and Applications.* Cambridge: Cambridge University Press.

Yeung, H. W. 1994. Critical reviews of geographical perspectives on business organisations and the organisation of production: towards a network approach. *Progress in Human Geography*, 18(4): 460-490.

CIRCLE ELECTRONIC WORKING PAPERS SERIES (EWP)

CIRCLE (Centre for Innovation, Research and Competence in the Learning Economy) is a multidisciplinary research centre set off by several faculties at Lund University and Blekinge Institute of Technology. The founding fathers of CIRCLE include Lund Institute of Technology, Administrative, Economic and Social Sciences, Department of Business Administration, and Research Center for Urban Management and Regional Development.

The CIRCLE Electronic Working Paper Series are intended to be an instrument for early dissemination of the research undertaken by CIRCLE researchers, associates and visiting scholars and stimulate discussion and critical comment.

The working papers present research results that in whole or in part are suitable for submission to a refereed journal or to the editor of a book or have already been submitted and/or accepted for publication.

CIRCLE EWPs are available on-line at: http://www.circle.lu.se/publications

Available papers:

2006

WP 2006/01
The Swedish Paradox
Ejermo, Olof; Kander, Astrid

WP 2006/02
Building RIS in Developing Countries: Policy Lessons from Bangalore, India
Vang, Jan; Chaminade, Cristina

WP 2006/03
Innovation Policy for Asian SMEs: Exploring cluster differences
Chaminade, Cristina; Vang, Jan.

WP 2006/04
Rationales for public intervention from a system of innovation approach: the case of VINNOVA.
Chaminade, Cristina; Edquist, Charles

WP 2006/05
Technology and Trade: an analysis of technology specialization and export flows
Andersson, Martin; Ejermo, Olof

WP 2006/06
A Knowledge-based Categorization of Research-based Spin-off Creation
Gabrielsson, Jonas; Landström, Hans; Brunsnes, E. Thomas

WP2006/07
Board control and corporate innovation: an empirical study of small technology-based firms
Gabrielsson, Jonas; Politis, Diamanto

WP2006/08
On and Off the Beaten Path:
Transferring Knowledge through Formal and Informal Networks
Rick Aalbers; Otto Koppius; Wilfred Dolfsma

WP2006/09
Trends in R&D, innovation and productivity in Sweden 1985-2002
Ejermo, Olof; Kander, Astrid

WP2006/10
Development Blocks and the Second Industrial Revolution, Sweden 1900-1974
Enflo, Kerstin; Kander, Astrid; Schön, Lennart

WP 2006/11
The uneven and selective nature of cluster knowledge networks: evidence from the wine industry
Giuliani, Elisa

2005

WP 2005/1
Constructing Regional Advantage at the Northern Edge
Coenen, Lars; Asheim, Bjørn

WP 2005/02
From Theory to Practice: The Use of the Systems of Innovation Approach for Innovation Policy
Chaminade, Cristina; Edquist, Charles

WP 2005/03
The Role of Regional Innovation Systems in a Globalising Economy: Comparing Knowledge Bases and Institutional Frameworks in Nordic Clusters
Asheim, Bjørn; Coenen, Lars

WP 2005/04
How does Accessibility to Knowledge Sources Affect the Innovativeness of Corporations? Evidence from Sweden
Andersson, Martin; Ejermo, Olof

WP 2005/05
Contextualizing Regional Innovation Systems in a Globalizing Learning Economy: On Knowledge Bases and Institutional Frameworks
Asheim, Bjørn; Coenen, Lars

WP 2005/06
Innovation Policies for Asian SMEs: An Innovation Systems Perspective
Chaminade, Cristina; Vang, Jan

WP 2005/07
Re-norming the Science-Society Relation
Jacob, Merle

WP 2005/08
Corporate innovation and competitive environment
Huse, Morten; Neubaum, Donald O.; Gabrielsson, Jonas

WP 2005/09
Knowledge and accountability: Outside directors' contribution in the corporate value chain
Huse, Morten, Gabrielsson, Jonas; Minichilli, Alessandro

WP 2005/10
Rethinking the Spatial Organization of Creative Industries
Vang, Jan

WP 2005/11
Interregional Inventor Networks as Studied by Patent Co-inventorships
Ejermo, Olof; Karlsson, Charlie

WP 2005/12
Knowledge Bases and Spatial Patterns of Collaboration: Comparing the Pharma and Agro-Food Bioregions Scania and Saskatoon
Coenen, Lars; Moodysson, Jerker; Ryan, Camille; Asheim, Bjørn; Phillips, Peter

WP 2005/13
Regional Innovation System Policy: a Knowledge-based Approach
Asheim, Bjørn; Coenen, Lars; Moodysson, Jerker; Vang, Jan

WP 2005/14
Face-to-Face, Buzz and Knowledge Bases: Socio-spatial implications for learning and innovation policy
Asheim, Bjørn; Coenen, Lars, Vang, Jan

WP 2005/15
The Creative Class and Regional Growth: Towards a Knowledge Based Approach
Kalsø Hansen, Høgni; Vang, Jan; Bjørn T. Asheim

WP 2005/16
Emergence and Growth of Mjärdevi Science Park in Linköping, Sweden
Hommen, Leif; Doloreux, David; Larsson, Emma

WP 2005/17
Trademark Statistics as Innovation Indicators? – A Micro Study
Malmberg, Claes