Structure patterns in cluster knowledge networks: the case of the Spanish ceramic tile cluster

F. Xavier Molina-Morales · Luis Martínez-Cháfer

Published online: 27 March 2013

© International Network of Business and Management 2013

Abstract Clusters have received a great deal of attention in economic literature. The aim of this paper is to find out which type of firms feed these clusters with knowledge and what is the influence of their network capabilities on this matter. Questions are addressed using empirical evidence collected in the specific context of the Spanish ceramic tile cluster where its knowledge network is built through a sample of 166 companies. Individual firm data are then analyzed using a combination of network analysis and multivariant techniques. Overall results confirm the explanatory capacity of the selected factors highlighting the positive effects of external linkages, productive activities, and brokering activities on knowledge sourcing skills. Our study goes beyond simply acknowledging the importance and diffusion of knowledge in clusters. In fact, findings of the research question the simple and direct effect of physical proximity on firm knowledge acquisition and exploitation. These results have also implications on cluster policy promoting access to local knowledge networks. In fact, knowing the characteristics of the firms acting as sources of knowledge to feed the cluster may provide useful insights on how to design better services for potential users. We acknowledge the specificities of the analyzed industry and the urgent need for more empirical evidence covering different sectors to strengthen the robustness of the analysis. This should encourage future research along with themes like the role of local institutions and supporting organizations and the different types of cluster-internal networks.

Keywords Knowledge · Social networks · Clusters · Ceramic industry

F. X. Molina-Morales · L. Martínez-Cháfer (✉)
Universitat Jaume I, Castellón de la Plana, Castellón, Spain
e-mail: chafer@emp.uji.es

F. X. Molina-Morales
e-mail: molina@emp.uji.es

Introduction

Over the past two decades a great deal of attention has been devoted to firms and organizations located in the so-called territorial clusters. For several reasons and from different theoretical perspectives, these agglomerations have been seen as a model of local or regional development (Becattini 1990); a source of each individual firm's competitiveness (Porter 1990); or an ambit for policy action (Cooke 2001). Generally, it is argued that proximity and closeness facilitate acquisition, sharing, and exploitation of knowledge resources among firms and organizations in clusters (Spender 1998). These processes are particularly relevant, since a firm's value creation is in most cases a result of new knowledge resources or new combinations of them (Cohen and Levinthal 1990; Kogut and Zander 1992).

In order to analyze territorial clusters, authors have frequently used the metaphor of the network (Boschma and Ter Wal 2007; Branston et al. 2005; Parrilli and Sacchetti 2008). Networks can map and describe the actors in a cluster and the interactions that take place among them in an appropriate manner. In fact, the existing relational perspectives offer a comprehensive theoretical framework to understand the potential advantages as well as the restraints of clustered firms and organizations.

Previous research has focused on specific challenges, including proving the heterogeneous and asymmetric distribution of knowledge in a cluster (Dosi 1997; Giuliani 2007) or distinguishing between the categories of *information* and *knowledge* networks (Morrison and Rabelotti 2009). In fact, this perspective has generated some new and relevant research questions. Specifically, this study raises questions about the view that the diffusion of knowledge in clusters tends to be persistent among the different productive activities of the value system that the cluster is involved in. For instance, firms and organizations, which belong to different productive activities, that are, specialized in different phases of the production process form most clusters. Keeping that in mind, our paper addresses this specific question: which are the firms or organizations that are really feeding the entire cluster network with knowledge?

The study is based on individual firm data and uses a combination of network analysis and multivariate techniques. Questions are addressed using empirical evidence collected in the specific context of the Spanish ceramic tile cluster (see for instance, Molina-Morales and Martínez-Fernández 2009). The knowledge network of the Spanish ceramic tile cluster was built through a sample of 166 companies, to test the theoretical propositions.

We aim to contribute to the debate in the literature in several ways. Our study goes beyond simply acknowledging the importance and diffusion of knowledge in clusters. With respect to network studies, our results on the role of internal cluster networks do not coincide fully with the prevailing view. More generally, this new evidence contributes to the group of research studies that use social network analysis to investigate linkages among firms and the different actors in clusters (Boschma and Ter Wal 2007; Giuliani 2007; Morrison 2008; Sammarra and Biggiero 2008). Specifically, findings of the research must question the simple and direct effect of physical proximity on firm knowledge acquisition and exploitation.

Hence, findings must support a more recent contribution in this field (Giuliani and Bell 2005; Giuliani 2007; Morrison and Rabellotti 2009). In addition, such a large sample of firms as we have used allows the robustness of the analysis to be improved by avoiding the most common restraints of case studies or samples that are too small. Finally, other fields such as the innovation literature can also benefit from our findings.

The paper is structured as follows. First, we have presented the outlines, the conceptual framework, and the research questions. Then, we have explained the methodology applied in this research and the operationalization of concepts. Finally, we have discussed our conclusions and their potential implications.

Theoretical framework

Industrial clusters are usually identified as local production systems, which generate competitive products using similar organizational forms. Building on the huge body of literature on territorial clusters or industrial districts (Becattini 1990; Brusco 1982; Porter 1990), a cluster may be conceptualized as a geographically delimited area where the business structure is composed of locally owned enterprises that usually keep decisions within its boundaries.

Cluster and social capital

Many authors have considered the idea of social capital to be something that is inherently spatial (Martin 1994; Staber 2001). Although we agree that long-distance ties obviously exist, those which are informal in nature are produced within a short radius from home (Malecki 1995). In bounded geographical contexts, proximity among similar organizations favors diverse forms of social capital (McEvily and Zaheer 1999) and has been considered as a factor explaining the potential advantages of clustered firms (Cooke 2002; Trigilia 2001; Wolfe 2002). Research on social capital includes a great number of perspectives to be classified. Comprehensive reviews of research on social capital have considered it a multidimensional construct that yields distinctly different information and knowledge sources, and can contribute in many ways to the creation of new value for organization (e.g., Koka and Prescott 2002; Nahapiet and Ghoshal 1998; Tsai 2000; Tsai and Ghoshal 1998).

As outlined above, we have used the network as a metaphor to explain the relationships among firms and organizations in clusters. Previous literature has already supported the identification between the concept of cluster and network. The cluster can be defined as a network within a production context in a geographically defined area (Boschma and Ter Wal 2007; Branston et al. 2005; Parrilli and Sacchetti 2008). Contexts of geographical proximity such as those defined as industrial clusters (Inkpen and Tsang 2005; Porter 1998; Tallman et al. 2004) can be viewed as networks since many different actors are involved, including final product firms, suppliers, customers, service providers, local institutions, policy agents, and so on.

Through geographical proximity, common learning and knowledge flows among different actors become frequent phenomena. Thus, the local networks are viewed as vehicles of knowledge transfers and diffusion (Boschma and Ter Wal 2007). In these communities, the network of relationships among firms is typically characterized as a web of dense and overlapping ties which rapidly diffuses knowledge throughout the geographical cluster (McEvily and Zaheer 1999). In fact, a cluster may be identified as a dense and strong-tie network with intense, frequent, and close relationships between members (Cooke 2002; Trigilia 2001; Wolfe 2002).

Inside the cluster

In the case of industrial clusters, companies and institutions tend to be physically and cognitively close to each other. A recurrent argument suggests that this proximity favors better access to knowledge sources and it, therefore, represents an advantage for companies in their capacity to innovate (Capello 1999; Molina-Morales and Martínez-Fernández 2010; BarNir and Smith 2002; Darroch 2005; Goh 2002). In the same vein, it is frequently argued that clusters provide substantial benefits for the firms involved, because of the social capital that exists, for instance, in terms of flows of knowledge (Uzzi 1996).

The literature on territorial agglomerations has traditionally assumed that there is a high degree of internal homogeneity in these firms (Becattini 1979, 1990; Signorini 1994). As a result, knowledge is facilitated by geographical proximity and by the fact that the different actors in the cluster have common norms and values (Maskell 2001). According to this view, outsiders are excluded from the contacts that allow the free transmission of knowledge inside the cluster. In other words, a significant amount of knowledge resources are public inside the cluster, but are private with respect to the non-member external firms. Nevertheless, critical voices can be heard, arguing that they also have negative effects such as redundancy and obsolescence of the transmitted knowledge (Glasmeier 1991; Grabher 1993).

Moreover, some recent cluster literature seems to be abandoning these rather simplistic perspectives on the clustering effect on firms and has moved to a more realistic and complex consideration of these networks of organizations. According to McEvily and Zaheer (1999), companies can be integrated into the whole group of actors in the network in various ways, each with its own specific and distinctive opportunities and restrictions. In consequence, it can be argued that the development of particular social relations also provides different results for firms (Aharonson et al. 2008; Kautonen et al. 2010).

Furthermore, authors are increasingly in agreement with the idea that not all firms in a cluster are involved in local networks (Bathelt et al. 2004; Giuliani 2007; Ter Wal 2011). In consequence, being located in the cluster is not enough *per se* to gain access to the flows of knowledge. In fact, access to knowledge is usually restricted to subgroups within the network (Boschma and Ter Wal 2007; Giuliani and Bell 2005; Lissoni 2001; Malipiero et al. 2005).

Additionally, according to recent research (Breschi and Lissoni 2009; Nooteboom 1999; Parra-Requena et al. 2010) different kinds of proximity, other than just the geographical, exert an influence on knowledge diffusion. These authors have

conceptualized and proven that other dimensions of proximity (cognitive, social, or institutional) are not only relevant, but in some cases also have a more decisive effect on knowledge transmission than mere geographical proximity. As a result, it can be stated that knowledge spreads unevenly among the members of a local agglomeration of economic activities (Giuliani and Bell 2005). This unevenness is caused by the internal heterogeneity of the firms in the cluster, and also generates diverse consequences for the international networks.

Discussing the diversity of internal networks has represented a step forward in the research on clusters. In Giuliani (2007), findings showed that physical proximity allows the company to join a business network between the other firms in the clusters. The knowledge associated with innovation, however, is distributed in a selective and uneven manner. In the same vein, Morrison and Rabellotti (2009) studied the relationships between the characteristics of the firms and the structure of the knowledge network. Findings supported the idea that knowledge flows are restricted to a strongly closed group of local producers that are significantly different from the rest of the members of the cluster. In consequence, when it comes to exchanging, firms deliberately focus on and choose other organizations that offer better solutions to their problems, no matter whether they are located. In other words, in the local networks there may be firms which are not involved in the flows of knowledge, probably because they have nothing to offer the rest of the firms and neither do they have the capacity to absorb the external knowledge they could access. Moreover, Giuliani and Bell (2005) proved that firms can transfer knowledge asymmetrically, that is to say, knowledge exchange can occur even when reciprocity is not happening (Bouty 2000).

Research questions

For the purposes of this research the *knowledge network* is particularly relevant. This network is composed of all the actors that give or receive relevant knowledge related to the innovation processes within the cluster network (Giuliani 2007). We have tried to go further than previous research as we investigate in the causes and potential implications of the roles played by actors in the cluster knowledge network. Inside the network, actors can adopt different roles and positions. According to the balance in the number of ties that actors develop to receive or provide knowledge resources in the network, they can be classified as: (1) absorber: when an actor is a net absorber of knowledge, (2) source: when it is a net source of knowledge, (3) mutual exchanger: when an actor has the same number ties to receive and provide knowledge, and finally (4) isolated: actors that do not have any contact with other actors.

As is also well known, industrial clusters are made up of a set of firms and organizations that in most cases include companies specialized in the different phases of the production process. Unlike the case of large, vertically integrated firms, in clusters, auxiliary and related activities are carried out. Assuming the critical relevance of the net contributions to the knowledge network, we aim to shed light on which are the actors that fuel the network, that is, actors with net contributions, and how are they like. In order to do that, we have proposed that the

role depends on a number of factors like the degree of external openness of the actor, its intermediation capabilities, or the type of productive activity they develop in the cluster. Gaining knowledge about how the actors that behave as sources of the knowledge network are becomes a significant contribution that also has relevant implications for both individual actors and the whole cluster network.

Finally, going a step further to scrutinize the characteristics of these *sources* of knowledge, we are also interested in knowing if the size of the companies explains their capacity to offer knowledge resources to the entire cluster network.

Empirical setting

The research context

The empirical study is contextualized in the Spanish ceramic tile industry situated in the province of Castellón and more specifically in the districts of *la Plana Alta*, *la Plana Baixa*, and *L'Alcalaten*. Over 90 % of the Spanish output of ceramic floor tiles is manufactured in this area, which has a radius of only 20 km. Together with the firms, there is also a set of local institutions and supporting organizations that offer support and services to the whole cluster. These institutions include the local university, research institutes, policy agents, trade associations, and others. Previous research within the context of the cluster or district literature has already identified and analyzed the Spanish ceramic tile cluster. In seminal works in the Spanish context, Ybarra (1991) and more recently Boix and Galletto (2006) and Boix (2009) clearly identified this ceramic tile agglomeration as a case of Marshallian-type industrial cluster (district). Even Porter (1990) mentioned the existence of this Spanish ceramic tile concentration when describing international competitors of the Italian ceramic tile case. Moreover, Molina-Morales (2002) offered a comprehensive description of the whole process of creation of knowledge and innovation in this cluster. Finally, Molina-Morales et al. (2002) and Molina-Morales (2005) analyzed the role played by the specific local institutions in the transmission of knowledge in this cluster.

Data collection

This study is based on data collected from the Spanish ceramic tile cluster at firm level using questionnaires and interviews, which were carried out with firms' managers and engineers in charge of R&D activities or the production process. In view of the characteristics of the companies, we consider this profile as the most adequate to answer our questionnaire (see Table 1). The survey was carried out between February 2011 and July 2011 and was directed toward companies from a variety of cluster activities, that is, ceramic floor and wall tiles, decorative pieces, chemical additives, glazes and frits, machinery and equipment, and atomized clay producers. Table 2 reports how the sample of companies was distributed into the productive activities. The survey was directed toward a universe of 238 cluster companies. Finally, we collected a total of 166 completed questionnaires,

Table 1 Respondents' profile

Position	Number of interviewed	%
General manager	61	36
R&D director	48	29
Chief technical officer	41	25
Other staff members	16	10
Total	166	

Table 2 Sample distribution by cluster productive activities

Activities	Number of companies	%
Ceramic wall and floor tile producers	83	50.0
Glaze and frit producers	21	12.7
Machinery and equipment producers	36	21.7
Special and decorative ceramic pieces producers	16	9.6
Atomized clay producers	6	3.6
Chemical additives producers	4	2.4
Total	166	100

accounting for 69.75 % of the total number of firms. According to Stork and Richards (1992) network researchers often face similar response rates than the one we obtained (Albrecht 1984; Roberts and O'Reilly 1978, 1979; Dean Jr and Brass 1985; Moch 1980; Monge et al. 1983). In any case we ended up restricting our attention to the subset of individuals for whom network information is complete to avoid problems of representativity (Robins et al. 2004). This has been done after asking for approval to a panel of experts from different agents such as firms, research centers, trade associations, the local university, etc. The experts' clearance is based on the fact that the principal key players of the cluster are included in our sample.

Questionnaire questions

At this point we followed recent research on this specific topic (Giuliani 2007; Giuliani and Bell 2005). In particular, we used these previous references to name the constructs and indicators. However, we have obviously translated and adapted the writing to the specific context of our case.

Knowledge communication patterns

The relational data were collected through a roster recall method: each firm was presented with a complete list (roster) of the other firms in the cluster and they were asked the following questions:

Question 1 If you need technical advice or technical support, to which of the firms and organizations mentioned in the roster do you turn?^[1] [Please indicate the importance to the knowledge obtained in each case by marking the identified firms on the following scale: 0 = none; 1 = low; 2 = medium; and 3 = high].

Question 2 Which of the firms and organizations mentioned in the roster has benefited from your technical advice or technical support? [Please indicate the importance to the knowledge given in each case by marking the identified firms on the following scale: 0 = none; 1 = low; 2 = medium; and 3 = high].

These questions specifically address *problem solving and technical assistance*, since they are involved with producing improvements and change within the activity of a firm. We focus on local stocks of knowledge that are accessible to and absorbed by localized firms. We explained these questions very clearly to the respondents in order to distinguish technical support from the mere information exchanges which companies can obtain from many other conventional sources such as reviews, fairs, and so on. After collecting all the responses we encountered different points of view among interviewees in terms of relationships existence and their intensity. To configure the final network matrices the receiver opinion prevailed in cases of conflict. Finally, we have to remark that even though we asked the respondents to value their relationships we dichotomized all values above 0 in the final matrices as a requirement to calculate the specific network indicators that apply to the final regression analysis.

Empirical findings

The structure of the knowledge network

To conduct the analysis of the social networks we defined the *knowledge network*. This analysis begins with a graphic representation of the relationships among network actors. In this case we obtained a matrix of 166 rows by 166 columns, where the relationships that each actor claims to maintain with the rest of the actors are reported (Fig. 1). We have used the NetDraw module included in the software package UCINET (Borgatti et al. 2002).

The first graph represents a general view of the network. As was expected, a visual examination of the knowledge network shows different positioning of the actors in the cluster. The figure displays a concentration of actors in the central position of the network, surrounded by actors who occupy a more peripheral position in the network. It can also be seen how, in the external ring, there are some isolated actors who are not connected with others. On the other hand, in the same external ring of the graph, there are two actors who are only connected to each other.

¹ We added some blank spaces in order to capture relationships with relevant actors not suggested in the roster.

Fig. 1 The structure of the knowledge network (Color figure online)

In Fig. 2 we have represented the companies graphically and grouped them according to the productive activity they belong to. Actors are also classified according to their balance between indegree and outdegree linkages. The graph shows the density surrounding actors identified as sources of knowledge (depicted as lighter tones), which is greater than that of mutual exchangers (equal number of both types of ties) and very similar to the case of absorbers (firms that are net receivers of knowledge).

The next step was to individualize the knowledge network graphs by each of six cluster activities.

The graphs in Fig. 3 represent the knowledge network by each activity. The graphs display the net contribution of firms to the overall knowledge network and, more particularly, the pattern of the structure of each network. The visual representation of

Fig. 2 The classification of firms by activities and knowledge net contribution to the network

the comparison between structures makes it possible to observe, on the one hand, a similar pattern among networks but on the other, significant differences in terms of concentration properties. Particularly, atomized clay producers and chemical additives producers are not connected to each other, thus indicating that there is no direct collaboration between them and also that the atomized clay producers make a poor net contribution to the knowledge network.

Network structure indicators

Once we have visualized the structure of the knowledge network in the cluster graphically, we specifically analyze the network structure indicators. To do so, we computed the Centralization Index of Power and Betweenness, and the Heterogeneity Index.

- (1) *Centralization indexes*: To capture the centralization index, we computed the Centralization Index of Power (degree) and the Centralization Index of Betweenness. Both are complementary indexes to measure the centralization of the network structure (Wasserman and Faust 1994). These indicators express the degree of inequality or variance in the network as a percentage (Hanneman and Riddle 2001). Freeman 1978; Freeman et al. 1991 felt that it would be useful to express the degree of variability in the degrees of actors in our observed network as a percentage of that in a star network of the same size. Higher centralization (or concentration) of both indexes means that one actor is the leader of the communication network.
- (2) *Heterogeneity index*: To explore how knowledge is shared throughout the local network and whether there is a dominant actor, or group of actors, we computed the degree of variability (that is heterogeneity). The heterogeneity

Fig. 3 Individualized knowledge network of the cluster activities

index is equivalent to the coefficient of variation (standard deviation divided by the mean times 100). Higher variance implies higher inequality, that is, actors have different abilities to produce, acquire, and control flows of information and knowledge.

Tables 3 and 4 show a Network Centralization Index (Betweenness) of 8.990 % of its theoretical maximum. In addition, the Network Centralization Index of Power (Degree) is 39.02 and 20.71 % for the dichotomized and weighted networks, respectively. We can conclude that there is a moderate amount of concentration or centralization in this whole network. In other words, the cluster knowledge network is far from being a star-type network. That is, the power of individual actors varies rather substantially, and this means that, overall, positional advantages are rather unequally distributed in this network. Results for the network point to the presence of many actors acting as bridges in the knowledge network.

In addition, Tables 3 and 4 show that the network has a high degree of heterogeneity for both centralization indexes: 232.93 for betweenness and 108.45–110.45 for power

Table 3 Network centralization index of betweenness

Indicator/index	Value
Network centralization index (betweenness)	8.990 %
Mean	145.988
Std. Dev.	340.057
Heterogeneity	232.93

Table 4 Network centralization index of power (degree)

Symmetrized and dichotomized network	
Network centralization	39.02 %
Heterogeneity	108.45
Symmetrized and weighted network	
Network centralization	20.71 %
Heterogeneity	110.45

or degree. This implies that actors have different abilities with respect to the knowledge network.

Finally, a very interesting comparison between productive activities in the cluster is shown in Table 5. It must be noted that only the ceramic glaze and frit producers reach a concentration mean around the overall mean (145.98). The rest of the activities show much lower values. Particularly the mean of the special and decorative ceramic pieces producers is low. Findings confirm a very poor concentration and in consequence a very “equal” network of actors for most of the activities.

Individual network indicators

In order to gain a better understanding of the knowledge network in the cluster, we ran a second round of analyses. So far we have analyzed what the knowledge network is like and which firms act as the sources of knowledge. Now, we would like to know the factors explaining which firms are the sources of cluster

Table 5 Network centralization index of betweenness by activities

Productive activity	Mean of the centralization index of betweenness
Glaze and frit producers	145.99
Wall and floor tile producers	83.54
Machinery and equipment producers	132.53
Special and decorative ceramic pieces producers	10.62
Atomized clay producers	124.35
Chemical additive producers	94.26

knowledge. Statistics and network algorithms were used to measure different dimensions of the firms in the cluster.

- (1) *External Openness*: The questionnaire asked about the firms' acquisition of knowledge from sources outside the cluster, both at the national and international level. Specifically, respondents were shown a roster of possible extra-cluster sources of knowledge (universities, technological centers, other groups of firms, customers, suppliers, consultants, public research centers, research institutes, etc.) and asked to name the ones that had contributed to the technical enhancement of firms. More specifically the following question was formulated:

Question 3 Could you indicate or mark among these sources of knowledge, those that have transferred technical knowledge or have collaborated with your firm? [Please indicate the geographical location of the source of knowledge in each case by marking the identified firms on the following scale: 1 = Local; 2 = National; 3 = European; and 4 = Other Countries].

In order to obtain the final measure we summarize the number of times the respondent marked a relationship with the specified sources of knowledge in an international context (Europe or Other Countries).

- (2) *Net Contribution*: This indicator measures the ratio between the knowledge transferred (*Outdegree*) and received (*Indegree*) by each firm. Thus, four categories can be found:
 - **ABSORBER**: If $O/I < 1$, the firm is a net absorber of knowledge.
 - **SOURCE**: If $O/I > 1$, the firm is a net source of knowledge.
 - **MUTUAL EXCHANGER**: If O/I is about 1, the firm engages in the mutual exchange of knowledge.
 - **ISOLATED**: Firms with both *Outdegree* and *Indegree* centralities close to 0.
- (3) *Betweenness*: Actor betweenness centrality is a measure of centrality that considers the position of nodes in between the geodesic (that is the shortest path) that links with any other node in the network.

Let g_{jk} be the proportion of all geodesics linking node j and node k which pass through node i , and the betweenness of node i is the sum of all g_{jk} , where i, j , and k are distinct. $CB(ni) = \sum_{j < k} g_{jk}(ni)/g_{jk}$. This index has a minimum of zero when ni falls on no geodesics and a maximum that is $(g-1)(g-2)$ (g = total nodes in the network), which is the number of pairs of nodes not including ni .

Betweenness centrality can be regarded as an indicator of the control that one actor has over the flow of information between others (Newman 2005). In this line some authors have considered the betweenness centrality as an indicator of power (Brass 1984; Freeman 1978). Thus, we consider that an actor with an intermediary position can manage a greater amount of more diverse knowledge and has higher potential to act as a source of knowledge for the network in the cluster.

Productive specialization

As we have proven in the previous analysis, knowledge networks of the productive activities in the cluster present significant differences in terms of their capacity to be sources of knowledge to the entire cluster network. We have included the productive activity as a set of dummy variables in order to explain the sourcing capacity of the firm (Table 6).

Size

Size was operationalized by running a factor analysis of the following items: (1) number of employees, (2) total assets, and (3) total revenues for the last year. We can assume that greater organizations have more capacity to acquire and generate knowledge resources, and consequently can offer more knowledge to the rest of the actors in the network.

Overall results of the analysis confirm the explanatory capacity of the selected factors, since the *Adjusted R*² was 0.442. At first glance, size shows no significant correlation with the net contribution. Second, the results of the regression analysis supported the claim that firms with higher betweenness (power) can act as knowledge brokers and have more capacity to feed the cluster knowledge network. Third, as we have observed in the previous section, the productive activity is also an important factor explaining the actors' potential for being a source of knowledge. The regression leaves out the tile producer activity so the results have to be analyzed in comparative terms. In this case we observe how being a chemical additive producer is important to become a net contributor in comparison to the tile producing activity. In the same line, Machinery and Glaze and Frits activities are also significant. Finally, external openness is not a significant variable. Firms with more external linkages were expected to have diverse sources of knowledge, and thus provide the cluster with new ideas, technologies, and so on. However, the results show no evidence of that behavior. We believe that, in this case, the dummy

Table 6 Regression analysis for the net contribution

	Net contribution
Constant	−0.427 (0.086)***
Size	0.005 (0.075)
External openness	0.033 (0.079)
Betweenness	0.262 (0.069)***
Glaze and frits	0.798 (0.217)***
Machinery	0.859 (0.169)***
Special pieces	0.377 (0.202)*
Atomization	0.679 (0.310)**
Chemical additives	2.923 (0.399)***
Non-standard coefficients	<i>F</i> 16.559***
(errors in parentheses)	<i>R</i> ² 0.471
<i>N</i> = 166; *** <i>p</i> < 0.01;	Adjusted <i>R</i> ² 0.442
** <i>p</i> < 0.05; * <i>p</i> < 0.1	

Table 7 ANOVA test for the average external openness

	Average external openness
Tile manufacturers	0.600
Glaze and frits	3.579
Machinery	0.694
Special pieces	0.188
Atomization	0.833
Chemical additives	3.500
<i>F</i>	11.530***

$N = 166$; *** $p < 0.01$;

** $p < 0.05$; * $p < 0.1$

variables are shadowing the effect of the external openness variable given the fact that some activities like Glaze and Frits and Chemical Additives tend to have more international relationships. In order to prove this we run an ANOVA test whose results are shown in Table 7.

The ANOVA results confirm higher external openness values for both Chemical additives and Glaze and Frits activities. Thus, we believe that this is the main reason why external openness is a non-significant variable on the regression. This is also confirmed by a correlation test that gives significant values to the correlations between external openness and some of the activities like Glaze and Frits (Pearson coefficient = 0.476***), chemical additives (Pearson coefficient = 0.195**), and tile manufacturers (Pearson coefficient = -0.227^{**}).

Conclusions

Although many scholars have recently suggested that contacts are relevant and effective channels for sharing knowledge in clusters, few empirical studies can be found. This study has provided detailed and convincing results, and contributes by offering empirical firm-level evidence about contacts in the Spanish ceramic tile cluster in order to understand the structural characteristics of the knowledge network. Additionally, it also shows how the firm-level characteristics, such as extra-cluster linkages and power characteristics, may affect their structural position in the knowledge network.

In the case of the ceramic tile cluster, findings from our analysis question the extent to which clustering *per se* influences the knowledge processes of the firms. In fact, clustered firms showed a wide range of different communication alternatives. First, as we have focused on firms providing knowledge in the clusters, we can conclude that sources of knowledge are determined to some extent by the type of productive activity of the firms. Particularly, activities like chemical additives, frit and glazes, and machinery are the most relevant providers of knowledge in the cluster. A first interpretation of this result confirms the identification of the ceramic cluster as a *supplier-dominated* case, as proposed by Pavitt (1984). This category of industry corresponds to the traditional sectors where the suppliers determine the sources and directions of technical change. However, as we understand it, this does not mean that other activities along the value chain do not undergo knowledge and

innovation processes. Since we have focused on technological knowledge and innovation, we cannot detect market or non-technological innovation. According to the interviews carried out, this may be the case of end-product firms (ceramic wall and floor tile producers).

In ceramic tile industry, differences in indicators are not so relevant. The network cannot be considered as a centralized one. In contrast to what may happen in other cases, in the ceramic tile cluster, internal differences are still not so significant. This point is important to avoid problematic asymmetries among actors in the network. Moreover, the individualized analysis of the different productive activity networks confirms that some of them follow similar patterns, but others are only partially involved in the cluster, suggesting a poorly centralized network.

In the current case of the ceramic cluster, a wide range of relational patterns can be observed. In some cases, knowledge links with other organizations ran strongly outside the cluster boundaries, and a substantial number of other firms were almost totally isolated within the cluster or outside it. Spatial clustering is not the only factor to be considered on the knowledge networks of firms. Ceramic cluster firms showed a broad variety of communication and learning behaviors. Factors related to the capacity to act as sources of knowledge depend on a number of individual firm factors, such as external openness, power or betweenness, and productive specialization or position in the value system. This series of factors offer a comprehensive model to gain a better understanding of the relational patterns of clustered firms and the actual role of the spatial clustering.

Our research findings are in agreement with a recently increasing body of literature in which it has been shown that knowledge is unevenly distributed in clusters (Dahl and Pedersen 2004; Giuliani 2007; Giuliani and Bell 2005; Lissoni and Pagani 2003; Morrison 2008). Keeping our findings in mind can help us to avoid conducting a biased analysis and giving the wrong impression about implications for policy. In particular, cluster policy promoting access to local knowledge network should take into account the existence of specific productive activities and value system phases, and eventually select them as a policy target rather than the geographical cluster as a whole. Moreover, knowing the characteristics of the firms acting as sources of knowledge to feed the cluster may provide useful insights on how to design better services for potential users.

Limitations

This study presents a number of limitations. The empirical analysis is based on a single industry: ceramic tiles. We acknowledge that specificities of the analyzed case can produce biased results and concerns may be raised about the potential universality of the conclusions. However, it should be highlighted that the empirical study was drawn from a large sample, thereby overcoming the limitations of a small number of firms. We realize that operating with such a large sample makes it difficult to collect unique and complete relational data. In order to strengthen the robustness of our conclusions, there is an urgent need for more empirical evidence from case studies covering different sectors and geographical areas. Although the operationalization of complex concepts into observable and measurable indicators

necessarily requires simplification, probably the most important limitation concerns the need for a richer conceptualization in order to gain a deeper understanding of the process of knowledge creation and diffusion. In conclusion, we hope these limitations will encourage further research on this topic.

Future research

To conclude, we suggest that some issues that have been dealt with only marginally in this study deserve more attention in the literature. Further research should explore themes like the role of local institutions and supporting organizations, given that network analyses in clusters have so far been focused mainly on firms, while less is known about the structural characteristics of these supporting actors. Another interesting question to be addressed is related to the different types of cluster-internal networks, in line with recent studies (Morrison and Rabellotti 2009). Finally, the dynamics of the networks remains almost unexplored; hence, an effort to collect longitudinal data on inter-firm collaboration within clusters would be a very welcome contribution.

Acknowledgments This research was financially supported by the Spanish Ministerio de Economía y Competitividad, Plan Nacional de I+D+i, Research Project Number ECO2012-32663.

References

- Aharonson, B. S., Baum, J. A. C., & Plunket, A. (2008). Inventive and uninventive clusters: The case of Canadian biotechnology. *Research Policy*, 37(6–7), 1108–1131.
- Albrecht, T. L. (1984). Managerial communication and work perception. In R. Bostrom (Ed.), *Communication yearbook 8* (pp. 538–552). Beverly Hills: Sage.
- BarNir, A., & Smith, K. A. (2002). Interfirm alliances in the small business: The role of social networks. *Journal of Small Business Management*, 40(3), 219–232.
- Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, 28, 31–56.
- Becattini, G. (1979). Dal settore industriale al distretto industriale. *Rivista di Economia e Politica Industriale*, 1, 1–8.
- Becattini, G. (1990). The marshallian industrial district as a socio-economic notion. In en Pyke, F., Becattini, G. y Sengenberger, W. (Eds.), *Industrial districts and local economic regeneration*. Ginebra: International Institute for Labor Studies.
- Boix, R. (2009). The empirical evidence of industrial districts in Spain. In G. Becattini, M. Bellandi, & L. De Propris (Eds.), *A handbook of industrial districts*. Cheltenham: Edward Elgar.
- Boix, R., & Galletto, V. (2006). El nuevo mapa de los distritos industriales de España y su comparación con Italia y el Reino Unido. Documento de trabajo 06.04. Departament d'Economia Aplicada. Universitat Autònoma de Barcelona.
- Borgatti, S. P., Everett, M., & Freeman, L. (2002). *Ucinet for windows: Software for social network analysis*. Harvard: Analytic Technologies.
- Boschma, R. A., & Ter Wal, A. L. J. (2007). Knowledge networks and innovative performance in an industrial district. *Industry and Innovation*, 14(2), 177–199.
- Bouty, I. (2000). Interpersonal and interaction influences on informal resource exchanges between R&D researchers across organizational boundaries. *Academy of Management Journal*, 43(1), 50–66.
- Branston, J. R., Rubini, L., Sugden, R., & Wilson, J. R. (2005). Healthy governance: economic policy and the health industry model. In M. R. Di Tommaso & S. O. Schweitzer (Eds.), *Promoting high-tech industries. Can growth lead the way* (pp. 45–58). Cheltenham: Edward Elgar.
- Brass, D. J. (1984). Being in the right place: A structural analysis of individual influence in an organization. *Administrative Science Quarterly*, 29(4), 518–539.

- Breschi, S., & Lissoni, F. (2009). Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows. *Journal of Economic Geography*, 9(4), 439.
- Brusco, S. (1982). The Emilian Model: productive decentralisation and social integration. *Cambridge Journal of Economics*, 6, 167–184.
- Capello, R. (1999). Spatial transfer of knowledge in high technology milieux: Learning versus collective learning processes. *Regional Studies*, 33(4), 353–365.
- Cohen, W., & Levinthal, D. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128–152.
- Cooke, P. (2001). Sistemas de innovación regional: conceptos, análisis y tipología. In M. Olazarán & M. Gómez (Eds.), *Sistemas regionales de innovación* (pp. 73–91). Bilbao: Universidad del País Vasco.
- Cooke, P. (2002). *Knowledge economies: Clusters, learning and cooperative advantage*. London: Routledge.
- Dahl, M. S., & Pedersen, C. O. R. (2004). Knowledge flows through informal contacts in industrial clusters: Myth or reality? *Research Policy*, 33(10), 1673–1686.
- Darroch, J. (2005). Knowledge management, innovation and firm performance. *Journal of Knowledge Management*, 9(3), 101–115.
- Dean, J. W. Jr, & Brass, D. J. (1985). Social interaction and the perception of job characteristics in an organization. *Human Relations*, 38(6), 571–582.
- Dosi, G. (1997). Opportunities, incentives and the collective patterns of technological change. *The Economic Journal*, 107(444), 1530–1547.
- Freeman, L. C. (1978). Centrality in social networks conceptual clarification. *Social Networks*, 1(3), 215–239. doi:[10.1016/0378-8733\(78\)90021-7](https://doi.org/10.1016/0378-8733(78)90021-7).
- Freeman, L. C., Borgatti, S. P., & White, D. R. (1991). Centrality in valued graphs: A measure of betweenness based on network flow. *Social Networks*, 13(2), 141–154. doi:[10.1016/0378-8733\(91\)90017-N](https://doi.org/10.1016/0378-8733(91)90017-N).
- Giuliani, E. (2007). The selective nature of knowledge networks in clusters: Evidence from the wine industry. *Journal of Economic Geography*, 7, 139–168.
- Giuliani, E., & Bell, M. (2005). The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. *Research Policy*, 34, 47–68.
- Glassemeier, A. (1991). Technological discontinuities and flexible production networks: The case of Switzerland and the world watch industry. *Research Policy*, 20, 469–485.
- Goh, S. C. (2002). Managing effective knowledge transfer: an integrative framework and some practice implications. *Journal of Knowledge Management*, 6(1), 23–30.
- Grabher, G. (1993). The weakness of strong ties: The lock-in of regional development in the ruhr area. In G. Grabher (Ed.), *The embedded firm: On the socioeconomics of industrial networks*. Londres: Routledge.
- Hanneman, R. A., & Riddle, M. (2001). *Social network analysis*. Riverside: University of California.
- Inkpen, A. C., & Tsang, E. W. K. (2005). Social capital, networks, and knowledge transfer. *The Academy of Management Review*, 30, 146–165.
- Kautonen, T., Zolin, R., Kuckertz, A., & Viljamaa, A. (2010). Ties that blind? How strong ties affect small business owner-managers' perceived trustworthiness of their advisors. *Entrepreneurship and Regional Development*, 22(2), 189–209.
- Kogut, B., & Zander, I. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, 3(3), 383–397.
- Koka, B. R., & Prescott, J. E. (2002). Strategic alliances as social capital: A multidimensional view. *Strategic Management Journal*, 23(9), 795–816.
- Lissoni, F. (2001). Knowledge codification and the geography of innovation: the case of Brescia mechanical cluster. *Research Policy*, 30(9), 1479–1500.
- Lissoni, F., & Pagani, M. (2003). How many networks in a local cluster? Textile machine production and innovation in Brescia. In T. Brenner & D. Fornahl (Eds.), *Cooperation, networks, and institutions in regional innovation systems* (pp. 220–246). Cheltenham: Edward Elgar.
- Malecki, E. (1995). Culture as mediator of global and local forces. In B. Van der Knaap & R. Le Heron (Eds.), *Human resources and industrial spaces: A perspective on globalization and localization* (pp. 105–127). Chichester: John Wiley & Sons.
- Malipiero, A., Munari, F., & Sobrero, M. (2005). Focal firms as technological gatekeepers within industrial districts: Evidence from the packaging machinery industry. In Contribución presentada en la 2005 DRUID Winter Conference, Skorpung (Dinamarca).

- Martin, R. (1994). Economic theory and human geography. In D. Gregory, R. Martin, & G. Smith (Eds.), *Human geography: Society, space and social science* (pp. 21–53). Minneapolis: University of Minnesota Press.
- Maskell, P. (2001). Knowledge creation and diffusion in geographic clusters. *International Journal of Innovation Management*, 5(2), 213–237.
- McEvily, B., & Zaheer, A. (1999). Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal*, 20(12), 1133–1156.
- Moch, M. K. (1980). Job involvement, internal motivation, and employees' integration into networks of work relationships. *Organizational Behavior and Human Performance*, 25(1), 15–31.
- Molina-Morales, F. X. (2002). Industrial districts and innovation: the case of the Spanish ceramic tiles industry. *Entrepreneurship & Regional Development*, 14(4), 317–335.
- Molina-Morales, F. X. (2005). The territorial agglomerations of firms: A social capital perspective from the Spanish tile industry. *Growth and Change*, 36(1), 74–99.
- Molina-Morales, F. X., & Martínez-Fernández, M. T. (2009). Too much love in the neighborhood can hurt: how an excess of intensity and trust in relationships may produce negative effects on firms. *Strategic Management Journal*, 30(9), 1013–1023.
- Molina-Morales, F. X., & Martínez-Fernández, M. T. (2010). Social networks: Effects of social capital on firm innovation. *Journal of Small Business Management*, 48(2), 258–279.
- Molina-Morales, F. X., López-Navarro, M. A., & Guia-Julve, J. (2002). The role of local institutions as intermediary agents in the industrial district. *European urban and regional studies*, 9(4), 315–329.
- Monge, P. R., Edwards, J. A., & Kirste, K. K. (1983). Determinants of communication network involvement: Connectedness and integration. *Group & Organization Management*, 8(1), 83–111.
- Morrison, A. (2008). 'Gatekeepers of knowledge' within industrial districts: Who they are, how they interact. *Regional Studies*, 42(6), 817–835.
- Morrison, A., & Rabbellotti, R. (2009). Knowledge and information networks in an Italian wine cluster. *European Planning Studies*, 17(7), 983–1006.
- Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*, 23(2), 242–266.
- Newman, M. E. (2005). A measure of betweenness centrality based on random walks. *Social Networks*, 27(1), 39–54.
- Nooteboom, B. (1999). Innovation, learning and industrial organisation. *Cambridge Journal of Economics*, 23(2), 127–150.
- Parra-Requena, G., Molina-Morales, F. X., & García-Villaverde, P. M. (2010). The mediating effect of cognitive social capital on knowledge acquisition in clustered firms. *Growth and Change*, 41, 59–84.
- Parrilli, M. D., & Sacchetti, S. (2008). Linking learning with governance in networks and clusters: key issues for analysis and policy. *Entrepreneurship & Regional Development*, 20(4), 387–408.
- Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, 13(6), 343–373.
- Porter, M. E. (1990). *The competitive advantage of nations*. New York: Free Press.
- Porter, M. E. (1998). *On competition (The Harvard business review book series)*. Boston: Harvard Business School Publishing.
- Roberts, K. H., & O'Reilly, C. A. (1978). Organizations as communication structures: an empirical approach. *Human Communication Research*, 4(4), 283–293.
- Roberts, K. H., & O'Reilly, C. A. (1979). Some correlations of communication roles in organizations. *Academy of Management Journal*, 22(1), 42–57.
- Robins, G., Pattison, P., & Woolcock, J. (2004). Missing data in networks: exponential random graph (p^*) models for networks with non-respondents. *Social Networks*, 26(3), 257–283.
- Sammara, A., & Biggiero, L. (2008). Heterogeneity and specificity of inter-firm knowledge flows in innovation networks. *Journal of Management Studies*, 45(4), 800–829.
- Signorini, L. F. (1994). The price of prato, or measuring the ID effect. *Papers in Regional Science*, 73, 369–392.
- Spender, J. C. (1998). The geographies of strategic competence: Borrowing from social and educational psychology to sketch and activity and Knowledge-Based Theory of the Firm. In A. D. Chandler Jr., P. Hagström, & Ö. Sölvell (Eds.), *The dynamic firm. The role of technology, strategy, organization, and regions*. New York: Oxford University Press.
- Staber, U. (2001). The structure of networks in industrial districts. *International Journal of Urban and Regional Research*, 25(3), 537–552.

- Stork, D., & Richards, W. D. (1992). Nonrespondents in communication network studies: Problems and possibilities. *Group & Organization Management*, 17(2), 193–209.
- Tallman, S., Jenkins, M., Henry, N., & Pinch, S. (2004). Knowledge, clusters, and competitive advantage. *The Academy of Management Review*, 29, 258–271.
- Ter Wal, A. L. J. (2011). Cluster emergence and network evolution: A longitudinal analysis of the inventor network in Sophia-Antipolis. *Regional Studies*, 45(7), 919–933.
- Triglia, C. (2001). Social capital and local development. *European Journal of Social Theory*, 4(4), 427–442.
- Tsai, W. (2000). Social capital, strategic relatedness and the formation of interorganizational linkages. *Strategic Management Journal*, 21(9), 925–939.
- Tsai, W., & Ghoshal, S. (1998). Social capital and value creation: The role of intrafirm networks. *Academy of Management Journal*, 41(4), 464–478.
- Uzzi, B. (1996). The sources and consequences of embeddedness for economic performance of organizations: the network effect. *American Sociological Review*, 61, 674–698.
- Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications*. Cambridge: Cambridge University Press.
- Wolfe, D. (2002). Social capital and cluster development in learning regions. In J. A. Holbrook & D. Wolfe (Eds.), *Knowledge, clusters and regional innovation: economic development in Canada* (pp. 11–38). Kingston: Queen's School of Policy Studies and McGill-Queen's University Press.
- Ybarra, J. A. (1991). Determinación cuantitativa de distritos industriales: la experiencia del País Valenciano. *Estudios Territoriales*, 37, 53–67.