The different roles of proximity in multilevel networks. Evidence from the cluster of High Technology applied to Cultural Goods in Tuscany

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Keywords: proximity, cluster, informal ties, Exponential Random Graph Models (ERGM)

JEL: D85, L14, L84

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1 We express our gratitude to Dr. Renzo Salimbeni, former Director of the IFAC-CNR, and Dr. Salvatore Siano of the IFAC-CNR, for providing the list of firms connected to IFAC-CNR operating in technological restoration. We are also grateful to POLIS, the management organisation of the Technological District of Cultural Goods, specifically Prof Marco Bellandi for providing the list of firms adhering to the district. Many thanks to Amir Maghsudipour for data collection.
1. Introduction

The role of proximity in enabling the transmission of knowledge in innovation and inter-organisational networks has recently received increasing attention in management (Ritter and Gemunden, 2003a; 2003b; Knoben and Oerlemans, 2006; Presutti et al., 2013; Molina-Morales et al., 2014; 2015), organisational studies (Oerlemans and Meeus, 2005) and urban and regional studies (Kirat and Lung, 1999; Huber, 2012).

This stream of research has been mainly influenced from Boshma’s (2005) seminal article in Evolutionary Economic Geography studies, which enlarges the concept of geographical proximity by considering cognitive, institutional, organisational and social dimensions (Boschma and Frenken, 2010; Ter Wal, 2014).

Geographical proximity remains the most studied typology. Although stemmed from Economic Geography studies, the concept has taken a multidisciplinary turn in literature. In particular, management studies have commonly recognised how the concentration of firms, specialized sub-suppliers, research centres and universities in specific areas facilitate knowledge diffusion (Bathelt et al., 2004) and so-called ‘knowledge spill-overs’ (Audretsch and Feldman, 1996; Breschi and Lissoni, 2001), thus promoting collaboration among local actors and the development of organisation networks (Asheim and Isaksen, 2002; Sedita and Belussi, 2012). Although utilised in various disciplines and well-established in the literature, with the growing globalisation and “virtualisation” of relationships among firms, the role of geographical proximity has been the object of substantial criticisms, which often emphasise the overestimation of its capacity for collaboration and network development (Fitjar and Rodriguez Pose, 2016). Some of this contributions criticise the metaphor of the Marshallian industrial ‘atmosphere’ of business interaction and knowledge flows occurring in geographical concentrations (Giuliani, 2007), arriving to state that ‘Nothing is in the air’ indicating that there may be “much less in the air” than is generally assumed in the literature (Fitjar and Rodriguez Pose, 2016).

Thus, an increasing number of contributions have addressed the relevance of different types of proximity in the transmission of knowledge for inter-organisational collaborations (Ritter and Gemunden, 2003; Knoben and Oerlemans, 2006) and for the performance (Oerlemans and Meeus, 2005) and innovativeness (Lai et al., 2014) of enterprises.

Despite the rich literature devoted to proximity and its role in cultivating collaboration among firms (Knoben and Oerlemans, 2006), most contributions on networks principally focus on just one type of relationships and mainly consider formal relationships, such as R&D
partnerships (D’Este et al., 2012; Capaldo and Petruzzelli, 2014), EU projects (Balland, 2012; Balland et al., 2013, etc.) or patents (Ter Wal, 2014). Meanwhile, informal networks and personal bonds are still under-researched, with few exceptions.

A new field of research is in fact developing, which investigates the role of informal collaborations for innovation (Dahl and Pedersen, 2004; Allen et al., 2007; Salavisa et al., 2012; Casanueva et al., 2013; Balland et al., 2016), underlining that innovation is influenced by either formal relationships or informal ties.

This is also related to the fact that collecting network informal relationship are time-consuming and request hard work. In addition, most contributions on informal relationship focus on business relationships, while is not usually considered the role of social relationships and personal bonds for innovation (See for instance the club of old guys in Broekel and Boschma (2012). Besides since Granovetter’s work (1975), it is highlighted that is important to consider also the social context where people and firms are embedded.

From this standpoint, some recent contributions (Caniëls et al., 2014; Werker et al., 2016) have focused on the analysing personal relationships and proximity in collaboration and have shown that firms’ relationships are strongly grounded in the relations between persons and that personal proximity is a relevant, determining factor still widely under-investigated.

Our general hypothesis is that informal relationships, in business and social context, influence the establishment of innovation collaborations (Zappa and Robins, 2016; Ferriani et al., 2013). Innovation is in fact developed in networks of multilevel relationships: formal relationships (R&D projects, Consortium, alliances); informal business relationships (innovation relationships, technical advices networks) and finally informal social relationships (friendships, family ties, social ties).

The general idea of the paper is that multiple relationships have to be analysed together in order to grasp the real pattern of inter-organisational collaborations for innovation. This shift can be also observed following the recent advancements of the statistical methodologies that permit to analyse multilevel (relationships) networks or multiplex networks (Lazega and Snijders, 2015; Wang et al., 2013; Snijders et al., 2013).

The present study contributes to this debate by exploring the impact of various forms of proximity in multiple relationships the cluster of technological restoration of cultural goods in Tuscany (Lazzeretti and Capone, 2016). Specifically, we consider the structure of informal relationships, assuming that the roles of various forms of proximity are different according to the nature of the relationship.
To conduct this research, an online questionnaire was administered to all firms constituting the Technological District of Cultural Goods in Tuscany\textsuperscript{2} during the spring and summer of 2015. We analysed three informal networks: the firms’ knowledge network for innovation, technical advice and friendship networks to investigate whether the importance of various forms of proximity change in different types of relationships. Social Network Analysis was applied to the constructed networks to analyse the different networks’ structures and Exponential Random Graph Models (ERGM) were applied to measure the impact of the various forms of proximity in the three networks.

The paper is structured as follows. The next section discusses the role of proximity in enabling or hindering collaborations, specifically formal and informal networks, and discussing also the raising research field of multilevel/multiplex networks. Section 3 presents the research design, while Section 4 describes characteristics of the surveyed firms. Section 5 applies Social Network Analysis to the three networks of innovation, technical advice, and friendship to underline similarities and differences among them. Section 6 presents the ERGM methodology, the operationalization of the various forms of proximity and the results of measuring the impact produced by the various dimensions of proximity in the three networks. The paper ends with some conclusive remarks.

2. Proximity in formal and informal network collaboration

Scholars of network sciences have highlighted that interactive learning and inter-organisational collaboration occur more easily when the involved actors have similar features – a concept known as ‘homophily’ (Mc Pherson et al., 2001). Meanwhile in economics, several works have explored the role of proximity in developing relationships among actors and specifically in creating innovation networks.

The literature describes at least five dimensions of proximity (Boschma, 2005; Knoben and Oerlemans, 2006), including cognitive, organisational, institutional, social and geographical proximity. Each type influences the probability of forming a relationship with others. In other words, actors establish collaborations more easily among similar actors, in the same area, belonging to the same group, and so on. While several studies have considered the proximities in cultivating collaboration in general, Boschma’s (2005) study is one of the most important in discussing the role of the five forms of proximity in innovation collaborations.

\textsuperscript{2} Regional law 539/2011 on the Technological District of Cultural Goods, Tuscany Region.
‘Geographical proximity,’ i.e., the co-location of economic activities, has been traditionally considered as an important factor of competitiveness and innovation, beginning with Marshall and the concepts of agglomeration economies and industrial districts (Becattini et al., 2009) and then with the cluster debate (Porter, 1998). Geographical proximity is also related to the concept of tacit knowledge and its stickiness (Bathelt et al., 2004) and specifically to the importance and competitive advantage of networks in local clusters (Tallman et al., 2004).

‘Cognitive proximity’ is a particularly important element for promoting innovation, originating from the concept of absorptive capacity (Cohen and Levinthal, 1990), knowledge bases (Nooteboom, 2000) and from the French school of proximité (Rallet and Torre, 1999; Torre and Rallet, 2005). Cognitive proximity implies that actors are more likely to form ties with other actors who share the same knowledge base and competences. At the same time, interrelationships among actors with different knowledge bases are more difficult, but also more capable of generating new knowledge and radical innovations.

‘Organisational proximity’ indicates that firms of the same corporate group are more willing to share knowledge and find it easier to innovate (Balland, 2012), while institutional proximity is defined by the similarity of informal constraints and formal rules shared by actors of the same typology. Usually, institutional proximity is related to the belonging to different institutional forms, often indicated by the Triple Helix model or the literature on university–industry relations (Leydesdorff and Etzkowitz, 2000).

‘Social proximity’ is built upon the observation that economic relationships may reflect social ties (Granovetter, 1973). Broekel and Boschma (2012) emphasise the role of the “old boys network” highlighting the importance of previous individual relationships and trust-building for the development of innovation networks. Balland (2012) indicates that actors are usually more willing to form ties with other actors who share the same behaviours in relationship dynamics. From the social proximity perspective, more central actors will pair with other central actors in other sub-networks, while marginal actors will only be able to pair with other actors in their same position. This predicted pattern also complies with core–periphery dynamics and the importance of central positions in a network (Morrison and Rabellotti, 2009; Giuliani, 2013).

In the context, some recent contributions (Caniëls et al., 2014; Werker et al., 2016) have concentrated on personal relations and ‘personal proximity’ in inter-firm collaborations and have showed that firms’ interactions predominantly take place on a person-to-person basis. Therefore, personal proximity has a relevant, but under-investigated role. “So far little is known
about whether and how proximity on a personal level or a lack thereof affects collaborations” (Werker et al., 2015, p. 1).

To determine the role of personal proximity in collaborations, Caniëls et al. (2014) use the concept of personal proximity to consider the personal characteristics of partners involved in a collaboration. Personal proximity encompasses the degree of similarity in partners’ personal features, characteristics and behaviours. The hypothesis is that the more partners are similar at a personal level, the more likely they will collaborate. This kind of proximity enables collaboration thanks to mutual feelings of acceptance and appreciation as well as an interest in each other’s ideas (Caniëls et al., 2014).

Rather than examining personal proximity and its role in collaboration in general, other authors have instead focused on the role of informal networks in innovation collaborations (Allen et al., 2007; Salavisa et al., 2012; Casanueva et al., 2013; Balland et al., 2016). Such researchers have described how formal relationships do not develop into the actual network of firm relations. Casanueva et al. (2013) analyse the position of a firm in inter-organisational networks built in geographic clusters and how a firms’ position affects innovation. The study analyses a wide range of ties and how they impact the transmission of tacit and explicit knowledge in formal and informal networks. The results support the idea that a central position in both tacit and explicit knowledge networks is especially significant in formal and informal networks. Balland et al. (2016) explore formal and informal relations in a Spanish toy cluster. They show that geographical, cognitive and institutional proximities certainly have a positive impact on the quality of formal and informal relationships in a firm, but the analysis’ results also suggest that the two types of networks follow rather different dynamics. For example, proximity is more crucial in informal technical knowledge networks, whereas embeddedness plays a significant role in both formal and informal networks.

Dahl and Pedersen (2004) investigate the role of informal relationships in a wireless communication cluster in Norway. The authors highlight that engineers share quite valuable knowledge with informal contacts, demonstrating how informal relationships represent an important channel of knowledge diffusion. Salavisia et al. (2012) analyse sectorial differences in the access to knowledge (and complementary assets) through formal and informal relationships, providing a taxonomy of innovation networks in knowledge-intensive sectors based on informal relationships.

Given such investigations into informal relationships, a logical, subsequent step is to analyse the roles of the different types of proximity in collaborations among partners and specifically examine how proximities’ impacts differ in the various informal relationships of a networks.
Our general hypothesis is that informal relationships, in business and social context, influence the establishment of innovation collaborations and therefore it is important to consider multiple relationships to grasp the functioning of a network (Zappa and Robins, 2016; Ferriani et al., 2013).

Some recent works fit into this raising research field (Lazega and Snidjers, 2015). Ferriani et al. (2013) study inter-organizational network and in particular *multiplex* ties i.e., ties featuring both an economic and a social component. Authors study a longitudinal network located in an Italian multimedia cluster. Their results confirm that both social and economic drivers contribute to the emergence of network multiplexity, and that social ties have a stronger impact than economic ties on this process. Snidjers et al., (2013) investigate the co-evolution of two-mode and one-mode networks. This study underlines how employment preferences coevolve with friendship and advice relations. The implications of the study fits in the broader context of current efforts to model the co-evolutionary dynamics of multiple relationships in social networks. Finally, Zappa and Robins (2016) assess how inter-personal knowledge transfer is sustained by the organizational structure of interunit work-flow ties and by the level of specialism of the connected units. They also examines organizational learning through a multilevel network lens.

In conclusion, it is necessary also to consider that proximity does not always have a positive effect on collaborations. Firms and/or organisations with excessive proximity can be detrimental in that the proximity creates an environment of knowledge overload (Granovetter, 1973, Burt, 2009). Such exorbitant “closeness” may also be harmful for learning and generating new knowledge and thus creates lock-in problems (Geldes et al., 2015). This phenomenon has been called the “proximity paradox” (Broekel and Boschma, 2011; Cassi and Plunket, 2014). There is empirical evidence in the literature that demonstrates how excessive cognitive proximity may reduce inter-firm knowledge exchange, and too much closeness between partners on any proximity dimension eventually spoils their innovation performance. Ben Lataifa and Rabeau (2013) analyse the way proximity can hinder the creation of new entrepreneurship. Molina-Morales et al. (2015) investigate the possible negative effects deriving from the different dimensions of proximity and demonstrate a negative impact of excessive cognitive and institutional proximities on tie creation at an advanced stage of the cluster’s life cycle.
3. Research design

This research analyses the informal relationships of firms in the business of High Technology applied to Cultural Goods (HTCG) in Tuscany, where a technological cluster of small and medium-sized firms is localised and specialises in the restoration and enhancement of their rich and internationally-renowned cultural heritage (IRPET, 2012).

The local cluster started to develop in the early 2000s, thanks to policies supporting inter-organisational networks (Salimbeni, 2001). The cluster developed rapidly and, after about ten years, reached a total of more than 400 associated actors: firms, research centres and universities. In 2011, the Tuscany Region recognised the relevance of this sector and founded the Technological District of Cultural Goods (TDCG) to support local R&D activities and improve local governance.

HTCG is an increasingly interesting business from both a research perspective and policy relevance in terms of policy design and funding (Casprini et al., 2013; Di Pietro et al., 2014). The intrigue towards HTCG also stems from creativity and innovation in several clusters in Italy (Lazzeretti et al., 2008), which are characterised by the presence of small and medium firms operating in public–private partnerships, where project-based organisations are relevant (Sedita, 2008).

This research focuses on the technological restoration business as the cluster’s core activity. An online questionnaire was delivered to all firms constituting the Technological District of Cultural Goods in Tuscany during the spring and summer of 2015.

Because of a low response rate to the online questionnaire, telephone calls were made to the firms and, when possible, the questionnaire was completed by telephone. Through direct interviews with experts in the field and using online surveys, the most important firms in the cluster in terms of number of employees and turnover rate were contacted. Forty questionnaires were fully completed, which covered all the main firms operating in the cluster. Some individual and micro enterprises were not interviewed.

In addition to a section regarding general information about the enterprise and an innovation section, which are normally found in Community Innovation Surveys (CIS), the questionnaire included three specific questions aimed at examining the relations built by the respondents.

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3 To this end, we interviewed Dr. Renzo Salimbeni, director of IFAC-CNR at the time of the constitution of the Technological District, and the management organization (POLIS) of the Technological District of Cultural Goods, that provided us with the list of the participating firms.

4 Wasserman and Faust (1994) underline that it is not possible to use a sampling method in social network analysis, even though it somewhat possible when only marginal actors are not surveyed.
Participants were asked to indicate five main partners with whom they interact in order to: a) develop innovations, new products and services; b) ask for technical advice or cooperation in overcoming technical problems related to restoration; and c) build friendship relations.5

We then analysed the firms’ innovation, technical advice and friendship networks to investigate how various forms of proximity impact the networks’ formation.

Social Network Analysis was applied to the constructed networks to investigate their structure. An Exponential Random Graph Model (ERGM) was applied to the constructed networks through a statistical analysis using a STATNET ERGM package for R (Handcock et al., 2008; Hunter et al., 2008).

Exponential Random Graph Models are a class of statistical models used for analysing social networks (Contractor et al., 2013; Lusher et al., 2013). They account for the presence of network ties and so provide a model for networks’ structure. They help to understand how social network ties arise and are especially helpful for investigating the network structure.

Within the ERGM, De Stefano and Zaccarin (2013) identify the complex structure of relationships at the base of knowledge and innovation diffusion over two forms of knowledge-based relations – co-authorship and co-inventions. They fit a multivariate ERGM model to capture the variety and complexity of actor interactions. Molina-Morales et al. (2015) analysed a foodstuff cluster in Spain with ERGM, aiming to clarify the complementarities and detrimental effects that may arise among proximity dimensions.

The ERGM package for R (Handcock et al., 2008), a part of the STATNET suite of packages for statistical network analysis, provides tools for modelling networks based on a well-studied class of models called Exponential-Family Random Graph Models (ERGMs) or p* models (Wasserman and Pattison, 1996). The package allows users to obtain approximate (or, in some cases, exact) maximum likelihood estimates (MLEs); simulate random networks from a specified ERGM; and perform graphical goodness-of-fit (Hunter et al., 2008).

The aim of this methodology is to describe the selection forces that shape the global structure of networks. In other words, a network dataset may be considered like the response in a regression model, where the predictors may be something like the propensity for actors to form partnerships. This approach generates a simulated network, which can then be compared to the observed network to statistically assess network properties.

5 For the latter case, the respondents were asked to indicate the five main subjects (within their sector) with whom they entertain friendship relations, i.e. whom they meet outside the sphere of work, during their off-hours, in their spare time, and so on.
3.1. Research hypotheses

This study aims to measure the different impacts of various forms of proximity in informal networks. It will be developed according to the following research hypotheses (Table 1).

**Hypothesis 1**: Geographical proximity positively impacts the formation of networks. This means that partners are more likely to establish relationships with geographically close actors. However, globalisation and increasing competition often cause actors to search for partners outside their local context, possibly rendering geographical proximity less important. This trend is reported in the literature with the recent assertions that in clusters the “atmosphere is in the air” (Giuliani, 2007). Thus, geographical proximity is more relevant for technical advice, as technical rather than strategic knowledge is still searched in the local cluster. Moreover, geographical proximity is important for friendship networks, as friendship is more developed with people who are physically closer.

**Hypothesis 2**: Cognitive proximity positively impacts technical advice and friendship networks. This means that actors are more likely to search for technical advice from partners who are cognitively closer. Friendship also follows this dynamic. Besides being used for developing innovations, cognitive proximity negatively impacts the formation of innovation networks. In fact, actors are more likely to establish relationships with cognitively distant partners to acquire knowledge from different cognitive domains (Granovetter, 1973). This is particularly true in the HTCG business, where several different scientific areas must be integrated to create new products and services.

**Hypothesis 3**: Institutional proximity positively impacts friendship networks. This means that friendship is more developed among organisations in the same institutional domain. For instance, entrepreneurs are more likely to establish friendship relationships with other local entrepreneurs, restaurers with restaurers, academics with academics, and so on. However, institutional proximity negatively impacts formation of innovation networks. Innovation in fact, according to the Triple Helix paradigm (Leydesdorff and Etzkowitz, 2000), is more advanced and developed through partnerships among firms, universities and research centres. Moreover, due to increased competition among clusters, firms are less likely to share strategic knowledge with competitors regarding the development of new products and services.
**Hypothesis 4**: Social (relational) proximity are more relevant in the innovation network and positively impacts its formation. This means that the more relevant organisations are more connected to others and compose the core of innovation networks. The innovation network then follows a core–periphery structure (Morrison and Rabellotti, 2009). The technical advice network is similar to the innovation network, with a less pronounced impact of this type of proximity. Moreover, a friendship network is based on personal proximity and on the personal characteristics of collaboration partners so that social proximity (and centrality) have a negative impact on the friendship network. Thus, a friendship network is more dispersed and does not fit a core–periphery model.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Innovation network</th>
<th>Technical knowledge network</th>
<th>Friendship network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical proximity</td>
<td>+</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Institutional proximity</td>
<td>-</td>
<td>-/+</td>
<td>++</td>
</tr>
<tr>
<td>Cognitive proximity</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Social (relational) proximity</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: our elaboration.

**4. The characteristics of the surveyed firms**

The sample of interviewed enterprises was chiefly composed of small-sized firms. Seventy-five percent of the surveyed sample fell within the definition of micro-enterprise, i.e., firms with less than 10 employees, and an annual turnover or balance sheet total not exceeding two million Euros.

From the responses to the questionnaire, we inferred that the type of business pursued does not depend on firm size. For the most part, both small and large-sized firms in the cultural good section deal with diagnostics art restoration and information and communications technology.

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6 This recalls the concept of preferential attachment and of ‘the rich get richer’ (Powell et al., 1996).
7 A typical core–periphery network is composed by a cohesive core sub-graph in which the nodes are highly interconnected and a second one that is made up of a peripheral set of nodes that is loosely connected to the core.
(ICT). However, the larger enterprises conduct more diversified activities. For some of these firms, the HTCG sector only represents a niche business as compared to their general activity, with the aim of diversifying and increasing the corporate image.

Moreover, we used the questionnaire responses to analyse the time distribution with regards to establishing an HTCG firm. This sector began to develop after the 1966 Florence flood, an event that necessitated restoration of a large part of the city’s cultural heritage. Starting from the 1990s, the growth of the HTCG sector in terms of business start-ups has been rather constant.

As expected, the interviewed experts reported that their firms’ innovations had developed through collaborations with other actors. Sixty percent of the respondents believed that collaborations with other innovative institutions are very important, 37% believed that they are important and only 3% reported that they are of no relevance. Among the different types of collaboration, the most valued involve research jointly conducted with other firms or public–private partnerships for innovation (e.g., universities or research centres).

Activity of the cultural goods sector is distributed throughout Tuscany. Florence, where more than half of the enterprises in the sector are located, has a central role in the business, determined by the presence not only of a rich cultural heritage, but also of most of the research institutions with whom firms engage to develop innovation.

5. Innovation, technical advice and friendship networks in the technological restoration of cultural goods

In Figures 1-3, we present the results of the Social Network Analysis applied to the three networks. As aforementioned, we have also asked the participants whether they have relationships for innovation, technical advice or friendship with other actors. The responses allowed us to construct three different networks. A comparison of the three networks highlighted firms’ propensity for and behaviour towards external collaborations in innovation and, eventually, friendship relationships.

Figure 1 represents the entire innovation network emerging from the survey. Each firm could indicate the five main actors with whom they coupled to develop innovations, new products and services in technological restoration.

Nodes represent actors, while a tie between two nodes represents a relationship. The direction of the tie (indicated by arrows) explains which actor indicated the relationship.
Research centres and universities are represented by square, blue nodes, Institutions are indicated by green nodes, while interviewed firms are illustrated with red circles. Nodes have been sized based on the *Indegree*, as the three networks are all directed networks.

A notable observation of this representation result is that the main part of the network is connected, excluding two isolated actors on the right of Figure 1. The most interesting observation, however, is that, in the majority of cases, the red circles are connected in a blue rectangle. This suggests that firms connect with other firms only through indirect relationships with research centres and universities. In fact, there are few direct partnerships of firms with firms.

An explanation for this lack of firm-to-firm connection is that in the business of cultural goods, knowledge (related to new products and services) is particularly strategic; therefore, firms do not usually interact or partner with competitors, and there is almost no collaboration among firms with regards to developing new products and services. This is also confirmed by interviews with local actors, who described this behaviour at the firm level in the local cluster.

The low collaboration among firms is also relevant for technical advice networks. There are still few isolated nodes that are omitted from Figure 2. In the questionnaire, firms’ representatives were required to indicate the five main contacts for technical advice and problem solving, not related to innovation but to technical and ordinary restoration problems. In their technical advice networks, firms were still found to only be connected through research centres, the university and some institutions. Few firms had direct relationships with other firms. This suggests that in terms of seeking technical advice, business firms avoid establishing collaborations with competitors.
**Figure 1:** The *innovation* network in the technological restoration for cultural goods


**Figure 2:** The *technical advices* network in the technological restoration for cultural goods

Source: our elaboration on questionnaire. See legend above.
Figure 3 represents the friendship network that emerged from the survey. In the questionnaire, firms had to indicate the five main contacts of friendship. Unlike the previous networks, larger nodes represent firms and professionals. Figure 3 illustrates that friendship is an important factor in developing relations with other companies in the cultural goods sector. Relations of friendship are in fact developed principally among firms and not with universities, research centres and institutions.

This finding was substantiated by the conducted interviews. Many of the interviewees were restorers trained at the Opificio delle Pietre Dure, an international school for restorers located in Florence or in other specialist schools in the local cluster. Therefore, the interviewees often attended the same training school and shared a study path, so they became friends easily.

The only subject interviewed who was not a restorer but was instead connected with others was the IFAC-CNR with which some individuals share a friendship. This may be partly due to the training courses developed by IFAC-CNR over time, but also to the fact that in the other two networks IFAC-CNR proved to be a central subject and thus could befriend several actors.

Moreover, the importance of the friendship network lies in the possibility, underlined by the interviewed persons, of discussing technical problems and solutions related to the specific working area with friends. This suggests that these relationships are fundamental for the informal transmission of knowledge.

**Figure 3:** The *friendship* network in the technological restoration for cultural goods

Source: our elaboration on questionnaire. Legend: see above.
While firms were found to establish friendships with each other, this analysis revealed that firms in the cultural goods industry avoid establishing business relationships with competitors. In fact, innovation partnerships and collaborations occur more frequently with research centres and universities. This result is also confirmed by the technical advice network, which is developed with technicians and researchers. Though most firms tend to avoid developing business relationships with competing firms, friendly relations among restoration companies are mainly developed with other firms/restorers (that are considered competitors in the sector).

In the following section, we examine the structural composition of the three networks using ERGM modelling to better compare the three networks and highlight the impacts of the different forms of proximity on the three networks.

6. An ERGM analysis

6.1. Model

The ERGM package for R, a cornerstone of the STATNET suite of packages for statistical network analysis (Hunter et al. 2008), provides tools for modelling networks based on a well-studied class of models called exponential random graph models (ERGMs) or p* models (Wasserman and Pattison, 1996). The ERGM package allows users to obtain approximate maximum likelihood estimates (MLEs), simulate random networks from a specified ERGM and perform graphical goodness-of-fit tests (Hunter et al., 2008).

ERGMs are based on the Markov chain Monte Carlo technique. They are a class of algorithms for sampling from probability distributions based on a Markov chain with stationary distribution as the desired distribution (Hunter et al., 2008). After a certain number of steps, the state of the chain is used as a sample of the desired distribution.

The aim of the ERGM is to succinctly describe the selection forces that shape the global structure of a network. In other words, the network data set may be considered similar to the response in a regression model, where the predictors are variables such as the propensity for firms and organisations to form partnerships. This approach generates simulated networks, which can then be compared to the observed network to statistically assess network properties.

In contrast to the quite restrictive log-linear approach for modelling network dynamics (e.g. Wasserman and Faust, 1994), ERGMs can jointly analyse multiple endogenous structural
effects, such as tendencies toward transitivity or structural balance, while also allowing for continuous variable scales and permitting a goodness-of-fit.

6.2. Variables of the model

The various meanings of proximity as a driver of inter-firm cooperation concept have been converted into variables, which are represented in Table 2.

Geographical proximity is determined by the co-location of two actors forming a pair. This effect is based on the partner’s location at the municipality level.

Cognitive proximity occurs when organisations share the same kind of knowledge. Each firm and organisation has been classified based on its main activity, as indicated in the questionnaire, and with respect to its scientific domain (ICT, physics, chemistry, restoration, diagnostics, environment, conservation, optoelectronics, 3D visualisation, etc.).

Institutional proximity is usually defined as when organisations have the same institutional structure per the Triple Helix Model (Etzkowitz and Leydesdorff, 2000), as described in Balland (2012). Therefore, we classified actors based on the following four classes: research centres, institutions, firms and universities.

Social proximity is usually measured as a triangle or dyadic closure in a directed network, as cliques are not considered coherent measures in bipartite data. Balland (2012) explains that accounting transitive triplets to measure transitivity is inadequate for affiliation networks constructed from bipartite data and leads to an artificially high transitivity parameter. Social proximity is thus measured as the “opposite of the number of actor pairs at distance 2,” which is a measure of network closure already used in other research studies (Balland, 2012; Lazzeretti and Capone, 2016). Snijder et al. (2010) indicate that stronger network closure will lead to fewer geodesic distances equal to two. The number of actors at distance 2 considers indirect connections between actors. The fewer the indirect connections between actors, the stronger the tendency toward network closure.

Though this study considers geographical, cognitive, institutional and social proximity, it does not investigate organizational proximity, as firms of the same group are not relevant in this specific research context. HTCG is mainly composed of SMEs. Though many researchers have attempted to measure organisational proximity in prior collaborations among partners (D’Este et al., 2013), this information is not relevant for this study.
Table 2: Variables of the model

<table>
<thead>
<tr>
<th>Variables of proximity</th>
<th>Variables Operationalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Various forms of proximity</td>
<td>Geographical proximity: Co-location</td>
</tr>
<tr>
<td></td>
<td>Institutional proximity: Same typology</td>
</tr>
<tr>
<td></td>
<td>Cognitive proximity: Same scientific domain</td>
</tr>
<tr>
<td></td>
<td>Social proximity: Inverse of number of actors at distance 2</td>
</tr>
</tbody>
</table>

Source: our elaboration

6.3. Results

Estimations were made using the software R and the STATNET-ERGM package (Handcock et al., 2008). The estimates of parameters must be interpreted based on the gap between the network under study and a random network. In other words, a positive parameter indicates that the level of a factor’s presence is higher in the examined network as compared to a casual network.

For the three networks, the probability of an actor to develop relations with close subjects was estimated to analyse the role of geographical, institutional, social and cognitive proximity. This means investigating whether firms establish relationships with actors who are physically close to them, have a similar institutional structure, are socially compatible and/or have similar knowledge bases. These four aspects are often investigated and recognised as relevant in the proximity perspective (Boschma and Frenken, 2010).

Estimations are presented in Table 3. Geographical proximity had a positive impact on all three networks. The network of friendship represented the largest parameter, meaning that friendship relations were predominantly local and developed based on the actors’ geographical proximity. Because the parameter of geographical proximity was smaller in the innovation rather than in the technical advice network, geographical proximity is more important for establishing technical advice collaborations. When firms must solve a problem, they will probably look close to where they are located for support and will only search somewhere else if the proximal organisations do not solve the issue. The innovation network registered the smaller parameter, which evidences that this network is the least rooted in the local cluster and considers overcoming local boundaries. However, actors still collaborate with other close actors, even for innovation.

The parameter of institutional proximity was significant and negative in the innovation and technical advice networks, indicating that firms develop partnerships with different subjects.
(from an institutional point of view). The parameter of the innovation network was greater than that of the technical advice network, meaning that for conducting innovations, firms match with different subjects more frequently than for solving technical problems. This finding also emerged by comparing Figures 1 and 2. The network of friendship recorded a significant and positive parameter for institutional proximity, indicating that companies mainly pair with subjects of the same institutional form. Friendship, in this context, is important, as restorers usually discuss technical problems with friends during leisure or lunch time.

Cognitive proximity was relevant only in the technical advice networks. Firms seek advice and technical collaboration in firms belonging to the same cognitive domain. This proximity was not found to be significant in the other two networks.

Social (relational) proximity, which was measured with an index of SNA (opposite of number of actors at distance 2), was relevant for technical advice, but most relevant for the innovation network. However, social proximity was not relevant in the friendship network. This suggests that firms are more oriented to seek advice and collaborate for innovation with the most relevant actors (or more central actor) in the network. This dynamic is not present in the friendship network, indicating that the innovation network is close to a core–periphery model, while the friendship network is less hierarchical. The estimations of the various parameters are graphically presented in Figure 4.

Table 3: ERGM estimations on the three different networks

<table>
<thead>
<tr>
<th></th>
<th>Innovation network</th>
<th>Friendship network</th>
<th>Technical advices network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edges</td>
<td>-3.220***</td>
<td>-4.3534***</td>
<td>-3.4556***</td>
</tr>
<tr>
<td></td>
<td>0.1922</td>
<td>0.2838</td>
<td>0.1740</td>
</tr>
<tr>
<td>Institutional proximity</td>
<td>-2.1375***</td>
<td>1.0450***</td>
<td>-1.0891***</td>
</tr>
<tr>
<td></td>
<td>0.4689</td>
<td>0.3028</td>
<td>0.2627</td>
</tr>
<tr>
<td>Geographical proximity</td>
<td>0.4378*</td>
<td>0.8015**</td>
<td>0.8400***</td>
</tr>
<tr>
<td></td>
<td>0.2674</td>
<td>0.2457</td>
<td>0.2236</td>
</tr>
<tr>
<td>Cognitive Proximity</td>
<td>0.2108</td>
<td>0.2331</td>
<td>0.5031*</td>
</tr>
<tr>
<td></td>
<td>0.3591</td>
<td>0.2588</td>
<td>0.2400</td>
</tr>
<tr>
<td>Social proximity</td>
<td>2.9844***</td>
<td>2.8516***</td>
<td>0.7406</td>
</tr>
<tr>
<td></td>
<td>0.7222</td>
<td>0.7202</td>
<td>0.4792</td>
</tr>
<tr>
<td>AIC</td>
<td>491.7</td>
<td>632.8</td>
<td>775.2</td>
</tr>
<tr>
<td>BIC</td>
<td>520.1</td>
<td>663.1</td>
<td>805.3</td>
</tr>
</tbody>
</table>

Source: our elaboration.
**Figure 4:** The different roles of various proximity on the different networks.

Source: our elaboration. Non-significant parameters have been omitted.

### 7. Conclusions

The aim of this paper was to investigate the role of various forms of proximity in a multiple informal relationships network in an Italian cluster of firms involved in the technological restoration of cultural goods. The study specifically considered how proximities impacted informal relationships, assuming that the roles of various forms of proximity are different according to the type of relationship.

This contribution joins the line of research advanced by several works concerning the role of informal networks for innovation collaborations (Dahl and Pedersen, 2004; Allen et al., 2007; Salavisa et al., 2012; Casanueva et al., 2013; Balland et al., 2016). It underlines how formal relations do not develop into the actual network of firm relations and that informal relationships have a strategic role in the transmission of knowledge among clusters and districts. Other contributions have described, for example, how personal relationships, and thus personal proximity, constitute a determining factor in facilitating knowledge transmission (Caniëls et al., 2014; Werker et al., 2016).

This study explored the way the different types of proximity influence three network typologies: knowledge networks for innovation, technical knowledge networks and friendship networks. The aim was to evaluate the impact of proximity on various informal networks and investigate the role of personal ties in a variety of contexts by focusing on friendship networks.
Notwithstanding the criticisms of recent studies that reduce the role of territorial concentration of firms (Giuliani, 2007; Fitjar and Rodriguez-Pose, 2014; etc.), our case study confirms the importance of geographical proximity. Its impact on all types of networks under analysis was always positive -- although to varying extents. In the case of friendship networks, geographical proximity had its maximum impact, while its influence was lower in both technical knowledge and knowledge for innovation networks.

In the case of institutional proximity, the results were mixed: the impact on knowledge networks for innovation and technical advice was negative, whereas the impact was positive for friendship networks. Innovation networks are constituted of institutionally different actors, consistent with the Triple Helix paradigm, according to which innovations are promoted by the collaboration between heterogeneous actors (firms, universities and research centres).

While cognitive proximity was positive in friendship networks, it was not significant in technical knowledge and innovation networks. The hypothesis suggested that firms develop collaboration with partners cognitively distant from their scientific domain to access new information. However, the results indicate do not confirm this hypothesis.

Finally, social (relational) proximity emphasises that the dynamics of networks follow a more pronounced core–periphery pattern in innovation networks as compared to technical advice networks. In fact, the central actors in this network are increasingly important, as opposed to the marginal subjects who are increasingly excluded from the network of strategic knowledge. This sort of dynamic is not at play in friendship networks.

In conclusion, this study confirms the important contribution of the proximity approach to the study of relational dynamics for innovation in technological clusters and districts. However, much work must be done to explore the role played by the different forms of proximity in separate informal networks. Ultimately, friendship networks could be an important starting point for measuring personal relations as a tool for the transmission of innovation and technical knowledge.

Further research anyway are needed. How do the three network co-evolve toggether? What is the influence of friendships and technical advice ties on the innovation relationships? Further empirical work is need in order to fit into the raising research field of multilevel/multiplex networks (Lazega and Snijders, 2015; Zappa and Robins, 2016; Ferriani et al., 2013).

In conclusion, it is worth noting that these studies may have interesting managerial implications for public policies or private initiatives aimed at developing inter-organisational collaborative activities for innovation. Managers of enterprises should increasingly pay attention to the development of relational capability for innovation, in a context which is
increasingly in agreement with the open innovation paradigm. Even in local contexts, such as clusters and districts knowledge is strategic and the dynamics of knowledge flows are heterogeneous, complex and hierarchical. Investigating the transmission of knowledge in the firms’ environment can be a strategic element for supporting competitiveness and innovation.

References


IRPET. 2012, Il settore dell’Alta Tecnologia applicata ai beni culturali in Toscana, IRPET, Firenze.


