Competitiveness Review

Knowledge exchanges in innovation networks: evidences from an Italian aerospace cluster

Fernando G. Alberti Emanuele Pizzurno

Knowledge exchanges in innovation networks: evidences from an Italian aerospace cluster

Fernando G. Alberti and Emanuele Pizzurno
Institute for Entrepreneurship and Competitiveness, Universita' Cattaneo LIUC, Castellanza, Italy

Received 21 January 2015
Revised 1 February 2015
Accepted 12 February 2015

Abstract

Purpose – This paper aims at investigating the multifaceted nature of innovation networks by focusing on two research questions: Do cluster actors exchange only one type of innovation-related knowledge? Do cluster actors play different roles in innovation-related knowledge exchange?

Design/methodology/approach – This paper builds on data collected at the firm level in an Italian aerospace cluster, that is a technology-intensive industry where innovation is at the base of local competitiveness. A questionnaire was used to collect both attribute data and relational data concerning collaboration and the flows of knowledge in innovation networks. The authors distinguished among three types of knowledge (technological, managerial and market knowledge) and five types of brokerage roles (coordinator, gatekeeper, liaison, representative and consultant). Data analysis relied on social network analysis techniques and software.

Findings – Concerning the first research question, the findings show that different types of knowledge flow in different ways in innovation networks. The different types of knowledge are unevenly exchanged. The exchange of technological knowledge is open to everyone in the cluster. The exchange of market and managerial knowledge is selective. Concerning the second research question, the authors suggest that different types of cluster actors (large firms, small- and medium-sized enterprises, research centers and universities and institutions for collaboration) do play different roles in innovation networks, especially with reference to the three types of knowledge considered in this study.

Research limitations/implications – The present paper has some limitations. First of all, the analysis focuses on just one cluster (one industry in one specific location), cross- and comparative analyses with other clusters may illuminate the findings better, eliminating industry and geographical biases. Second, the paper focuses only on innovation-related knowledge exchanges within the cluster and not across it.

Practical implications – The results have practical implications both for policy makers and for managers. First, this research stresses how innovation often originates from a combination of different knowledge types acquired through the collaboration with heterogeneous cluster actors. Further, the analysis of brokerage roles in innovation-driven collaborations may help policy makers in designing programs for knowledge-transfer partnerships among the various actors of a cluster.

Social implications – The paper suggests a clear need of developing professional figures capable of operating at the interface of different knowledge domains.

The present research was financed by the Italian Ministry of Research as part of a national research project named SOCRATE, administered by the Institute of Cognitive Sciences and Technologies at CNR, chaired by Rosaria Conte. The authors are indebted to Salvatore Sciascia (IULM University) and Riccardo De Vita (University of Greenwich) for their support in data collection and analysis. Previous versions of this paper were presented at SUNBELT in San Diego, at the UK Social Network Conference in Greenwich and at the 2014 Competitiveness Research meeting at the Institute for Strategy and Competitiveness, Harvard Business School.

Competitiveness Review
Vol. 25 No. 3, 2015
pp. 258-287

1059-5422
DOI 10.1108/CR-01-2015-0004

Originality/value – The data illuminate several aspects of how innovation takes place in a cluster opening up intriguing aspects that have been overlooked by extant literature. The authors believe that this may trigger several lines of further research on the topic.

Keywords Knowledge, Italy, Network, Brokerage, Innovation, Cluster, Aerospace

Paper type Research paper

Introduction

Prior literature has underlined the importance of clusters as key drivers of innovation (Porter, 2008, 2010; Delgado *et al.*, 2014). A vast majority of studies have found that clustered firms show a higher innovative capacity than isolated firms (Baptista and Swann, 1998). Scholars agree that innovation is deeply rooted in clusters and is strongly related to knowledge exchanges (Tallman *et al.*, 2004; Maskell, 2005; Maskell and Malmberg, 1999). The interpretation is twofold:

(1) The general claim of the cluster literature is that geographical proximity facilitates knowledge sharing and thus innovation.

(2) Economic geographers suggest that it is the embeddedness of firms in localized networks that facilitates the diffusion of knowledge and is conducive to innovation in clusters.

According to these views, innovation-related knowledge is diffused in clusters in a pervasive and unstructured way that recalls the Marshallian idea of the "industrial atmosphere" (Marshall, 1921).

There has been increasing understanding in literature that innovation-related knowledge is selectively and unevenly exchanged in clusters and that firms play heterogeneous roles in knowledge exchange within and across clusters (Boschma and Ter Wal, 2007; Giuliani, 2007a, 2007b, 2007c; Morrison, 2008). Scholars on regional networks of innovation now acknowledge that not all the firms have equal access to knowledge (Tödtling *et al.*, 2013; Biggiero and Sammarra, 2010). Likewise, they describe learning in clusters as a "selective" process, challenging the view according to which spatial agglomeration is enough to promote knowledge diffusion. Most of the studies identify innovation networks on the base of the exchange of technological knowledge, even if there is evidence that firms engage in different forms of knowledge, using different networks (Alberti and Pizzurno, 2013). Further, while recent studies acknowledge a variety of roles in promoting innovation through knowledge exchanges, the study of such activities has been somehow reductive. Recent studies have started pointing out the fact that firms engage in the exchange of different types of knowledge (e.g. market knowledge, technological knowledge and managerial knowledge) and that such interactions take different forms (Sammarra and Biggiero, 2008).

However, still, little is known about how cluster actors (such as large firms, small firms, institutions, universities, etc.) engage in different kinds of innovation-related knowledge exchanges. To comply with such research gap, this paper focuses on two research questions:

(1) Do cluster actors exchange only one type of innovation-related knowledge?; and

(2) Do cluster actors play different roles in innovation-related knowledge exchange?

The study is based on the data collected at the firm level in a major Italian aerospace cluster, located in Lombardy (North-West Italy). Aerospace is a knowledge-intensive industry, where innovation is at the base of local competitiveness. The Lombardy aerospace cluster has a long history, and it comprises two large original equipment manufacturers (OEMs) (Alenia Aermacchi and Agusta-Westland), a few large firms, a variety of small- and medium-sized enterprises (SMEs) which produce subsystems and components in the avionic, aerostructural and equipment segments and several universities and research centers, as well as other institutions for collaboration (IFCs).

Data collection relied on a snowball sampling technique. By iteratively applying this procedure, a sample of 42 cluster actors was built that included 33 firms (2 large and 31 SMEs), 5 universities and research centers and 4 public and private IFCs. A questionnaire was used to collect both attribute data and relational data concerning collaboration and the flows of knowledge in innovation networks. We distinguished among three types of knowledge (technological, managerial and market) and five types of brokerage roles (coordinator, gatekeeper, liaison, representative and consultant). Data analysis relied on the social network analysis techniques and software.

Concerning the first research question, our findings show that different types of knowledge flow in different ways in innovation networks. The different types of knowledge are unevenly exchanged. The exchange of technological knowledge is open to everyone in the cluster. The exchange of market and managerial knowledge is selective. Concerning the second research question, we suggest that different types of cluster actors (large firms, SMEs, research centers and universities and IFCs) do play different roles in innovation networks, especially with reference to the three types of knowledge considered in this study.

The paper proceeds as follows. We begin by reviewing the literature on innovation and knowledge exchange in clusters with a focus on the aerospace industry. This is followed by a methodological section, where the research design of the study is illustrated. Next, we present and discuss our results. We conclude by providing final reflections and contributions as well as limitations.

Theoretical background

Innovation and knowledge exchanges in clusters

The geographic concentration of networks of organizations has been widely recognized in the literature as conducive to innovation and growth. After the influential contribution from Marshall (1921), regional agglomeration of firms received a great interest among scholars in the1970s until the concept of clusters was popularized by Porter (1990), who pointed out that clusters can influence the achievement of competitive advantage in three ways:

(1) increasing productivity;
(2) fostering innovation; and
(3) promoting new business creation.

The literature in this field has then grown exponentially, resulting in the proliferation of approaches and conceptualization (sometimes overlapping) to describe and understand the cluster phenomenon (Alberti *et al.*, 2014; Porter, 2008, 2010; Alberti, 2006).

One of the main explanations for the competitiveness of spatial agglomeration of firms is their capability to support innovation (Kesidou and Snijders, 2012; Meier-Comte, 2012). A knowledge-based approach has been developed to explain the innovativeness of regional clusters and scholars (Maskell, 2005; Maskell and Malmberg, 1999) have presented a knowledge view of clusters and learning, highlighting some factors such as path dependencies and proximity as key elements to understand the excellent performances of their innovation-related activities. More recent contributions (Allen and Stephen, 2013; Molina-Morales and Expósito-Langa, 2013; Stacke *et al.*, 2012; Zhang *et al.*, 2011) have studied this phenomenon, explaining and emphasizing the innovative and competitive performances of clusters.

Several authors (Tödtling *et al.*, 2011; Fritsch and Kauffeld-Monz, 2010) have recently recognize that – even sharing the same specific location – firms have diverse access to knowledge and that the effect of spatial proximity should be completed (Boschma, 2005) considering the effects of institutional, cognitive, organizational and social proximities. Consequently, some papers focused on understanding which features are more likely to explain the innovation level reached by clustered firms, whereas others developed a taxonomy of different positions and roles that companies can play within a local cluster. The absorptive capacity (AC) by Cohen and Levinthal (1990) has been highlighted as a key explanatory feature:

- Boschma and Ter Wal (2007) classified companies taking into consideration AC and their network profile, stating that AC is central in non-local technical knowledge networks, although less relevant in market-driven ones.
- Parra-Requena *et al.* (2013) and Giuliani and Bell (2005) found an association between AC and external openness.

However, this stream of literature (Boschma and Ter Wal, 2007) confirms that – due to the secondary importance of local inter-firm networks compared to other potential primary sources of information (e.g. informal contacts, trade fairs, etc.) (Huggins *et al.*, 2012) – AC is not related to network positions in local networks. The same authors analyzed in detail a number of forms of local and non-local networks and their impact on innovation. Results show how networking is positively associated with innovation, but also that spatial and cognitive proximities (Boschma, 2005) are not necessarily contributing to the setting of networks. Giuliani (2007a, 2007b, 2007c) confirmed geographical agglomerations as extremely selective in terms of learning and knowledge diffusion, whereas the mere local proximity resulted not sufficient. In terms of the roles played within those regional networks of innovation, according to Giuliani and Bell (2005), the AC of firms determine their position – those firms with higher AC represent the active dense core of the network, while those with lower AC are peripheral actors.

Technological gatekeepers (Giuliani and Bell, 2005) play an active role in the continuous development of the whole cluster. Firms in this role are those able to match internal innovative capabilities with the recombination of external (even global) and internal knowledge. The gatekeepers received a lot of attention in literature (Morrison, 2008), especially with reference to the following three roles:

(1) searching: absorbing external knowledge;

(2) transcoding: translating the acquired knowledge for an internal use; and

(3) sharing: disseminating knowledge in the cluster.

Another stream of literature, instead, points out the fact that universities and research institutions are engaged as gatekeepers, especially in local innovation networks (Graf and Henning, 2009, Kauffeld-Monz and Fritsch, 2010, Graf, 2011).

Several studies (Boschma and Ter Wal, 2007) have highlighted that companies exchange different types of knowledge in different forms. A well-known distinction used by scholars in this respect is between market and technological knowledge (Alberti and Pizzurno, 2013; Chiesa *et al.*, 2007). Market knowledge is reported to be exchanged more at the regional level among local companies. Leading firms act in this field as gatekeepers with external networks. Technological knowledge is reported to be exchanged by leading firms only with partners outside the region, without participating to the local exchange.

Sammarra and Biggiero (2008) added a further type of knowledge (managerial). The two authors, studying the Rome aerospace cluster, compared the exchange of market, managerial and technical knowledge. Sammarra and Biggiero (2008, Biggiero and Sammarra, 2010) in two different contributions further found that differences in exchanges are multiple – different knowledge exchanges involve different firms, which adopt different knowledge-sourcing strategies.

Giuliani (2007a, 2007b, 2007c) proposed a clear distinction between a knowledge network and a business network in which a firm is embedded, defining a knowledge network as a connection among firms searching for solutions to deal with complex critical problems and exchanging technical knowledge within the innovation process. The same author then operationalized Keeble and Wilkinson's (1999) definition of a business network as the interaction of a company with other companies about business-related issues and, meeting the expectations, business networks were found to be denser than knowledge ones. Furthermore, knowledge ties were distributed in a more heterogeneous way confirming the idea of a "selective and uneven" nature of learning in the cluster (Giuliani, 2007a, 2007b, 2007c). Morrison and Rabellotti (2009), studying the wine industry, shifted their attention on the flows of information on one side and technological knowledge on the other, and using these two concepts as proxies for explicit and tacit (i.e. technological) knowledge, respectively, they measured both frequency and intensity of these two exchanges. Knowledge networks were found much more selective and less dense than information networks and were based on reciprocated ties. Information networks were found more accessible to the larger part of the actors in the local cluster and not based on reciprocal ties.

A different approach was adopted by other authors (Tödtling *et al.*, 2009; Tödtling *et al.*, 2006) who developed a taxonomy of knowledge exchange in innovation systems based on two main factors:

(1) the formality of the knowledge exchange; and
(2) the nature (static or dynamic) of the knowledge interaction.

This framework led successively to the identification of only three forms of knowledge exchange:

(1) co-operative research;
(2) information exchange; and
(3) contract research.

The authors, however, did not find evident differences between the three relations, suggesting that the three types of interaction take place simultaneously between partners.

On the basis of an increasing awareness that geographical proximity *per se* is not enough to understand innovation in regional networks, but that cluster organizations are linked through a more complex web of relations, scholars started focusing on the structure of such networks, with the aim of understanding which structural properties are associated with innovation.

There is increasing evidence about the importance of institutional variety and richness in promoting innovation. For example, we can cite Patrucco (2003) who investigated the structure of the technological district of Brianza in Italy, showing how the combination of different knowledge bases is of great relevance to support innovation. Firms having access to different knowledge collaborating with more than one type of external partners (firms, universities and business service providers) with an open innovation approach (Pellegrini *et al.*, 2012) present higher innovation performances. Successive studies show that firms are mainly connected with universities and business service centers at a local level, while a non-local approach is more common when competitors are the main source of knowledge (Huggins and Johnston, 2010). They gave also a clear distinction between social capital and network capital as network resources more strategically managed by the firms, highlighting that while social capital investments are typically local, network capital investments do not appear to be associated with spatial proximity. Moreover, the study showed that dynamic networks, where firms show a higher aptitude to be engaged in knowledge exchange with new partners, are more expected to promote innovation. Such last consideration clearly remarks the importance of using longitudinal network approaches in the study or regional innovation networks (Huggins and Johnston, 2010; Ter Wal and Boschma, 2009). Measures used typically in networking (such as size, centralization, cohesion and density) have been used to compare knowledge networks in the industrial fields (Krätke and Brandt, 2009), linking networking with the innovativeness at the firm level (Krätke, 2010).

The combination of local and global relationships is another extremely relevant issue in the studies about regional innovation networks (Biggiero and Sammarra, 2010). In the aforementioned study about the aerospace cluster in Rome, they find how the involvement of companies in global knowledge networks is variable. Nonetheless, the cluster benefits both from local and global knowledge exchange for all the different types of knowledge analyzed (technological, market and managerial). The form of knowledge has a strong influence on the amount of knowledge exchanged and on the mix of local and non-local partnerships. The reason why local ties result more relevant is twofold:

(1) they involve the largest amount of knowledge; and

(2) technological knowledge (the most important for the cluster, Sammarra and Biggiero, 2008), is mainly exchanged at the local level.

The opposite occurs for what concerns managerial and market knowledge (Biggiero and Sammarra, 2010).

In conclusion, the review of the literature with a twofold perspective (networking and innovation generation in clusters) clearly remarked the shift of attention by scholars toward some specific issues, more specifically, the existence of:

- a diverse set of cluster actors involved – at a local level – in the generation of innovation;
- different roles that cluster actors perform with respect to the knowledge exchange process;
- a complex relational network linking actors, where different types of knowledge are exchanged; and
- different network structures according to the nature of the knowledge exchanged, the industry and the location.

These aforementioned points contributed to an advancement of the literature in this discipline, mainly through techniques capable to consider simultaneously network and firm-based variables. Despite the growing number of methodological advancements and contributions, still some gaps emerge in the literature, which provides an opportunity for further investigation about innovation processes in regional networks. More in details:

- *The prevalent focus on the exchange of technological knowledge.* A large part of the studies recognize innovation networks and open innovation on the base of the exchange of technological knowledge. However, there is evidence that firms, with different networks, exchange different forms of knowledge. Just a limited number of studies compared the exchange of other types of knowledge (Boschma and Ter Wal, 2007; Sammarra and Biggiero, 2008), but mostly using a limited set of network measures. Furthermore, the exchange of different forms of knowledge is often analyzed separately, and the interdependence between different knowledge relations is neglected.
- *A reductionist approach to brokerage and gatekeeping.* While recent studies acknowledge brokers and gatekeepers play a fundamental role in promoting innovation, the study of such activities has been somehow reductive. First, brokerage is a complex activity, which can be measured in different ways. Second, gatekeeping is described in terms of connecting local and non-local knowledge. However, the same function can be performed within the cluster; for example, bridging networks of different types of organizations.
- *The lack of studies incorporating more than one mode of actors.* Most of the studies are concentrated only on networks involving firms. Other studies remark on the importance of research centers and universities in supporting innovation efforts. But just few studies, however, comprise non-business organizations in their analyses and discuss in depth the roles played by different organizations in clusters.
- *The prevailing focus on leading firms.* The literature has so far underlined the role of leading firms in the process of knowledge exchange. This perspective does not recognize that roles of several organizations in clusters are much more complex and cannot be reduced to a sample dichotomy between leading and non-leading firms. There is, therefore, the opportunity to study the roles of SMEs in the innovative process at a cluster level.
- *The scarce use of network measures to study innovation networks in clusters.* Despite the recent introduction of social network analysis (SNA) in this research

field, most of the studies rely on a group of relative simple network measures. However, the potential of this methodology seems to be outstanding and the application of more advanced SNA tools and measures in understanding such regional innovation networks.

The combination of aforementioned evident interest toward this specific issue, emerged limitations of existing literature and research gaps bring to the identification of two research questions that will be addressed in the remaining parts of this paper:

RQ1. Do cluster actors exchange only one type of innovation-related knowledge?

RQ2. Do cluster actors play different roles in innovation-related knowledge exchange?

Innovation networks in the aerospace industry

The available literature widely treats the aerospace industry as global, hi-tech (Niosi and Zhegu, 2005) and of great relevance worldwide (Cooke and Ehret, 2009) because it is often a great opportunity of regional economic and technological development (van de Vijver and Vos, 2007). Among the main traits of the aerospace industry (Ecorys, 2009; Esposito and Raffa, 2006), we can mention the following:

- being a strategic industry;
- technological complexity;
- high technological level;
- long break-even periods and small markets;
- critical cash flows;
- high and increasing development costs; and
- high interdependencies between civil and defense markets.

In such a knowledge-intensive landscape (Longhi, 2005), innovation plays a paramount role, and it is on the basis of competitiveness of aerospace clusters and firms (Giuri *et al.*, 2007; Niosi and Zhegu, 2005). As a consequence, several scholars investigated issues related to R&D, innovation and technology management in this industry (Hatzichronoglou, 1997; Esposito, 2004; Giuri *et al.*, 2007).

The aerospace industry is also characterized by a marked organizational ambidexterity. In fact, it has a strong vertical hierarchy (Ecorys, 2009), which is the consequence of the action of leading companies (OEMs) in streamlining their supply chains for costs reduction and the internal development of core competencies in design, assembling and marketing (Niosi and Zhegu, 2005). At the same time, several exogenous factors (as specialization, the technological complexity of the industry and the global nature of the market) pushed several companies to collaborate and, consequently, firms – belonging to different layers in the structure of the industry – developed horizontal long-term ties. The cumulative nature of knowledge, the dependence from some contingent factors, the multicomponent and multiproduct nature of the industry and the specificity of some technologies and investments call, indeed, for the creation of stable networks between firms (Giuri *et al.*, 2007; Prencipe, 2004). These established trends do explain why aerospace industry clusters are diffused in many regions in the world (Elola *et al.*, 2013).

Among several types of collaborations, those based on innovation are well diffused in the industry, and the main reason has been detected in its technological complexity, thus the exchange of technological knowledge has been prevailingly studied. Esposito and Raffa (2006) reviewed the evolution of networks in the aerospace industry, describing the evolution of its knowledge base that – to be competitive – cannot be only technical, but also relational and organizational. The same authors recognize that firms are increasingly dealing with obstacles that are not strictly related to technical issues, but are also organizational, financial and market-related.

For these reasons, the evolution of industry collaborations pushed firms to develop further skills and to gradually achieve a new role from the pure outsourcing (similar to what Pellegrini *et al.*, 2012 have observed in the oil industry), becoming instead, relevant and expert partners, capable of system integration and of coordination with their own suppliers (Smith *et al.*, 2005). Furthermore, as a result of the shifts in the industry, innovation is less technology-push and more frequently driven by the requests of the clients and by the market (Sammarra and Biggiero, 2008). Further, the tendency toward international collaborations has increased more and more, starting from the 1960s and progressively including a growing number of countries. Another interesting point is related to the degree of vertical collaborations, which is positively associated with the technological level (Esposito, 2004). An explanation is connected to the technological complexity of the products, which need a multi-faced specialized support by different partners, thus stimulating collaborations and boosting innovation in the industry (Rose-Anderssen *et al.*, 2008). Thus, the relational network linking all different partners in the aerospace industry is rather complex. More complexity is added by the partner selection that is strongly influenced by political factors and alliances are, in some cases, related to specific contingencies or projects (Jordan and Lowe, 2004). In this way, therefore, simultaneous relationships (collaboration and competition) might coexist between the same cluster actors.

The nature and direction of relationships in aerospace networks are difficult to capture. Niosi and Zhegu (2005) and Sammarra and Biggiero (2008) remark how knowledge flows are bidirectional (top–down and bottom–up in the value chain, Giuri *et al.*, 2007):

- among firms of different sizes along the supply chain;
- among large firms collaborating in international projects; and
- from aerospace firms to actors in other industries, a cross-fertilization which generally benefits from knowledge spillovers.

Large firms and SMEs (Cooke and Ehret, 2009; Niosi and Zhegu, 2005) collaborate together in a complex relational tissue, where the aforementioned competitive pressures and factors, characterizing the industry, stimulate the creation of networks of partners, bringing together different competencies, in a net of defined and undefined relations (Ecorys, 2009; Esposito and Raffa, 2006). The role of firms has been largely integrated by several other organizations like research centers, universities, government laboratories, public institutions and consultants (McAdam *et al.*, 2008; Niosi and Zhegu, 2005). It is not surprising that some public bodies are listed as potential partners in aerospace networks due to the political relevance of this industry (Hickie, 2006). In those collaborations, participating organizations exchange different resources (knowledge, products and personnel) vertically and horizontally (Niosi and Zhegu, 2005).

Italy plays a key role in the global aerospace industry; it is the fourth largest actor in Europe and the sixth in the world (Ecorys, 2009). The structure of the Italian aerospace industry is characterized by a few large manufacturers, mainly part of the Finmeccanica Group, which is active in several segments:

- aeronautic (Alenia Aeronautica, Alenia Aermacchi, Aeronavali);
- helicopter (AgustaWestland);
- space (a joint-venture with the French group Thales);
- aircraft and naval engines (Avio); and
- avionics (Selex Galileo).

In addition, outputs of the Italian firms (such as aero-structures, products and components) are steadily part of the most relevant OEMs supply chain, such as Airbus, Boeing and Bombardier, but several firms are also engaged in the assembling of subsystems (Ecorys, 2009).

The Italian aerospace industry has been historically characterized by public interventions, both at the regional and national levels. Some of the most relevant public actors and initiatives are under the umbrella of the Italian Space Agency in conjunction with the National Research Council (CNR), the Italian Research Centre for the industry (CIRA). Also, some ministries are active in this filed (the Ministry of Education, University and Research and the Ministry of Defense). Policies in the aerospace industry are designed also at the region and province levels because some of them are active players in supporting local firms (SMEs among the others) and/or in formulating promotional initiatives at the local level.

The combination of the aforementioned effects (strong tradition in networking and regional policies addressed to a specific industry and geographical area), together with the presence of multinational companies favored the creation of clusters. This was favored also by the presence of several SMEs that were founded in proximity to larger firms to supply them with specialized products and services, often as a result of spinoff processes, as is common in several other well-studied clusters (Alberti *et al.*, 2008; Biggiero, 2002). Clustering processes in the industry were also facilitated by the presence of several excellent research poles such as the Polytechnics of Milan or Turin. Among the most relevant regional clusters in the Italian aerospace landscape, there are five main initiatives (Ecorys, 2009):

(1) Lombardy (in the area of Varese);
(2) Latium (in the area of Rome);
(3) Piedmont;
(4) Puglia; and
(5) Campania.

Those clusters have recently launched inter-cluster initiatives, due to the competitive nature of the industry worldwide and to its technology challenges. Moreover, such approach confirms the nature of the industry (Niosi and Zhegu, 2005), which combines relationships within local clusters with the need of collaborations on a wider scale, at least at the national level. As examples, Campania and Puglia started collaborating at the end of 2008, and the two regions signed another agreement with Piedmont in the same year.

Method

Research design

To answer our two research questions, we relied on SNA methods and techniques. SNA has been increasingly used in management science and business studies (Borgatti *et al.*, 2009) and, more specifically, to investigate innovation that quite often originates from collaboration networks and knowledge exchanges in regional systems (Cantner *et al.*, 2010). For these reasons, SNA is increasingly used to investigate innovation in clusters.

Thus, SNA is believed to be a suitable method to advance research at the frontier between innovation studies and economic geography, and cluster scholars may complement traditional research approaches with SNA (Coulon, 2005; Reid *et al.*, 2008; Van der Valk and Gijsbers, 2010), leveraging its potential to include in the analyses non-industrial players and to capture relations not measured by standard economic approaches. To this regard, in the editorial of the special issue "Embedding network analysis in spatial studies of innovation" in the *Annals of Regional Sciences*, Bergman, (2009) remarked the large potential of SNA as a common background to integrate the contributions of different sub-fields in the innovation studies area, as later remarked by another special issue in 2010 appeared in the journal *Innovation: Management, Policy & Practice*.

Empirical setting: the Lombardy aerospace cluster

The Lombardy aerospace cluster has ancient roots, specifically in the province of Varese where, historically, the majority of regional firms clustered (Grampa, 1994, 2002, 2003). According to the last available census, about 175 firms are located in the local aerospace cluster, covering different phases of the supply chain and relying on more than 14,000 employees (Comitato Promotore del Distretto Aerospaziale Lombardo, 2010). The composition of the cluster is heterogeneous: 2 large OEMs (Alenia Aermacchi and Agusta-Westland); 12 other large firms; 161 SMEs manufacturing subsystems and components in the avionic, aero-structural and equipment sectors; 13 universities; more than 40 research centers; and 5 IFCs (see Table I). Several other firms operate in related and supporting industries, with a special focus on the aerospace business. Network

Table I.
The structure of the Lombardy aerospace cluster

Large firms (> 250 employees)	SMEs	Universities and research centers	Institutions for collaboration (public and private)
14 firms, of which 10 units of large firms with their core business in the aerospace industry	161 SMEs, of which 29 medium-sized firms (50-249 employees) 132 small-sized firms (< 50 employees)	13 universities > 40 research centers	5 IFCs, such as Lombardy Regional Government Lombardy Aerospace Cluster Organization

Source: Comitato promotore del distretto aerospaziale lombardo (2010) relations, and, thus, innovation-driven collaborations, have undertaken a major shift as a consequence of the outsourcing policies taken by OEMs and the increased rivalry from emerging countries.

Data collection

According to other previous studies applying SNA to the study of innovation networks in aerospace clusters (Biggiero and Sammarra, 2010; Sammarra and Biggiero, 2008), we used a *snowball sampling* technique to collect data (Frank, 2005). The initial sample was not random, but built from a starting list of firms active in the cluster made available by the local cluster organization. That list was then validated by industry experts working in local cluster firms, and a few other nodes were added to the sample. Firms in the initial sample were then asked to nominate other actors involved in innovation-driven collaborations. Then, we included in the rounds of interviews those actors belonging to the cluster (on the basis of their geographical locations) cited and not been already interviewed.

The questionnaire consisted of six main sections:

(1) *Company profile*: Size and activities of the firm.

(2) *Internal innovation*: Orientation toward innovation, factors fostering and impeding innovation.

(3) *Relationships with customers*: Most relevant customers and areas of collaboration with them.

(4) *Relationships with suppliers*: Most relevant suppliers and areas of collaboration with them.

(5) *Firm knowledge base*: Self-assessment of internal market knowledge, technological knowledge, managerial knowledge.

(6) *Innovation-driven collaboration*: Identification of partners involved in innovation-driven collaborations *vis-à-vis* the exchange of three types of knowledge (i.e. technological, managerial and market knowledge).

All interviews were introduced by a formal letter and later phone calls explaining the purpose of the research and checking for availability to be included in the study.

The first five sections of the questionnaire were made available to interviewees in an electronic format (so to be filled in by a plurality of managerial figures in sampled firms), while the last section dedicated to sensitive innovation-driven collaborations was filled in face-to-face, with key managerial figures, such as the Managing Director or the R&D Manager. The average length of interviews was about 1.5 hours.

Data collection allowed the construction of four different networks. First, interviewees were asked to list all other organizations with whom they engaged in innovation-driven collaborations in the previous three years. For the purpose of this study, we relied on a very broad concept of innovation, that is as any kind of improvement, not strictly related to the technological area. Each one of the organizations mentioned during interviews was then complemented with data on their location and their profile. Finally, we asked to evaluate each collaboration in terms of market, technological and managerial knowledge received and transferred (see Table II).

Variables and measures

As mentioned, we distinguished among three types of knowledge (technological, managerial and market knowledge) and five types of brokerage roles (coordinator, gatekeeper, liaison, representative and consultant).

Market knowledge, technological knowledge, managerial knowledge

Knowledge is a broad concept (Amin and Cohendet, 2004) encompassing various types such as technological knowledge, market knowledge, industry-specific knowledge and managerial knowledge (Simonin, 1999). Most of the studies identify innovation networks on the base of the exchange of technological knowledge. Recent studies on innovation have shown that successful innovation does not depend exclusively on technological knowledge but rather on a heterogeneous recombination of a broader set of knowledge types (Rodan and Galunic, 2004; Boschma and Ter Wal, 2007). Brenner (2007) accounted for different types of knowledge exchanged in inter-firm innovation networks, and Sammarra and Biggiero (2008) went a step further suggesting how to discriminate among technological, managerial and market knowledge in innovation networks in clusters. Accordingly, in this study, technological knowledge – that is the type of knowledge most investigated in past research as reported by Sammarra and Biggiero (2008, p. 805) – refers to "know-how and competences necessary to the process and execution of product and process development, and includes scientific knowledge as well as applied and experimental knowledge". Market knowledge is typically defined as organized and structured information on the market (Li and Calantone, 1998), comprising "competences and know-how centered on customers' characteristics, preferences and needs that firms are requested to satisfy" (Sammarra and Biggiero, 2008, p. 805). Finally, managerial knowledge differs from the previous two, given that it refers to "competences and know-how necessary to efficiently and effectively coordinate and supervise organizational resources and processes" (Sammarra and Biggiero, 2008, p. 805), including operational and applied knowledge (e.g. total quality management, lean management, etc.) as well as more abstract and complex knowledge (e.g. decision-making, strategic processes, cross-functional competences, etc.).

Types of brokerage roles

Following Gould and Fernandez (1989), we define a broker as an actor *b* who has a tie to actors *a* and *c*, when *a* and *c* are not directly connected. The concept of brokerage is very popular in SNA literature (Burt, 2005) and is increasingly diffused among scholars of regional networks of innovation (Boschma and Ter Wal, 2007). According to Gould and Fernandez (1989), when the actors *a*, *b*, and *c* belong to different groups, five kinds of brokerage are possible. In the description below, the notation G(x) is used to indicate the group that actor x belongs to. It is important to assume that *a* is linked to *b* that is linked

Table II.
The structural variables: innovation and knowledge networks

Network properties	Innovation network	Knowledge networks Managerial	Market	Technological
Direction of ties	Not oriented	Oriented	Oriented	Oriented
Value of ties	0-1	0-3	0-3	0-3
Graph	Binary, symmetric	Valued, asymmetric	Valued, asymmetric	Valued, asymmetric

to *c*, that is a – > b – > c. For example, a (the source actor) gives information to b (the broker), who gives information to c (the destination actor). The five brokerage roles (see Figure 1) are operationalized and measured in the following way (Borgatti *et al.*, 2009):

(1) *Coordinator*: Counts the number of times b is a broker and G(a) = G(b) = G(c), that is all three nodes belong to the same group.
(2) *Consultant*: Counts the number of times b is a broker and G(a) = G(c), but G(b)^{1} G(a), that is the broker belongs to one group, and the other two belong to a different group.
(3) *Gatekeeper*: Counts the number of times b is a broker and G(a) ^{1} G(b) and G(b) = G(c), that is the source node belongs to a different group.
(4) *Representative*: Counts the number of times b is a broker and G(a) = G(b) and G(c) ^{1} G(b), that is the destination node belongs to a different group.
(5) *Liaison*: Counts the number of times b is a broker and G(a) ^{1} G(b) ^{1} G(c), that is each node belongs to a different group.

Types of cluster actors

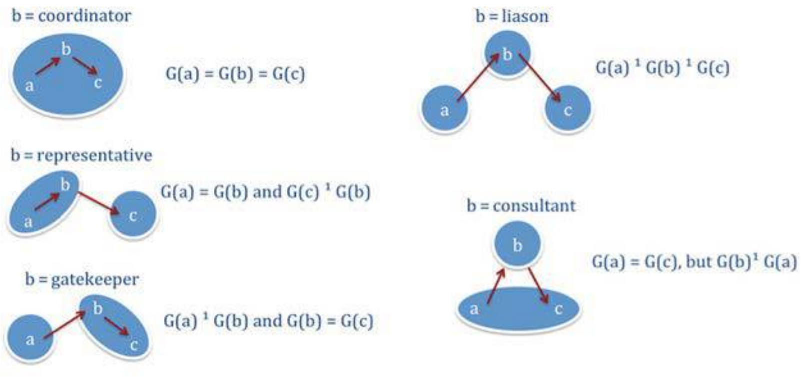
Finally, we considered four types of cluster actors in our study:

(1) large firms (with more than 250 employees);
(2) SMEs (with less than 250 employees);
(3) universities and research centers; and
(4) IFCs (i.e. private and public bodies, institutions and organizations operating in the cluster for the cluster).

Data analysis

For data analysis, we relied on SNA techniques and used UCINET 6 (Borgatti *et al.*, 2002) as a software package because it is the most frequently used package in SNA.

First, thanks to the software, we constructed four network graphs, namely, the entire innovation network (binary, symmetric and not oriented) and the three knowledge networks – technological, managerial and market knowledge (valued, symmetric and



Source: Adapted from Gould and Fernandez (1989)

Figure 1. Types of brokerage roles in networks

oriented). All networks and analyses have been anonymized to protect sensitive data, considering unintended drawbacks and implications of disclosing innovation practices in the aerospace industry. Additionally, we agreed to interviewees a two-year lag before publishing data to further reduce the risk of spreading sensitive innovation data through our study. To answer the first research question, first, we checked network density and isolates counts with reference to the three different types of knowledge considered and made a bootstrap *t*-test to check for significant differences in the density of couples of networks (Snijders and Borgatti, 1999).

To answer the second research question, thanks to UCINET software package, - we measured relative brokerage scores as ratios of the sum of brokerage relations per actor and the probability of any given brokerage relation per number of possible brokerage relations. The software package, first, provides the simple count of possible brokerage roles for each node in the network and calculates an overall brokerage roles value. Next, the software package computes the expected value of brokerage roles in the network. According to the operationalization of the five brokerage roles offered by Gould and Fernandez (1989) reported above, the number of times a node can act in a specific role is influenced by the number of groups and by their size. The UCINET computes the ratio between the observed and the expected value, and it highlights those cases showing values that differ significantly from the expected one.

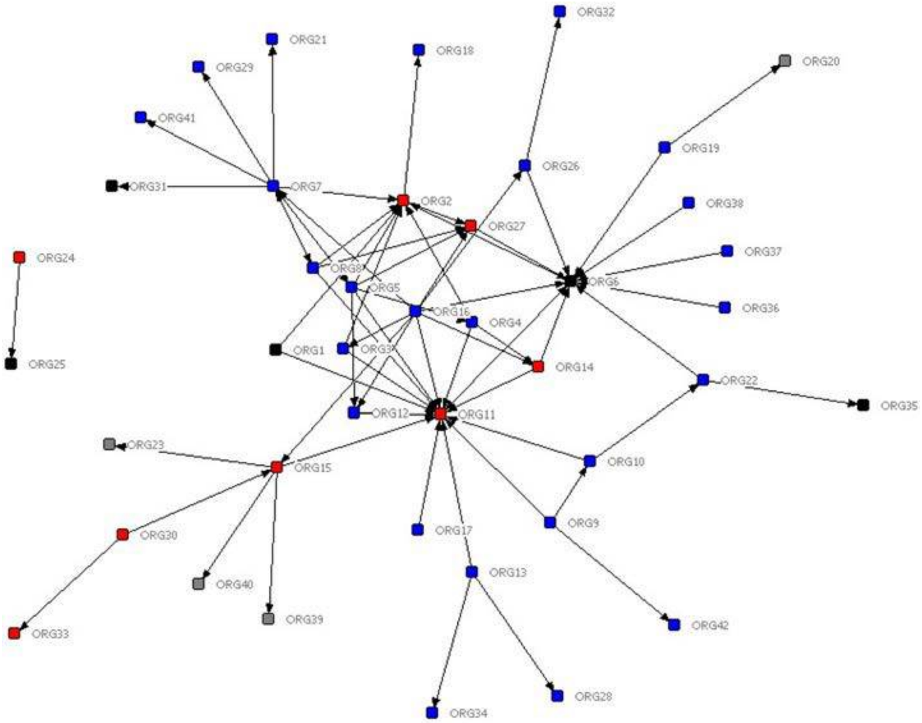
Findings and discussion

Innovation-driven collaborations, in the form of networks, are presented in Figures 2-5. Figure 2 reports all innovation-driven collaborations in the cluster, while Figures 3 to 5 report technological, market and managerial knowledge exchange networks, respectively. Our findings clearly show how the distinctive knowledge types imply different network structures and how the participation of different cluster actors in the networks differ according to the specific knowledge exchanges observed.

The first research question was aimed at understanding whether cluster actors exchange only one type of innovation-related knowledge. To answer this first question, we first applied a *t*-test to check for significant differences in the three network densities (Snijders and Borgatti, 1999) and allowed by the software package UCINET 6. The comparison of the three networks within the cluster is intended to reveal whether cluster actors exchange one type of knowledge more than others. The results of the *t*-testing, reported in Table III, show the significance of the difference between the density of the different knowledge networks within the cluster.

Our findings show that different types of knowledge flow in different ways in innovation networks. First of all, the density of the technological knowledge network is significantly higher than the density of market and managerial knowledge networks, meaning that cluster actors are prevailingly involved in the exchange of technological knowledge more than any other type of knowledge. No significant difference emerges instead comparing the exchange of managerial and market knowledge in the cluster.

Our findings confirm previous studies regarding innovation-driven collaborations in the aerospace industry (Sammarra and Biggiero, 2008), but they contrast the ones reported by Boschma and Ter Wal (2007), where market knowledge exchanges in the shoe cluster in Barletta (Italy) prevailed over technological ones. This suggests an industry bias in the way knowledge is exchanged in regional networks: market



Notes: Large firms in RED; SMEs in BLU; universities and research centers in BLACK; and IFCs in GRAY – no isolates; 42 nodes in total

Figure 2.
Innovation network

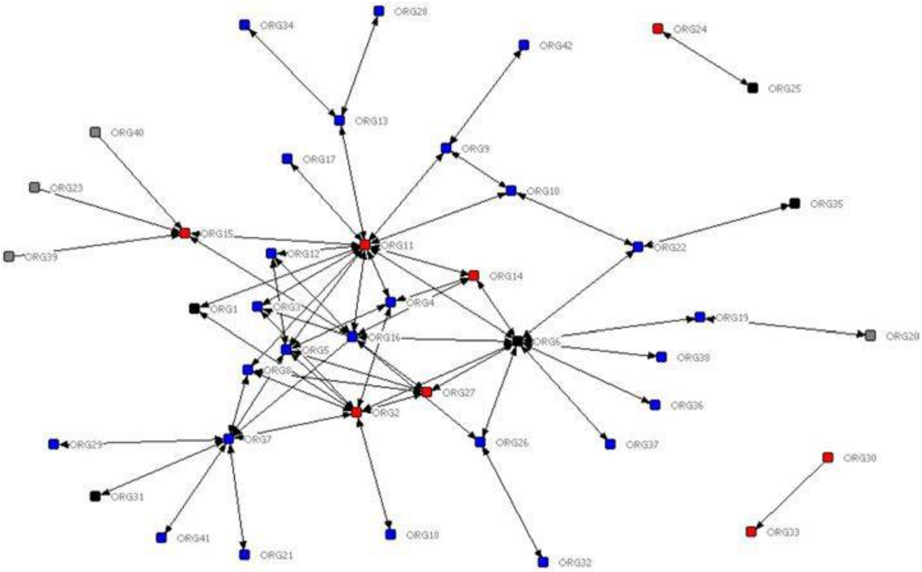
knowledge exchanges are denser in low-tech industries, and vice-versa technological knowledge exchanges are denser in high-tech industries.

In brief, our findings do confirm that different types of knowledge are exchanged in clusters in an uneven and selective way and that the prevalence of one knowledge exchange over the others (measured through network density) is an industry-specific trait.

In conclusion, the different types of knowledge are unevenly exchanged. The exchange of technological knowledge is open to everyone in the cluster (high density and no isolates in the network). The exchange of market and managerial knowledge is selective (low density and several isolates in the network).

Concerning the second research question, different types of cluster actors perform different roles in innovation networks. Figure 6 shows the relative brokerage scores in the innovation network, highlighting those cluster actors performing a brokerage role more times than it would be expected. Tables IV-VI summarize for each type of knowledge considered (technological, market and managerial) the most striking raw scores for each brokerage role to facilitate a more straightforward interpretation of findings.

First, our findings suggest that the brokerage of knowledge in innovation-driven collaborations is an activity performed by a limited set of cluster actors. Our findings are consistent with the literature on brokerage in SME networks (Kirkels and Duysters,



Notes: Large firms in RED; SMEs in BLU; universities and research centers in BLACK; and IFCs in GRAY – no isolates; 42 nodes in total

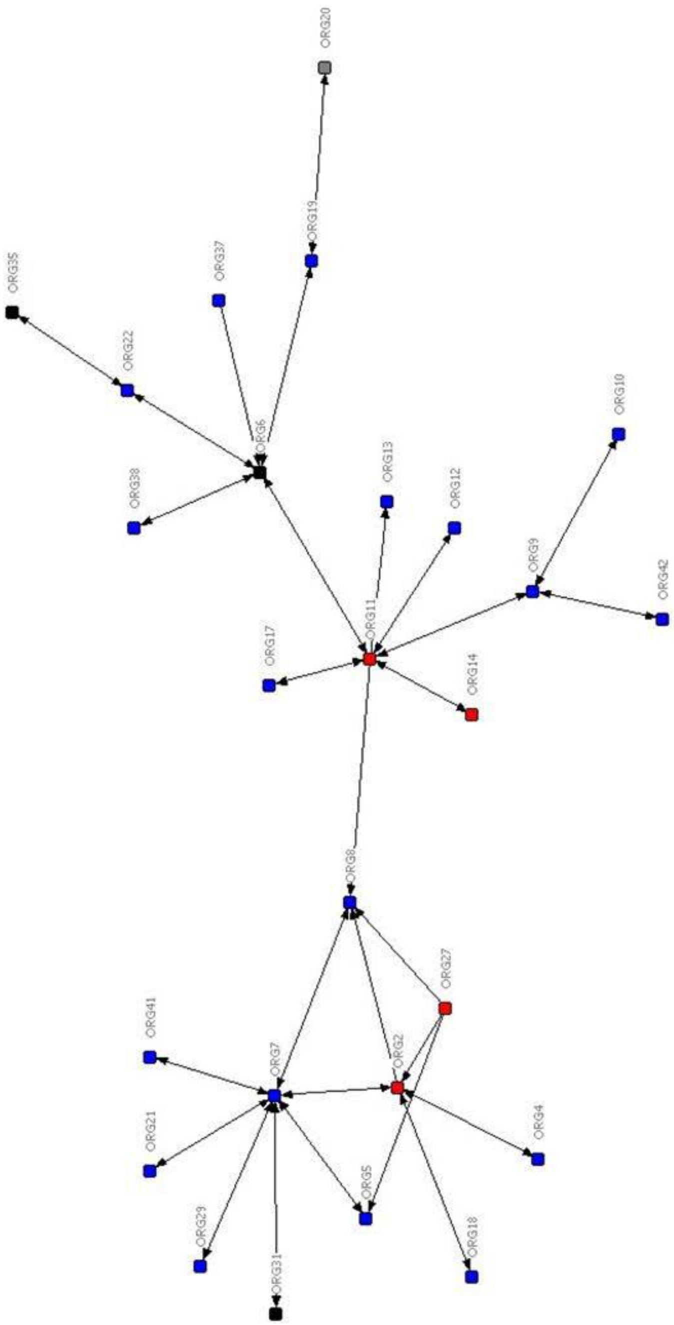
Figure 3.
Technological knowledge network

2010) that suggest that cluster actors do not necessarily aim at becoming brokers and the actual possibility of being a broker depends on several factors, such as the kind of relationships established and the type of knowledge available.

In the Lombardy aerospace cluster, the brokerage of technological knowledge is exclusively performed by firms (either large ones or SMEs). Conversely, market knowledge is also brokered by research centers and universities who can provide market scenarios and trends to firms, and more in general provide the "big picture" of the industry to cluster actors that, due to their focused specializations, have a partial or biased view of the final market. The use of universities and research centers to acquire knowledge about the final market may allow to overcome the technological bias of that industry and, thus, the strategic myopia typical of some clusters (Alberti, 2006).

Finally, as far as managerial knowledge is concerned, again, brokers are almost exclusively cluster firms (with the exception of liaison role played by a research center). Large firms, in particular, only act as consultants to the rest of the cluster in terms of new managerial practices and processes, such as lean manufacturing techniques, enterprise resource planning system integrations, total quality control procedures, etc.

Large firms prevailingly play the role of consultants (i.e. they act as pollinators for the three types of knowledge) as well as liaisons (i.e. they "translate" the three types of knowledge for different collaborators, SMEs, research centers and universities). SMEs are mainly coordinators *vis-à-vis* technological and market knowledge, with sporadic roles of interaction with other groups (gatekeeper/representative/liaison) suggesting a specialization of roles *vis-à-vis* the restructuring of global value chains. Research centers and universities act as liaisons (translators of meaning) and consultants (pollinators) *vis-à-vis* market and managerial knowledge (not technological knowledge, whose



Notes: Large firms in RED; SMEs in BLU; universities and research centers in BLACK; and IFCs in GRAY – 16 isolates removed from the network; 42 nodes in total

Figure 4.
Market knowledge network

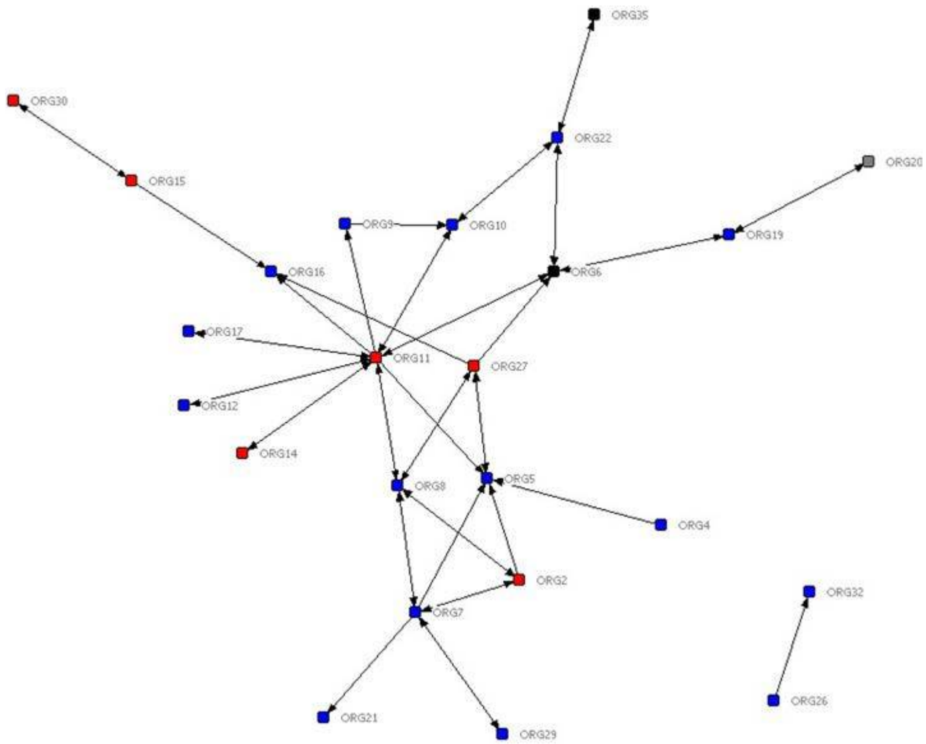


Figure 5.
Managerial knowledge network

Notes: Large firms in RED; SMEs in BLU; universities and research centers in BLACK; and IFCs in GRAY – 18 isolates removed from the network; 42 nodes in total

Table III.
Differences in knowledge exchange in innovation networks

Network properties	Innovation network	Technological knowledge network	Market knowledge network	Managerial knowledge network
# Nodes	42	42	42	42
Density	0.0743	0.0691	0.0285	0.0279
Isolates	0	0	16	18
				***t*-test**
Technological-market K				2.3597
Technological-managerial K				2.3857
Market-managerial K				0.0489

Note: K = Knowledge

brokerage is exclusively dominated by firms), thus, as said, contrasting the strategic myopia that frequently occurs in technology-oriented clusters.

Surprisingly enough, IFCs that are supposed to be crucial in the brokerage of any kind of knowledge in a cluster (Porter and Emmons, 2003; Sölvell *et al.*, 2003, 2008) and

```
Relative Brokerage (raw scores divided by expected values given group sizes)

                    1         2         3         4         5         6
             Coordinat Gatekeepe Represent Consultan   Liaison     Total
            ------------------------------------------------------------
 42 ORG24 |         0         0         0         0         0         0 |
  2  ORG2 |         0         0         0     5.179         0     1.000 |
 23 ORG14 |         0         0         0         0         0         0 |
  4 ORG11 |         0         0         0     4.143     0.933     1.000 |
 26 ORG30 |         0         0         0         0         0         0 |
 29 ORG33 |         0         0         0         0         0         0 |
 17 ORG27 |         0         0         0     5.179         0     1.000 |
 25 ORG15 |         0         0         0         0         0         0 |
           -------------------------------------------------------------
  9 ORG22 |         0         0         0         0         0         0 |
 16 ORG26 |         0         0         0         0         0         0 |
  1 ORG36 |         0         0         0         0         0         0 |
 22 ORG28 |         0         0         0         0         0         0 |
  3 ORG10 |         0         0     5.179         0         0     1.000 |
 14 ORG37 |         0         0         0         0         0         0 |
 31 ORG34 |         0         0         0         0         0         0 |
  5 ORG18 |         0         0         0         0         0         0 |
  7 ORG19 |         0         0         0         0         0         0 |
 18 ORG12 |         0         0         0         0         0         0 |
 19 ORG38 |         0         0         0         0         0         0 |
 20 ORG13 |         0         0         0         0         0         0 |
 41 ORG17 |         0         0         0         0         0         0 |
 21  ORG4 |         0         0         0         0         0         0 |
 13  ORG9 |         0         0         0         0         0         0 |
 24 ORG29 |         0         0         0         0         0         0 |
 15  ORG3 |         0         0         0         0         0         0 |
 36  ORG7 |     1.211     2.589     1.295         0         0     1.000 |
 37  ORG8 |         0         0         0         0         0         0 |
 28 ORG32 |         0         0         0         0         0         0 |
  8 ORG21 |         0         0         0         0         0         0 |
 30  ORG5 |         0         0     1.726     3.453         0     1.000 |
 38 ORG41 |         0         0         0         0         0         0 |
 39 ORG42 |         0         0         0         0         0         0 |
 40 ORG16 |         0         0         0         0         0         0 |
           -------------------------------------------------------------
 12 ORG25 |         0         0         0         0         0         0 |
 32 ORG35 |         0         0         0         0         0         0 |
 27 ORG31 |         0         0         0         0         0         0 |
 10  ORG1 |         0         0         0         0         0         0 |
 33  ORG6 |         0         0         0         0     4.667     1.000 |
           -------------------------------------------------------------
  6 ORG20 |         0         0         0         0         0         0 |
 35 ORG40 |         0         0         0         0         0         0 |
 34 ORG39 |         0         0         0         0         0         0 |
 11 ORG23 |         0         0         0         0         0         0 |
            ------------------------------------------------------------
```

Figure 6. Relative brokerage scores in the innovation network

Cluster actors	Coordinator	Gatekeeper	Representative	Consultant	Liaison
Large firms	0	0	0	**	*
SMEs	**	*	*	0	*
Research centers and universities	0	0	0	0	0
IFCs	0	0	0	0	0

Notes: ** = relative brokerage score is RBS > 1; * = relative brokerage score is 0 < RBS > = 1

Table IV. Brokerage roles in the technological knowledge network that in literature are considered as those cluster actors that through leadership, strategic view, activating networks and channeling resources contribute to the increased efficiency of a cluster (Waxell and Malmberg, 2007; Ketels and Memedovic, 2008) are completely excluded from any brokerage role in all three knowledge exchanges. Despite the key role attributed to IFCs in clusters and the increasing resources invested in IFCs worldwide (Ketels *et al.*, 2012), the literature on IFCs is scanty, with very little empirical research, no in-depth case studies and poor theorizing on the role of IFCs. Anecdotic evidence reports that competitive clusters do rely on IFCs as brokers of knowledge and network builders. Nevertheless, cluster literature lacks in-depth studies on this topic, and our findings may shed new light on their role, suggesting new research avenues.

Conclusions

Research contributions

The present study sheds light on a number of theoretical issues, given that it lays in the hotspot of research on clusters (Delgado *et al.*, 2014) and regional networks of innovation (Tödtling *et al.*, 2011) through the lenses of SNA (Ter Wal and Boschma, 2009).

Our findings confirm the multifaceted nature of innovation networks, stating that innovation-driven collaborations are the result of the exchange of multiple types of knowledge that are unevenly and selectively exchanged within a cluster. This result further confirms the recent debate about the fact that geographical proximity is not enough to allow collaborations and, hence, foster innovation among cluster actors (Boschma, 2005; Biggiero and Sammarra, 2010).

With respect to our first research question, the study shows that cluster actors exchange different types of knowledge in different ways in innovation networks. More precisely, the three types of knowledge considered (i.e. technological, market and managerial knowledge) are unevenly exchanged in the cluster. The exchange of technological knowledge is open to everyone in the cluster. The exchange of market and

Table V. Brokerage roles in the market knowledge network

Cluster actors	Coordinator	Gatekeeper	Representative	Consultant	Liaison
Large firms	0	0	0	**	*
SMEs	**	*	0	0	0
Research centers and universities	0	0	0	**	**
IFCs	0	0	0	0	0

Notes: ** = relative brokerage score is RBS > 1; * = relative brokerage score is 0 < RBS > = 1

Table VI. Brokerage roles in the managerial knowledge network

Cluster actors	Coordinator	Gatekeeper	Representative	Consultant	Liaison
Large firms	0	0	0	**	*
SMEs	*	*	**	*	0
Research centers and universities	0	0	0	0	*
IFCs	0	0	0	0	0

Notes: ** = relative brokerage score is RBS > 1; * = relative brokerage score is 0 < RBS > = 1 managerial knowledge is selective. These aspects confirm the heterogeneity of knowledge exchanges suggested in recent literature (Giuliani, 2007a, 2007b, 2007c). In line with the recent emphasis on organizational heteromorphism in clusters (Boschma and Fornahl, 2011; Ter Wal and Boschma, 2011), our study illuminates a variety of roles played by cluster actors in innovation-related knowledge exchanges *vis-à-vis* different types of knowledge.

With respect to our second research question, this study sheds new light on the different types of cluster actors (in our case, large firms, SMEs, research centers and universities and IFCs) with respect to the different roles they can play in innovation networks, especially with reference to the three types of knowledge considered in this study. Our brokerage analysis on the different knowledge networks reveals heterogeneous roles for the different categories of cluster actors. Our main contribution concerns the fact that each type of cluster actor do perform specific brokerage roles and that while technological and managerial knowledge are brokered only by firms (both large and SMEs with distinct brokerage roles), market knowledge is also brokered by universities and research centers. This is an unexpected and counter-intuitive result because one might expect technical and technological universities and research centers to master almost exclusively the brokerage of technological knowledge instead of market knowledge. Two possible interpretations apply to this regard:

(1) some of the cluster firms – given their high specialization or the large amounts of resources invested in R&D – could rely on a technological knowledge base more advanced than the one of universities; and

(2) those universities involved in innovation networks, despite their technical profile, are also active and well-known for their competencies in market analyses and scenarios.

Furthermore, IFCs do not seem to play any brokerage role with respect to all three types of knowledge. Again this constitutes a striking evidence, given the abundant debate among cluster managers, practitioners and academics on the crucial role IFCs are supposed to play in clusters in terms of fostering networks formation, managing and facilitating interactions and the sharing of knowledge, as well as in providing a cognitive framework for transforming information into useful knowledge (Sölvell and Williams, 2013; Ketels *et al.*, 2012). A possible interpretation of our findings,(Alberti *et al.* (2015)) is that IFCs are not directly involved in networks and, thus, in brokerage roles, but they do set proper cluster ecosystem conditions in terms of social capital, for other cluster actors to collaborate (Aragon *et al.*, 2012).

Policy and managerial implications

Our results have practical implications both for policy makers and for managers. First, our research stresses how innovation often originates from a combination of different knowledge types acquired through the collaboration with heterogeneous cluster actors. Hence, managers may design innovation strategies balancing their portfolio of collaborations to maximize the absorption of relevant knowledge. Consistently with other studies (Nieto and Santamaria, 2007; Tödtling *et al.*, 2009) our research remarks the importance of relying on network heterogeneity to sustain innovation. Firms are, therefore, called to simultaneously maintain collaboration with business partners, research centers and institutions.

Our study suggests that there are several possible interventions for policy makers at the cluster level too. Understanding the mechanisms sustaining knowledge transfer in the aerospace industry is fundamental, due to its capacity to generate spillovers and to its strategic nature (Ecorys, 2009; Giuri *et al.*, 2007), given that often technological developments in the aerospace industry are applicable to a plurality of industries, such as mining, transport engineering, textile and medical applications (Giuri *et al.*, 2007). Further, our analysis of brokerage roles in innovation-driven collaborations may help policy makers in designing programs for knowledge-transfer partnerships among the various actors of a cluster. Finally, there is also the clear need of the development of professional figures capable of operating at the interface of different knowledge domains.

Limitations and future research

The present paper has some limitations. First of all, the analysis focuses on just one cluster (one industry in one specific location); cross- and comparative analyses with other clusters may illuminate our findings better, eliminating industry and geographical biases. Second, the paper focuses only on innovation-related knowledge exchanges within the cluster and not across it. Both theory and empirical evidence acknowledge the AC of clusters from the outer environment, and knowledge flows and networks often cross cluster borders to reach global value chains (Morrison *et al.*, 2013; Eiriz *et al.*, 2013; Valdaliso *et al.*, 2011; Boschma and Ter Wal, 2007; Gugler and Brunner, 2007; Giuliani and Bell, 2005). Future studies may focus on innovation networks that cross cluster boundaries, following Morrison and Rabellotti (2009), deepening the differences in performances between companies located within and outside the cluster. Likewise, the role of gatekeeping – that has received large attention in literature with respect to clusters – in our analysis was limited to the brokerage of knowledge within the cluster and deserves further research on knowledge gatekeeping at the interface between local and global knowledge networks (Mitchell *et al.*, 2014; Munari *et al.*, 2012). Moreover, continuing on both sides of performances and roles, another possible stream of research is related to the higher productive or innovative returns of firms, if these can control a specific type of knowledge or position within a network (or within a regional cluster).

Despite these limitations, our data illuminate several aspects of how innovation takes place in a cluster, opening up intriguing aspects that have been overlooked by extant literature. We believe that this may trigger several lines of further research on the topic.

First of all, future studies may consider the multiplexity in knowledge networks (Gimeno and Woo, 1996) that occurs when two cluster actors collaborate in exchanging more than one knowledge type at a time. During interviews, our respondents insinuated the idea that in some collaborations, the transfer of technological knowledge acts as a platform to convey also market and managerial knowledge, thus suggesting the idea that different types of knowledge may be embedded one in the other or that the exchange of one type of knowledge may deliberately or unconsciously imply the exchange of other types of knowledge. This may also explain why technological knowledge is open to everyone in the cluster because it becomes a common platform/language to convey also other types of related knowledge.

Future research avenues may also discriminate among different types of SMEs that in our study were treated as a homogeneous body. The aerospace industry actually comprises a plurality of SMEs, ranging from medium-sized system integrators to micro hyper-specialized technology providers that vary a lot in their role in the global aerospace value chain as well as in their positioning in vertical and horizontal inter-organizational networks (Niosi and Zhegu, 2005; Giuri *et al.*, 2007; Ecorys, 2009).

Additionally, future paths of research on the topic may even consider other attributes of cluster actors (such as their international collaborations, their cluster seniority, their reputation, etc.) to better discriminate among them in knowledge exchanges. This may be coupled even with proximity data, embracing the approach initially suggested by Boschma (2005), according to which at least five dimensions of proximity (i.e. cognitive, organizational, social, institutional and geographical proximity) play a role in relation to innovation.

Likewise, future studies may also consider other categorizations of knowledge, besides technological, managerial and market knowledge (Amin and Cohendet, 2004); for example, industry-specific knowledge (i.e. idiosyncratic competencies that strictly refer to a specific sector), financial knowledge (i.e. access to finance and competencies on how to deal with financial players) and institutional knowledge (i.e. translation of historical data, traditions, values and norms).

Further, the results regarding the lack of involvement of IFCs in knowledge brokerage roles in the cluster deserve further investigations that on one side call for in-depth case studies to illuminate on their actual role in clusters competitiveness – as recently suggested by Alberti *et al.* (2015) – and on the other, account for their capability in strengthening a cluster social capital – as suggested by Aragon *et al.* (2012).

The relation between local and non-local ties is an other area of further research, and it is aimed at explaining whether:

- these are associated with performance and the development of networks over time; and
- there are significant differences in the type of knowledge exchanged between local and non-local network ties due to higher AC within regional clusters.

Finally, future research paths may lead to a longitudinal approach – and consequently longitudinal SNA techniques and methods – to the study of innovation-driven collaborations in clusters, accounting for the recent turn in cluster studies about their lifecycle (Menzel and Fornahl, 2010; Boschma and Fornahl, 2011; Elola *et al.*, 2012).

References

Alberti, F.G. (2006), "The decline of the industrial district of Como: recession, relocation or reconversion?", *Entrepreneurship and Regional Development*, Vol. 18 No. 6, pp. 473-501.

Alberti, F.G., Sciascia, S., Tripodi, C. and Visconti, F. (2008), *Entrepreneurial Growth in Industrial Districts. Four Italian Cases*, Edward Elgar, Cheltenham, UK/Northampton, MA.

Alberti, F.G., Giusti, J.D., Papa, F. and Pizzurno, E. (2014), "Competitiveness policies for medical tourism clusters: government initiatives in Thailand", *International Journal of Economic Policy in Emerging Economies*, Vol. 7 No. 3, pp. 281-309.

Alberti, F.G., Giusti, J.D. and Pizzurno, E. (2015), "The role of institutions for collaboration in setting a competitive cluster ecosystem: the case of the French Omega-3 cluster", *International Journal of Competitiveness*, Vol. 1, No. 1, Forthcoming.

Alberti, F.G. and Pizzurno, E. (2013), "Technology, innovation and performance in family firms", *International Journal of Entrepreneurship and Innovation Management*, Vol. 17 Nos 1/2/3, pp. 142-161.

Allen, T.A. and Stephen, J.C. (2013), "Innovation: a knowledge transfer perspective", *Production Planning & Control*, Vol. 24 Nos 2/3, pp. 208-225.

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

Aragon, C., Aranguren, M.J., Iturrioz, C. and Wilson, J.R. (2012), "A social capital approach for network policy learning: the case of an established cluster initiative", *European Urban and Regional Studies*, Vol. 21 No. 1, pp. 128-145.

Baptista, R. and Swann, P. (1998), "Do firms in clusters innovate more?", *International Journal of Industrial Organization*, Vol. 18 No. 3, pp. 515-535.

Bergman, E.M. (2009), "Embedding network analysis in spatial studies of innovation", *The Annals of Regional Science*, Vol. 43 No. 3, pp. 559-565.

Biggiero, L. (2002), "The location of multinationals in industrial districts: knowledge transfer in biomedicals", *Journal of Technology Transfer*, Vol. 27 No. 1, pp. 111-122.

Biggiero, L. and Sammarra, A. (2010), "Does geographical proximity enhance knowledge exchange? The case of the aerospace industrial cluster of centre Italy", *International Journal of Technology Transfer and Commercialisation*, Vol. 9 No. 4, pp. 283-305.

Borgatti, S.P., Everett, M.G. and Freeman, L.C. (2002), *Ucinet for Windows: Software for Social Network Analysis*, Analytic Technologies, Lexington.

Borgatti, S.P., Mehra, A., Brass, D.J. and Labianca, G. (2009), "Network analysis in the social sciences", *Science*, Vol. 323 No. 5916, pp. 892-895.

Boschma, R.A. (2005), "Proximity and innovation: a critical assessment", *Regional Studies*, Vol. 39 No. 1, pp. 61-74.

Boschma, R. and D. Fornahl (2011), "Cluster evolution and a roadmap for future research", *Regional Studies*, Vol. 45 No. 1, pp. 1295-1298.

Boschma, R.A. and Ter Wal, A.L.J. (2007), "Knowledge networks and innovative performance in an industrial district: the case of a footwear district in the south of Italy", *Industry and Innovation*, Vol. 14 No. 2, pp. 177-199.

Brenner, T. (2007), "Local knowledge resources and knowledge flows", *Industry and Innovation*, Vol. 14 No. 2, pp. 121-128.

Burt, R.S. (2005), *Brokerage and Closure: An Introduction to Social Capital*, Oxford University Press, Oxford.

Cantner, U., Meder, A. and Ter Wal, A.L.J. (2010), "Innovator networks and regional knowledge base", *Technovation*, Vol. 30 Nos 9/10, pp. 496-507.

Chiesa, V., Frattini, F., Gilardoni, E., Manzini, R. and Pizzurno, E. (2007), "Searching for factors influencing technological asset value", *European Journal of Innovation Management*, Vol. 10 No. 4, pp. 467-488.

Cohen, W.M. and Levinthal, D.A. (1990), "Absorptive capacity: a new perspective on learning and innovation", *Administrative Science Quarterly*, Vol. 35 No. 1, pp. 128-152.

Comitato Promotore del Distretto Aerospaziale Lombardo (2010), "Aerospaziale lombardo I numeri, le tecnologie, il posizionamento", paper presented at 1st Convention Distretto Aerospaziale Lombardo 22 January, Varese.

Cooke, P. and Ehret, O. (2009), "Proximity and procurement: a study of agglomeration in the Welsh aerospace industry", *European Planning Studies*, Vol. 17 No. 4, pp. 549-567.

Coulon, F. (2005), "The use of social network analysis in innovation research: literature review", paper presented DRUID Academy Winter 2005 PhD Conference, Aalborg, 18 May.

Delgado, M., Porter, M.E. and Stern, S. (2014), "Clusters, convergence, and economic performance", *Research Policy*, Vol. 43 No. 10, pp. 1785-1799.

Ecorys (2009), "Competitiveness of the EU aerospace industry: framework contract of sectoral competitiveness studies", available at: http://ec.europa.eu/enterprise/sectors/aerospace/files/aerospace_studies/aerospace_study_en.pdf (accessed 20 May 2013).

Eiriz, V., Barbosa, N. and Lima, V. (2013), "Differences of absorptive capacity between firms within a cluster", *Transformations in Business and Economics*, Vol. 12 No. 3, pp. 203-214.

Elola, A., Valdaliso, J.M., Aranguren, M.J. and López, S. (2012), "Cluster life cycles, path dependency and regional economic development: insights from a meta-study on basque clusters", *European Planning Studies*, Vol. 20, No. 2, pp. 257-279.

Elola, A., Valdaliso, J.M. and López, S. (2013), "The competitive position of the Basque aeroespatial cluster in global value chains: a historical analysis", *European Planning Studies*, Vol. 21 No. 7, pp. 1029-1045.

Esposito, E. (2004), "Strategic alliances and internationalisation in the aircraft manufacturing industry", *Technological Forecasting and Social Change*, Vol. 71 No. 5, pp. 443-468.

Esposito, E. and Raffa, L. (2006), "Evolution of the supply chain in the aircraft industry", *Proceedings of the IPSERA Conference, Archamps*.

Frank, O. (2005), "Network sampling and model fitting", in Carrington, P.J., Scott, J. and Wasserman, S. (Eds), *Models and Methods in Social Network Analysis*, Cambridge University Press, New York, NY, pp. 31-56.

Fritsch, M. and Kauffeld-Monz, M. (2010), "The impact of network structure on knowledge transfer: an application of social network analysis in the context of regional innovation networks", *The Annals of Regional Science*, Vol. 44 No. 1, pp. 21-38.

Gimeno, J. and Woo, C.Y. (1996), "Economic multiplexity: the structural embeddedness of cooperation in multiple relations of interdependence", in Baum, J.A.C. and Dutton, J.E. (Eds), *Advances in Strategic Management - The Embeddedness of Strategy*, JAI Pressm, Greenwich, CT, pp. 323-361.

Giuliani, E. (2007a), "Cluster absorptive capacity: why do some clusters forge ahead and others lag behind?", *European Urban and Regional Studies*, Vol. 12 No. 3, pp. 269-288.

Giuliani, E. (2007b), "The selective nature of knowledge networks in clusters: evidence from the wine industry", *Journal of Economic Geography*, Vol. 7 No. 2, pp. 139-168.

Giuliani, E. (2007c), "The selective nature of knowledge networks in clusters: evidence from the wine industry", *Journal of Economic Geography*, Vol. 7 No. 2, pp. 139-168.

Giuliani, E. and Bell, M. (2005), "The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster", *Research Policy*, Vol. 34 No. 1, pp. 47-68.

Giuri, P., Tomasi, C. and Dosi, G. (2007), *L'Industria Aerospaziale. Innovazione, Tecnologia E Strategia Economica*, Il Sole 24 Ore, Milano.

Gould, R.V. and Fernandez, R.M. (1989), "Structures of mediation: a formal approach to brokerage in transaction networks", *Sociological Methodology*, Vol. 19 No. 1, pp. 89-126.

Graf, H. (2011), "Gatekeepers in regional networks of innovators", *Cambridge Journal of Economics*, Vol. 35 No. 1, pp. 173-198.

Graf, H. and Henning, T. (2009), "Public research in regional networks of innovators: a comparative study of four East German regions", *Regional Studies*, Vol. 43, No. 10, pp. 1349-1368.

Grampa, A. (1994), *Busto Arsizio e la storia dell" aviazione*, Macchione Editore, Varese.

Grampa, A. (2002), *Agusta: Un secolo di aeronautica*, Macchione Editore, Varese.

Grampa, A. (2003), *Qui si vola*, Macchione Editore, Varese.

Gugler, P. and Brunner, S. (2007), "FDI effects on national competitiveness: a cluster approach", *International Advances in Economic Research*, Vol. 13 No. 3, pp. 268-284.

Hatzichronoglou, T. (1997), "Revision of the high-technology sector and product classification", working paper 1997/2, OECD Science, Technology and Industry Working Papers.

Hickie, D. (2006), "Knowledge and competitiveness in the aerospace industry: the cases of Toulouse, Seattle and North-West England", *European Planning Studies*, Vol. 14 No. 5, pp. 697-716.

Huggins, R. and Johnston, A. (2010), "Knowledge flow and inter-firm networks: the influence of network resources, spatial proximity and firm size", *Entrepreneurship and Regional Development*, Vol. 22 No. 5, pp. 457-484.

Huggins, R., Johnston, A. and Thompson, P. (2012), "Network capital, social capital and knowledge flow: how the nature of inter-organizational networks impacts on innovation", *Industry and Innovation*, Vol. 19 No. 3, pp. 203-232.

Jordan, J. and Lowe, J. (2004), "Protecting strategic knowledge: insights from collaborative agreements in the aerospace sector", *Technology Analysis and Strategic Management*, Vol. 16 No. 2, pp. 241-259.

Kauffeld-Monz, M. and Fritsch, M. (2010), "Who are the knowledge brokers in regional systems of innovation? A multi-actor network analysis" *Regional Studies*, Vol. 47 No. 5, pp. 669-685.

Keeble, D. and Wilkinson, F. (1999), "Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe", *Regional Studies*, Vol. 33 No. 4, pp. 295-303.

Kesidou, E. and Snijders, C. (2012), "External knowledge and innovation performance in clusters: empirical evidence from the Uruguay software cluster", *Industry and Innovation*, Vol. 19 No. 5, pp. 437-457.

Ketels, C.H.M. and Memedovic, O. (2008), "From clusters to cluster-based economic development", *International Journal of Technological Learning, Innovation and Development*, Vol. 1 No. 3, pp. 375-392.

Ketels, C.H.M., Lindqvist, G. and Solvell, O. (2012), "Strengthening clusters and competitiveness in Europe: the role of cluster organizations", available at: www.clusterobservatory.eu/system/modules/com.gridnine.opencms.modules.eco/providers/getpdf.jsp?uid=bef8b501-ec16-44ad-b7ec-42f3ad1f25ea (accessed 1 September 2013).

Kirkels, Y. and Duysters, G. (2010), "Brokerage in SME networks", *Research Policy*, Vol. 39 No. 3, pp. 375-385.

Krätke, S. (2010), "Regional knowledge networks: a network analysis approach to the interlinking of knowledge resources", *European Urban and Regional Studies*, Vol. 17 No. 1, pp. 83-97.

Krätke, S. and Brandt, A. (2009), "Knowledge networks as a regional development resource: a network analysis of the interlinks between scientific institutions and regional firms in the metropolitan region of Hanover, Germany", *European Planning Studies*, Vol. 17 No. 1, pp. 43-63.

Li, T. and Calantone, R.J. (1998), "The impact of market knowledge competence on new product advantage: conceptualization and empirical examination", *Journal of Marketing*, Vol. 62 No. 4, pp. 13-29.

Longhi, C. (2005), "A French revolution: technology management in the aerospace industry, the case of Toulouse", *International Journal of Technology Management*, Vol. 29 No. 3, pp. 194-215.

McAdam, R., O'Hare, T. and Moffett, S. (2008), "Collaborative knowledge sharing in composite new product development: an aerospace study", *Technovation*, Vol. 28 No. 5, pp. 245-256.

Marshall, A. (1921), *Industry and Trade*, Macmillan, London.

Maskell, P. (2005), "Towards a knowledge-based theory of the geographical cluster", in Breschi, S. and Malerba, F. (Eds), *Clusters, Networks, and Innovation*, Oxford University Press, New York, NY, pp. 411-432.

Maskell, P. and Malmberg, A. (1999), "Localised learning and industrial competitiveness", *Cambridge Journal of Economics*, Vol. 23 No. 2, pp. 167-185.

Meier-Comte, E. (2012), *Knowledge Transfer and Innovation for a Western Multinational Company in Chinese and Indian Technology Clusters*, Rainer Hampp Verlag, Mering.

Menzel, M. and Fornahl, D. (2010), "Cluster life cycles-dimensions and rationales of cluster evolution", *Industrial and Corporate Change*, Vol. 19 No. 1, pp. 205-238.

Mitchell, R., Boyle, B., Burgess, J. and McNeil, K. (2014), "You can't make good wine without a few beers: gatekeepers and knowledge flow in industrial districts", *Journal of Business Research*, Vol. 67 No. 10, pp. 2198-2206.

Molina-Morales, F.X. and Expósito-Langa, M. (2013), "Overcoming undesirable knowledge redundancy in territorial clusters", *Industry and Innovation*, Vol. 20 No. 8, pp. 739-758.

Morrison, A. (2008), "Gatekeepers of knowledge within industrial districts: who they are, how they interact", *Regional Studies*, Vol. 42 No. 6, pp. 817-835.

Morrison, A. and Rabellotti, R. (2009), "Knowledge and information networks in an Italian wine cluster", *European Planning Studies*, Vol. 17 No. 7, pp. 983-1006.

Morrison, A., Rabellotti, R. and Zirulia, L. (2013), "When do global pipelines enhance the diffusion of knowledge in clusters?", *Economic Geography*, Vol. 89 No. 1, pp. 77-96.

Munari, F., Sobrero, M. and Malipiero, A. (2012), "Absorptive capacity and localized spillovers: focal firms as technological gatekeepers in industrial districts". *Industrial and Corporate Change*, Vol. 21 No. 2, pp. 429-462.

Nieto, M.J. and Santamaria, L. (2007), "The importance of diverse collaborative networks for the novelty of product innovation", *Technovation*, Vol. 27 Nos 6/7, pp. 367-377.

Niosi, J. and Zhegu, M. (2005), "Aerospace clusters: local or global knowledge spillovers?", *Industry and Innovation*, Vol. 12 No. 1, pp. 5-29.

Parra-Requena, G., Ruiz-Ortega, M.J. and Garcia-Villaverde, P.M. (2013), "Social capital and effective innovation in industrial districts: dual effect of absorptive capacity", *Industry and Innovation*, Vol. 20 No. 2, pp. 157-179.

Patrucco, P.P. (2003), "Institutional variety, networking and knowledge exchange: communication and innovation in the case of the Brianza technological district", *Regional Studies*, Vol. 37 No. 2, pp. 159-172.

Pellegrini, L., Lazzarotti, V. and Pizzurno, E. (2012), "From outsourcing to Open Innovation: a case study in the oil industry", *International Journal of Technology Intelligence and Planning*, Vol. 8 No. 2, pp. 182-196.

Porter, M.E. (1990), *The Competitive Advantage of Nation*, Free Press, New York, NY.

Porter, M.E. (2008), *On Competition*, Harvard Business School Press, Boston.

Porter, M.E. (2010), "Microeconomics of competitiveness", Lecture given at the Faculty Workshop on 13 December, Harvard Business School, Cambridge, MA.

Porter, M.E. and Emmons, W. (2003), *Institutions for Collaboration: Overview*, Harvard Business School, Boston, case 9-703-436.

Prencipe, A. (2004), "The changing boundaries of the firm: empirical evidence from the aircraft engine industry", in Cantwell, J., Gambardella, A. and Granstrand, O. (Eds), *The Economics and Management of Technological Diversification*, Routledge, London and New York, pp. 234-261.

Reid, N., Smith, B.W. and Carroll, M.C. (2008), "Cluster regions: a social network perspective", *Economic Development Quarterly*, Vol. 22 No. 4, pp. 345-352.

Rodan, S. and Galunic, D. (2004), "More than network structure: how knowledge heterogeneity influences managerial performance and innovativeness", *Strategic Management Journal*, Vol. 25 No. 6, pp. 541-562.

Rose-Anderssen, C., Baldwin, J.S., Ridgway, K., Allen, P.M. and Varga, L. (2008), "Aerospace supply chains as evolutionary networks of activities: innovation via risk-sharing partnerships", *Creativity and Innovation Management*, Vol. 17 No. 4, pp. 304-318.

Sammarra, A. and Biggiero, L. (2008), "Heterogeneity and specificity of inter-firm knowledge flows in innovation networks", *Journal of Management Studies*, Vol. 45 No. 4, pp. 800-829.

Simonin, B.L. (1999), "Transfer of marketing know-how in international strategic alliances: an empirical investigation of the role and antecedents of knowledge ambiguity", *Journal of International Business Studies*, Vol. 30 No. 3, pp. 463-490.

Smith, D.J., Tranfield, D.R., Street, B. and Bedfordshire, M.K. (2005), "Talented suppliers? Strategic change and innovation in the UK aerospace industry", *R&D Management*, Vol. 35 No. 1, pp. 37-49.

Snijders, T.A.B. and Borgatti, S.P. (1999), "Non-Parametric standard errors and tests for network statistics", *Connections*, Vol. 22 No. 2, pp. 161-170.

Sölvell, Ö. and Williams, M. (2013), *Building the Cluster Commons – An Evaluation of 12 Cluster Organizations in Sweden 2005-2012*, Ivory Tower Publishers, Stockholm.

Sölvell, Ö., Lindqvist, G. and Ketels, C. (2003), *The Cluster Initiative Greenbook*, Bromma Tryck AB, Stockholm.

Sölvell, Ö., Ketels, C. and Lindqvist, G. (2008), "Industrial specialization and regional clusters in the ten new EU member states", *Competitiveness Review: An International Business Journal Incorporating Journal of Global Competitiveness*, Vol. 18 Nos 1/2, pp. 104-130.

Stacke, A.R.N.P., Hoffmann, V.E. and Costa, H.A. (2012), "Knowledge transfer among clustered firms: a study of Brazil", *Anatolia*, Vol. 23 No. 1, pp. 90-106.

Tallman, S., Jenkins, M., Henry, N. and Pinch, S. (2004), "Knowledge, clusters, and competitive advantage", *Academy of Management Review*, Vol. 29 No. 2, pp. 258-271.

Ter Wal, A.L.J. and Boschma, R.A. (2009), "Applying social network analysis in economic geography: framing some key analytic issues", *The Annals of Regional Science*, Vol. 43 No. 3, pp. 739-756.

Ter Wal, A.L.J. and Boschma, R.A. (2011), "Co-evolution of firms, industries and networks in space", *Regional Studies*, Vol. 45 No. 7, pp. 919-933.

Tödtling, F., Lehner, P. and Trippl, M. (2006), "Innovation in knowledge intensive industries: the nature and geography of knowledge links", *European Planning Studies*, Vol. 14 No. 8, pp. 1035-1058.

Tödtling, F., Lehner, P. and Kaufmann, A. (2009), "Do different types of innovation rely on specific kinds of knowledge interactions?", *Technovation*, Vol. 29 No. 1, pp. 59-71.

Tödtling, F., Lengauer, L. and Höglinger, C. (2011), "Knowledge sourcing and innovation in 'thick' and 'thin' regional innovation systems - comparing ICT firms in two Austrian regions", *European Planning Studies*, Vol. 19 No. 7, pp. 1245-1276.

Tödtling, F., Asheim, B. and Boschma, R. (2013), "Knowledge sourcing, innovation and constructing advantage in regions of Europe", *European Urban and Regional studies*, Vol. 20 No. 2, pp. 161-169.

Valdaliso, J.M., Elola, A., Aranguren, M.J. and Lopez, S. (2011), "Social capital, internationalization and absorptive capacity: the electronics and ICT cluster of the Basque Country", *Entrepreneurship and Regional Development*, Vol. 23 Nos 9/10, pp. 707-733.

Van der Valk, T. and Gijsbers, G. (2010), "The use of social network analysis in innovation studies: mapping actors and technologies", *Innovation: Management, Policy and Practice*, Vol. 12 No. 1, pp. 5-17.

van de Vijver, M. and Vos, B. (2007), "Improving competitive positioning in the aerospace industry: a case study of Dutch participation in the F-35 Lightning II (JSF), programme", *Defence and Peace Economics*, Vol. 18 No. 6, pp. 509-517.

Waxell, A. and Malmberg, A. (2007), "What is global and what is local in knowledge-generating interaction? The case of the biotech cluster in Uppsala", *Sweden, Entrepreneurship and Regional Development*, Vol. 19 No. 2, pp. 137-159.

Zhang, G., Xu, Q. and Liu, X. (2011), "Knowledge diffusion within the Datang sock-manufacturing cluster in China", *Regional Studies*, Vol. 45 No. 7, pp. 977-996.

Further reading

Alberti, F.G., Sciascia, S., Tripodi, C. and Visconti, F. (2011), "The entrepreneurial growth of firms located in clusters: a cross-case study", *International Journal of Technology Management*, Vol. 54 No. 1, pp. 53-79.

Broekel, T. and Boschma, R. (2011), "Aviation, space or aerospace? Exploring the knowledge networks of two industries in the Netherlands", *European Planning Studies*, Vol. 19 No. 7, pp. 1205-1227.

Broekel, T. and Boschma, R. (2012), "Knowledge networks in the Dutch aviation industry: the proximity paradox", *Journal of Economic Geography*, Vol. 12 No. 2, pp. 409-433.

CEI Piemonte (2009), "Settore aerospaziale", available at: www.centroestero.org (accessed 12 November 2013).

Giuliani, E. (2011), "Role of technological gatekeepers in the growth of industrial clusters: evidence from Chile", *Regional Studies*, Vol. 45 No. 10, pp. 1329-1348.

Corresponding author

Fernando G. Alberti can be contacted at: falberti@liuc.it

This article has been cited by:

1. Igor Etxabe, Jesús M. Valdaliso. 2016. Measuring structural social capital in a cluster policy network: insights from the Basque Country. *European Planning Studies* **24**:5, 884-903. [CrossRef]
2. Julian Kahl Department for Urban and Regional Economics, Ruhr University of Bochum, Bochum, Germany Christian Hundt Department for Urban and Regional Economics, Ruhr-University Bochum, Bochum, Germany . 2015. Employment performance in times of crisis. *Competitiveness Review* **25**:4, 371-391. [Abstract] [Full Text] [PDF]
3. Lucio BiggieroNetwork Analysis for Economics and Management Studies 1-60. [CrossRef]