

NETWORK POSITIONS AND INNOVATION CAPABILITIES IN THE REGIONAL INNOVATION NETWORK

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This paper investigates the positioning of actors characterized by different natures in a regional innovation network and explores how these actors improve their innovation capabilities by assuming prominence or brokering positions. Innovation capability is widely seen to be the driving force in building regional competitive advantage, therefore investigating how the positioning of actors improves their innovation-related activities is relevant in terms of regional competitiveness. This paper builds on a survey conducted on the Sicilian regional area in Italy. A questionnaire was used to collect data concerning the relationships established between actors and the extent to which these relationships impact actors' innovation capability. Results suggest that regional actors cannot be considered as a homogeneous group regarding their positioning in a regional network and that the innovation benefits of assuming different network positions depend on their nature. This paper offers some theoretical implications to the literature on regional innovation network and practical suggestions to organizations and regional policy makers.

Keywords: Regional innovation network, Regional competitiveness, Innovation capabilities, Network positions, Social Network Analysis

Introduction

The increasing globalization has highlighted the importance for regions to develop innovation capabilities in order to increase their competitiveness (Capello, 2017). Because localized learning processes and sticky knowledge embedded in local patterns of interaction are essential to innovate and compete across regional boundaries, the cooperation among actors that reside in a specific region is considered as a critical driver for developing regional innovation capabilities (Asheim and Coenen, 2005; Asheim and Isaksen, 2012).

One of the theoretical lens used by regional scholars (e.g. Sternberg, 2000) to investigate innovation capabilities in regional contexts is the social network theory (Burt, 1992; Ahuja, 2000; Koka and Prescott, 2002). Regional cooperation shapes what in the literature is known as *regional innovation network* (Levén et al., 2014). Regional innovation networks can be defined as inter-organizational networks formed from heterogeneous actors that reside in the same geographical area and cooperate to develop innovation capabilities and sustain their competitiveness (Park, 2016; Stuck et al., 2016). Several are the examples of successful regional innovation networks such as that of Silicon Valley in the US, Baden-Württemberg in Germany and Emilia Romagna in Italy (Doloreux and Parto, 2005). The main peculiarity of regional innovation networks is the geographical proximity among actors embedded in such networks. The spatial proximity is important since it permits actors having face to face contacts and frequent interactions that, in turn, allow them to share critical and tacit knowledge enhancing actors' innovation capabilities (Kauffeld-Monz and Fritsch, 2013; Baycan et al., 2017). Moreover, regional innovation networks are characterized by the presence of actors with heterogeneous natures, e.g. private firms, universities, government agencies, non-profit organizations and technology centers (Pekkarinen and Harmaakorpi, 2006). This heterogeneity is an important source of advantages and competitiveness for actors embedded in regional innovation network, because it enables a broader and deeper understanding of information and

technologies from different perspectives and, in turn, fosters organizations' innovation capabilities (Corsaro et al., 2012).

Previous literature addressing innovation capabilities in region has increasingly adopted such a network perspective mainly investigating policy implications and knowledge sharing aspects of regional innovation networks (e.g. Van Looy et al., 2003; Fritsch and Kauffeld-Monz, 2010; Levén et al., 2014; Alberti and Pizzurno, 2015). To date studies have failed to clarify the role of the structural network embeddedness in relation to the regional innovation capabilities. The structural network embeddedness is the position of actors within a network in terms of ties, connectivity, centrality and hierarchy (Nahapiet and Ghoshal, 1998; Moran, 2005). Therefore, it remains unexplored how actors choose different positions within a regional innovation network to improve their innovation capabilities. What is recognized from the social network theory is that organizations can assume different positions within a network, such as prominence or brokering, in order to improve their innovation performance (e.g. Ahuja, 2000; Koka and Prescott, 2002; Gilsing et al., 2008; Mazzola et al., 2016). In fact, accessing both high quantity and non-redundant information, organizations can foster their innovation capabilities (Koka and Prescott, 2002; Shipilov and Li, 2008). In this study we aim to fill this gap by investigating the structural network embeddedness of regional innovation networks clarifying how different actors can assume alternative positions in the network to gain the most advantageous benefits.

To empirically investigate the network embeddedness in the context of regional networks, we relied on a survey conducted on the organizations belonging to the Sicilian regional area in Italy. We choose the Sicilian context because it seems appropriate to investigate the relationship between network structural embeddedness and innovation capabilities. The Sicilian region is, indeed, characterized by the presence of heterogeneous actors (e.g. universities, private firms, government agencies and technology centers) that synergically

contribute to the development of the regional innovation capabilities (Bosco, 2007). Moreover, these heterogeneous actors strongly take advantages from the high geographical proximity with other regional partners establishing collaborative relationships that enhance the innovation capabilities (Abramo et al., 2012).

Following previous social network scholars, we analyse the structural network among Sicilian actors by leveraging the social network theory (Burt, 1992; Ahuja, 2000; Koka and Prescott, 2002) and using the Social Network Analysis (SNA) (e.g. Gilsing et al., 2008; Mazzola et al., 2015). SNA is, in fact, the appropriate analytical and empirical toolbox when the innovation is basically developed through the collaborations of many actors as in a regional innovation network (e.g. Martínez-Torres, 2014). The final sample is composed of 122 Sicilian actors including private firms, government organizations and agencies, institutions for collaboration, universities and other research organizations.

This paper attempts to offer some theoretical implications to the literature on regional innovation networks (e.g. Alberti and Pizzurno, 2015; Park, 2016) and practical suggestions to organizations by shedding some lights on the different network structural positions and the relations between these positions, the actors' nature and their innovation capabilities.

Literature review

Over the past decades, research on innovation capabilities in regions has grown significantly driven by a growing interest in innovation as a tool for sustaining regional competitive advantage and the need for new policy that can solve regional inequalities and divergence fostering innovation (Doloreux and Gomez, 2016). Regional innovation capabilities are built from both the individually regional actors and the cooperation among them (Tura and Harmaakorpi, 2005). Innovation capabilities in regions are therefore more than just the sum of the innovation capabilities of the single regional actors since they are *“the result of a collective,*

dynamic process of numerous players in a region creating a network of synergy-promoting linkages” (Sternberg, 2000: 392).

In accordance with this reasoning, a fairly large number of studies investigating the innovation capabilities in regions have adopted a network perspective to explore several and different aspects of this topic. One cluster of literature addresses the relation between the social capital of a regional innovation network and the regional innovation capabilities (e.g. Fromhold-Eisebith, 2004; Tura and Harmaakorpi, 2005; Rutten and Boekema, 2007; Malecki, 2012). These studies conceptualize regional social capital as an intangible resource that allows actors in a regional innovation network to access the material, economic and intellectual resources of the whole network (Tura and Harmaakorpi, 2005). As such, scholars in this cluster examine the social nature of the innovative processes in the regional contexts placing emphasis on how the relationships established among regional actors can enhance the innovation capabilities in the region.

A second cluster of studies examines the role played by institutions and policy makers in stimulating the regional innovation capabilities (e.g. Asheim et al., 2003; Doloreux and Parto, 2005; Tödtling and Trippl, 2005; Van Looy et al., 2003; Levén et al., 2014). Some of these researches are comparative studies that explore both the generalities and the particularities of different regional innovation networks and analyze the related policy implications (e.g. Tödtling and Trippl, 2005;). Some others explore how the policy makers can enhance the regional innovation capabilities by focusing on the role of specific actors embedded in the regional innovation network (e.g. universities, SMEs, entrepreneurial firms and technology transfer agencies) (e.g. Asheim et al., 2003).

Recognizing the knowledge as a strategic resource to develop innovation capabilities in regions, another cluster of research explores the flows of knowledge exchanged among regional actors (e.g. Boschma and Ter Wal, 2007; Cantner et al., 2010; Fritsch and Kauffeld-Monz,

2010; Krätke, 2010; Biggiero and Samarra, 2010; Alberti and Pizzurno, 2015). Findings from this cluster suggest that innovation-related knowledge is selectively and unevenly exchanged in the regional context meaning that different actors embedded in a regional innovation network have access to different knowledge flows.

Finally, highlighting the importance for regional actors to access global knowledge and resources, a further cluster of literature focuses on the role of inter-regional collaborations in building regional innovation capabilities (e.g. Krätke and Brandt, 2009; Belussi et al., 2010; Kauffeld-Monz and Fritsch, 2013; Letaifa and Rabeau, 2013; Sun and Grimes, 2017; Park, 2016). Some studies investigate the effect of inter-regional collaboration by adopting the lens of the Open Innovation paradigm (e.g. Belussi et al. 2010; Letaifa and Rabeau, 2013). Particularly, they explore how the adoption of an innovation strategy which overcomes not only the boundaries of the organizations but also the boundaries of the region influences the innovation capabilities of organizations embedded in regional innovation networks. Other studies in this research cluster focus on the role of brokering gatekeepers in regional innovation networks, i.e. those actors that access knowledge beyond the regional boundaries and transfer such global knowledge to regional partners (e.g. Kauffeld-Monz and Fritsch, 2013).

Summing up, we observe that there are not studies that have investigated how regional actors choose different positions within a regional innovation network to improve their innovation capabilities. To overcome such a limitation in literature this study aims to investigate the relation between alternative prominence and brokering positions and the innovation capabilities developed by heterogeneous actors within a regional innovation network.

Theoretical background: prominent and brokering positions in the regional innovation network

Leveraging on social network literature (Moran, 2005; Koka and Prescott, 2002, 2008), we study the network embeddedness of regional innovation networks by analysing the two alternative network positions that actors can assume in a network, i.e. brokering and prominence positions.

The prominence network position is assumed by actors that are either directly tied to many other actors or connected to actors who are themselves linked to many actors (Koka and Prescott, 2008). Having a prominence position in a regional innovation network allows actors to gain several kinds of benefits (Ahuja, 2000; Mazzola et al., 2015). First, prominent actors are able to gather large quantities of information from actors with diverse natures, and consequently, they have potentially a greater capacity of monitoring their external environment and finding relevant innovation-related knowledge (Ahuja, 2000). Second, the accumulation of high quantity of information enhances the actors' capacity to absorb new ideas from diverse actors and then recombine and transform them into novel innovations (Cohen and Levinthal, 1990; Ahuja, 2000). Moreover, the learning capacities provided by high volumes of information allow actors to develop further relational capabilities so improving their ability to manage collaborative relationships established with actors characterized by diverse natures (Kale and Singh, 2007). Finally, assuming a prominence network position an actor can reduce the search costs when looking for external resources to improve their innovation processes (Mazzola et al., 2015).

The brokering position draws on Burt's (1992) structural hole's concept, a gap in the flows of information between actors in a network (Zaheer and Bell, 2005). When an actor spans a structural hole it has an entrepreneurial role meaning that it is linked to actors that are not tied to each other (Burt, 1992). Actors that bridge structural hole act as intermediaries able to access diverse information from unconnected parts of the network (Burt, 1992). In a regional innovation network, specifically, a brokering position allows actors to access flows of different

information from alters with diverse natures (Koka and Prescott, 2002; Parjanen et al., 2011; Kauffeld-Monz and Fritsch, 2013). Actors assuming these positions have a critical role in the context of a regional innovation network since they have to translate the knowledge absorbed into a language accessible to a wider range of actors and, then, disseminating such knowledge among actors with diverse nature in different parts of the network (Alberti and Pizzurno, 2015). Fulfilling this function and accessing diverse and non-redundant information from diverse parts of the network, actors that play as a broker are able to develop new understandings and novel innovation (Burt, 1992; Ahuja, 2000; Gilsing et al., 2008; Koka and Prescott, 2008). Indeed, acting as an entrepreneur between unconnected actors with heterogeneous nature a broker can benefit from a significant advantage recombining knowledge and information from different domains to create innovation (Rothaermel and Deeds, 2004; Gilsing and Nooteboom, 2006).

Research design

Sample and data collection

The analysis is based on a survey conducted on the Sicilian regional area in Italy. As suggested by some peculiar characteristics of its economic structure and innovative system, Sicily is an intermediate level of innovation development region. The region is characterized by the presence of many small and medium-sized enterprises (SMEs) alongside very few large firms (Cignano and Pinotti, 2016), low degree of internationalization (Calignano and Quarta, 2015), low level of investments in R&D and a scarce presence of technology districts (Quatraro, 2009; Bertamino et al., 2016). These contextual peculiarities limit the ability of Sicilian actors to innovate all alone. Thus, in such a context, leveraging on network relationships with geographically close partners is the answer to the innovation needs of Sicilian actors (Doloreux and Dionne, 2008; Varis et al., 2012). Shaping regional innovation networks allows Sicilian actors to overcome the hostilities related to the presence of few innovative and large firms, the

scarce availability of public policies fostering innovation, and a limited critical mass in technological sectors. For all these reasons, the Sicilian region seems a particularly relevant research setting to investigate the relationship between the network structural embeddedness and the innovation capabilities.

Following some previous studies on regional innovation networks (e.g. Biggiero and Sammarra, 2010; Alberti and Pizzurno, 2015), a snowball sampling technique has been used to select the sample of actors shaping the Sicilian regional innovation network and collect data about them. The initial sample was built from a starting list of actors that are recognized as highly innovative in the region. This list was validated by industry experts and a few others actors were added to the sample. Then, organizations in the initial list were asked to nominate other actors involved in their innovation-based collaborations beyond those previously identified. Finally, we interviewed those organizations belonging to the list validated by the experts and those actors nominated by these organizations. Totally, 253 different actors have been involved in the study and 107 of them responded, so resulting in a response rate of 42.3%. Then, following some previous studies on regional innovation networks (e.g. Fritsch and Kauffeld-Monz, 2010), organizations which did not respond to the questionnaire but that have been indicated as partner by at least two of the responding actors have been included in the analysis. The final sample is constituted by 122 actors active in the Sicilian region. As shown in Figure 1 about 33.3% of actors in the final sample are *private firms* characterized by the presence of both manufacturing and service SMEs having on average 30 employees. *Government organizations and agencies* consist of 11.4% and includes, for example, chambers of commerce and public economic development. Moreover, the 26.0% are public and private *institutions for collaboration (IFCs)* supporting the cooperation among actors and the development of entrepreneurial business ideas (i.e. fablab, incubators, innovation centers, science parks, offices for technology transfer and innovation). Finally, *research centers and*

universities are about the 29.3% of the sample. This group of actors includes, among others, the three largest Universities operating in the Sicilian region.

[Figure 1 near here]

The questionnaires were made available to interviewees in an electronic format and consisted of two main sections. The first focuses on the organizations' profiles and it collects information about actors' profile (e.g. nature and geographic location) and the most significant innovation projects in which they are involved. The second section concerns the relationships among actors and it explores the extent to which actors in the Sicilian region know each other, the direct relationships established among the actors of the sample and the main characteristics of these relationships. Specifically, data related to the regional innovation network were collected using the roster method (Marsden, 1990): participants are asked to indicate their partners choosing them from the complete list of organizations. Then, actors are asked to describe the extent to which each established network relationship impacts their innovation capability.

Network construction and measures

We compute the network measures by using UCINET, a general software package for social network analysis (Borgatti et al., 2002). Because UCINET requires data in the form of two-dimensional matrix, to compute the measures data were recorded in social network matrixes. Particularly, the matrix representing the regional innovation network is a squared matrix $A(n \times n)$, where n is the number of organizations involved in the network; the generic element of the matrix A , a_{ij} , is equal to 1, if actors i and j are involved in a relationship, 0 otherwise.

To assess the prominence network position, we employed the eigenvector centrality measure (Bonacich, 1987; Koka and Prescott, 2002) that has been commonly associated with a firm's prominence (Koka and Prescott, 2008; Shipilov and Li, 2008). Particularly, an actor

within a network has a high value of eigenvector centrality if it is connected to many alters who, in turn, are themselves connected to many alters. To evaluate the eigenvector centrality of an actor i , Eig_i , we used the ‘Eigenvector’ routine implemented in UCINET applied to the matrix $A(n \times n)$ (Borgatti et al., 2002).

To consider the brokering network positions, we employed the constraint score, which is the most used measure for accounting of brokering positions in a network (e.g. Koka and Prescott, 2002; Zaheer and Bell, 2005). We specifically measure the brokering network position of an actor i , SH_i , as one minus the constraint score of the actor computed by using the ‘Constraint’ routine implemented in UCINET applied to the matrix $A(n \times n)$ (Borgatti et al., 2002).

Moreover, to evaluate the effect that different network positions have on actors’ innovation capability we asked actors to assess, by adopting a Likert scale, the extent to which each relationship has improved their ability to sense the changes in the environment and exploit resources and competencies in order to create competitive advantage by innovation activities (Teece and Pisano 1998). Particularly, we computed the innovation capability for an actor i as the average of evaluation each actor i gave to its network relationships.

Findings and discussion

Network positioning and actors’ nature

Table 1 reports the descriptive statistics of the network measures.

[Table 1 near here]

The average value of eigenvector is 0.070, and the actor with the highest value of eigenvector (0.210) is a private firm, while the actor with the lowest rate (0.001) is one belonging to the

research centers and universities group. Figure 2 shows the ego-network of the private firm with the highest value of eigenvector, i.e. the red squared node. The size of actors embedded in the ego-network is proportional to their eigenvector centrality value and the shape of the nodes distinguishes the different nature of actors. Such an ego-network reflects the heterogeneity of a regional innovation network since it includes actors of all the different nature. This circumstance suggests how, because of the heterogeneity characteristic of the regional innovation networks, to assume a prominence position an organization needs to vary its portfolio of relationships and collaborate with all the different actors that populate the network.

[Figure 2 near here]

Table 1 also suggests that structural hole has an average value of 0.776. The maximum value 0.920 and it is associated to a research centers and universities actor, while the minimum value (0.296) is associated to an actor of the government organizations and agencies' group. Figure 3 shows the ego-network of the actor with the highest value of structural hole, i.e. the red triangular node. The size of actors embedded in the ego-network is proportional to their eigenvector centrality value and, also in this case, the shape of the nodes differentiates the actors' nature. The research centers and universities' actor acts as a bridge between two otherwise disconnected parts of the network. What emerges observing Figure 3 is that the two parts of research centers and universities actor's ego network are quite homogeneous in terms of actors' nature. In fact, one is exclusively populated by private firm while the other includes both IFCs and research centers and universities. This configuration emphasizes the intermediary role played by an actor assuming a brokering position since, connecting two different part of the regional innovation network, the red node acts as knowledge broker and

network builder channelling knowledge and resources between private firms and research centers and universities and private firms and IFCs actors.

[Figure 3 near here]

These initial evidences suggest that actors with different nature may prefer assuming different prominence or brokering positions in the regional innovation network. Indeed, differently from inter-organizational network characterized from the presence of actors homogeneous in nature (e.g. alliance network), the presence of heterogeneous actors suggest that in a regional innovation network the values, goals and ways of acting of the actors may differ significantly (Tura and Harmaakorpi, 2005). Thus, in order to deeply investigate the network positioning of actors with diverse nature we computed other statistics, as shown in Table 2.

[Table 2 near here]

Figure 4 compares the average eigenvector values of actors with different nature (Table 2) and highlights that actors with different nature cannot be considered as a homogeneous group regarding their level of prominence in the network.

[Figure 4 near here]

Specifically, Figure 4 clearly shows that the private firms are the group of actors that, on average, reach the highest level of eigenvector. IFCs, Government organizations and agencies and Research centers and Universities were found to have lower eigenvector values in the regional network. We performed the analysis of variance test, which indicates that the group

means of the eigenvector values for the four different kinds of actors significantly differ between each other (F-ratio 2.63; p-value <0.05). This result suggests that, compared to the actors with other natures, the manufacturing and service private firms build a higher number of relationships and establish relationships with those actors that are themselves related to many other actors, so having the higher level of prominence in the regional innovation network. Specifically, analysing the direct relationships of the private firms shown in Figure 5, it is possible to notice that the majority of their relationships are established with IFCs (48.8%) and Research centers and Universities (21.7%).

[Figure 5 near here]

This finding could be explained considering the benefits that private firms may gain establishing numerous relationships with IFCs, research centers and Universities. As is generally known from previous literature investigating innovation and networks, collaborating with actors such as universities, research organizations, incubators, technology centers, and training institutions, increases the probability for firms to access relevant knowledge (e.g. Belderbos et al. 2004; Mazzola et al., 2016). Moreover, assuming a prominence position is even more relevant when considering that in the regional context under investigation private firms are represented by SMEs (Kaufmann and Tödtling, 2002). In fact, it could be critical for SME to establish direct relationships with IFCs operating in the same geographical area since they can support and nurture the development of the SMEs by providing business assistance, co-working office spaces, administrative support and mentoring services (Bøllingtoft and Ulhøi, 2005; Wonglimpiyarat, 2016). In addition, since IFCs have a crucial role in the brokerage of knowledge in regional innovation networks, SMEs can rely on the relationships established with this kind of actors to more easily access other potential partners in the region (Alberti and

Pizzurno, 2015). Moreover, it could be relevant for SMEs to establish direct relationships with Universities and other research centers. Indeed, research centers and academic institutions can offer to the SMEs the possibility to access high volume of relevant external and global knowledge by overcoming the limitation of regional boundaries and avoiding the lock-in problem, i.e. the limited opportunity to learn since being exposed only to local information and routines (Kaufmann and Tödtling, 2002). Thus, assuming a prominent position in the regional innovation network allows private firms, and SMEs in particular, to benefit from advantageous knowledge exchanges that lead them to lower their search costs and increase return on scale during the new product development process (Ahuja, 2000).

Figure 4 also shows that the research centers and universities are characterized by the lowest average value of eigenvector in the regional network under investigation. This result suggests that, compared to actors with different natures, the research centers and universities establish on average a lower number of relationships within the regional innovation network assuming more peripheral positions. This finding is strongly related to previous literature investigating the inter-regional collaborations (e.g. Kauffeld-Monz and Fritsch, 2013; Alberti and Pizzurno, 2015). This literature suggests that universities and other research centers act in regional innovation networks as gatekeepers' organizations (Kauffeld-Monz and Fritsch, 2013). Gatekeepers are actors that bring new external, even global, knowledge within the regional innovation networks and they can benefit from matching diverse local innovative capabilities with both internal and global knowledge (Graf, 2011). To play as a gatekeeper actors not only have to possess the capacity to understand, absorb, and disseminate diverse knowledge but they also have to be able to access knowledge beyond regional boundaries (Cohen and Levinthal, 1990; Kauffeld-Monz and Fritsch, 2013). Thus, to perform such a role and sharing both local and global knowledge across the network, research centers and Universities have to assume less central positions within a regional innovation network.

Figure 6 focuses on the brokering positions of actors and it, specifically, compares the average structural hole values (reported in Table 2) of groups of actors with different natures in the regional innovation network under investigation.

[Figure 6 near here]

From Figure 6, it appears quite evident that actors with different natures cannot be considered as a homogeneous group regarding their brokering role in the network. Research centers and universities are the group of actors that on average reach the highest level of structural hole, and they are followed by IFCs, Private firms and Government organizations and agencies. The analysis of variance test also suggests that the group means of the structural hole values for the four different kinds of actors significantly differ between each other (F-ratio 2.71; p-value <0.05). This result highlights that, on average and in comparison to the actors with different natures, research centers and universities have an entrepreneurial role by acting as intermediaries between otherwise disconnected parts of the network. [This finding is consistent with results shown in Figure 4 and with previous social network literature \(Mazzola et al., 2016\), since prominence and brokering positions are complementary meaning that actors that have a prominence position in a network cannot occupy in the same time a brokering role. In addition, these results are also consistent with previous literature on regional innovation network suggesting that research organizations often benefit from information diversity by facilitating knowledge flows between actors that are no directly connected to one another across the network \(e.g. Fritsch and Kauffeld-Monz, 2010\). Specifically, research centers and universities are more inclined to assume a brokering role because, differently from the other actors in the regional network \(e.g. SMEs\), they are characterized by high R&D capacities to understand and absorb knowledge from different domains, they have access to both local and](#)

global knowledge and they are also not concerned about unintended knowledge spillovers (Kauffeld-Monz and Fritsch, 2013; Alberti and Pizzurno, 2015). Moreover, research centers and universities largely benefit from brokering positions that allow them to diversify their competencies and technological bases and access explorative learning mechanisms and recombine regional and global knowledge (Messeni Petruzzelli et al., 2010; Etzkowitz, 2003).

Also, Figure 6 shows that government organizations and agencies are characterized by the lowest average value of structural hole suggesting that, compared to actors with different natures, government organizations and agencies do not assume the role of brokers. In fact, since they have to set out the policies and procedures for the interactions among actors and the exchange of knowledge among them, government and local authorities (e.g. chambers of commerce and public economic development and government departments for the economic development) have to assume more central and leading positions in the regional innovation network (Etzkowitz, 2003). Moreover, government organizations and agencies often sponsor research and innovation initiatives and grant subsidies to stimulate the economy and ensure economic development of the region (Schwartz and Clements, 1999). As a consequence, to promote research and innovation programs and overcome the market imperfections in the best way, government organizations and agencies need to establish relationships with a large number of actors so assuming a prominent position in the regional network (Levén et al., 2014).

Network positioning and innovation capabilities

Once investigated the positioning of actors characterized by different nature in the Sicilian regional innovation network, we assessed how these different kinds of actors get benefits from their network relationships in terms of innovation capability. Particularly, network relationships can improve the innovation capability of an actor since by being embedded in a network of relationships the actor is able to monitor the innovative changes in the region, exploit network

synergies, leveraging on complementary knowledge, and develop new innovative processes (Teece and Pisano 1998). Thus, we assessed the improvement in actors' innovation capability coming from each relationship they established in the regional innovation network.

Figure 7 compares the average level of the innovation capability related to the four groups of actors distinguished by their nature. Research centers and universities are the actors that, on average, gain higher level of innovation capability from their network relationships (2.79), and they are followed by IFCs (2.14), government organizations and agencies (1.96) and then private firms (1.95). We performed the analysis of variance test, which indicates that the group means of the innovation capability values for the four different kinds of actors significantly differ between each other (F-ratio 5.58; p-value <0.01).

[Figure 7 near here]

Actors with different nature gain different benefits from their network relationships in terms of innovation capability and a possible explanation for this finding is related to the positioning of actors. As such, we argue that assuming prominence and brokering positions has a different effect on the capability to innovate of actors characterized by diverse nature. Thus, to explore the differences founded in Figure 7 we plotted the trend lines of the innovation capability of different actors for increasing value of both eigenvector and structural hole (Figure 8 and 9, respectively).

Considering Figure 8, we found that for increasing values of eigenvector some network actors have a positive trend of innovation capability, while some others have a negative one.

[Figure 8 near here]

Particularly, the group of actors that get higher benefits in terms of innovation when assuming more prominence positions are private firms, that in our sample are represented exclusively by SMEs (blue line). This result is in line with previous literature about social networks that focuses on the role of SMEs embedded in innovation networks (e.g. Zeng et al., 2010; Konsti-Laakso et al., 2012). SMEs must accumulate high-volumes of knowledge and information to develop innovation capabilities and accelerate innovation processes in order to continuously grow and improve their competitiveness (Teirlinck and Spithoven, 2013; Zeng et al., 2010). To accumulate high-volumes of knowledge and information SMEs need to establish several relationships that can support them in developing technological competences, conducting entrepreneurial activities, and acquiring market knowledge to identify new opportunities (Lin and Lin, 2016). Thus, in the regional innovation network context, private firms as SMEs assume more prominence positions to get more benefits from their network relationships in terms of innovation capability.

Also the second group of actors that benefits of prominence positions are the government organizations and agencies (red line). Figure 8 highlights how the actors' innovation capability increases when they assume more central positions. In the regional innovation network, government organizations and agencies establish many relationships with different regional actors to create channels of communication with their stakeholders. This finding supports previous regional innovation studies investigating the role of government in developing policies to foster regional innovation capabilities (e.g. Van Looy et al., 2003; Hewitt-Dundas, 2013; Levén et al., 2014) and, particularly, it can be interpreted as follow. First, government organizations and agencies assume leading central position in the regional innovation network to encourage diffusely the adoption of specific innovation-related policies and procedures and to promote their innovation programs among regional actors (Levén et al., 2014). Second, prominence position allows government organizations and agencies to better monitor the

regional environment so increasing their abilities to recognize highly innovative actors and improving the allocation of funding for supporting innovation (Ahuja, 2000; Hewitt-Dundas, 2013). Finally, assuming leading positions in the regional network government organizations can implement more effectively innovation-related programs by enhancing new innovation partnerships among actors within the regional boundaries such as university-industry collaborations (Van Looy et al., 2003; Levén et al., 2014). In sum, government organizations and agencies need to assume more prominence positions to get more benefits from their network relationships in terms of capability to innovate.

Analysing Figure 9, we found that for increasing values of structural hole some network actors have a positive trend of innovation capability, while some others have a negative one.

[Figure 9 near here]

Particularly, the groups of actors that get higher benefits when assuming more brokering positions are research centers (purple line) and universities and IFCs (green line). Considering the research centers and universities, this result shows how the actors' innovation capability increases when they assume more brokering positions in the regional innovation network. In fact, assuming these positions they can gain access to knowledge from different domains and can more easily reach knowledge beyond the regional boundaries (Kauffeld-Monz and Fritsch, 2010, Graf, 2011). Such knowledge diversity and the external contacts are vital for the innovativeness of research centers and universities since the recombination of valuable and non-redundant knowledge allows these actors to stimulate their knowledge creation processes and so develop novel knowledge (Huggins et al., 2008; Ardito et al., 2018). This result strengthened previous studies suggesting universities and research centers can enhance the innovation capabilities in regions by acting as knowledge gatekeeper in regional innovation

networks (Kauffeld-Monz and Fritsch, 2010, Graf, 2011). Thus, to get higher benefits from their network relationships in terms of innovation capability research centers and universities need to assume more brokering positions.

Finally, focusing on IFCs, this result highlights how the innovation capability of actors, such as science parks and incubators, increases when they occupy more brokering positions in the regional innovation network. The relevance in term of innovation of the brokering position for IFCs can be explained considering that by linking otherwise disconnected parts of the network, IFCs can foster technological spillovers, promote the knowledge sharing among key actors of a region and better support the development of innovative ideas (Comacchio et al., 2012). In fact, given the different nature of the knowledge that IFCs have the possibility to access, exchange and absorb from actors with different nature, assuming a brokering role IFC can not only activate contacts among unrelated actors, but also translate the knowledge into a language closer to actors with different nature (Carlile, 2004). Thus, by acting as a broker in the regional innovation network, IFCs can create the positive conditions for coordinating projects between actors with different natures and promoting regional cooperation in order to foster innovation capabilities in region (Corley et al., 2006). In sum, to benefit more from their network relationships in terms of innovation capability IFCs need to assume more brokering positions.

CONCLUSIONS

Leveraging the social network theory (Burt, 1992; Ahuja, 2000; Koka and Prescott, 2002) this paper investigates the network structural embeddedness of a regional innovation network with the aim to understand how its actors do assume different positions (prominence or brokering) to gain the most advantageous benefits in terms of innovation capabilities according to their different nature.

In order to pursue the aforementioned research aim, this paper examines the Sicilian regional area in Italy. Italy is characterized by evident disparities between advanced northern regions such as Lombardy and Emilia-Romagna and the marginal southern ones such as Sicily and Apulia (Calignano and Quarta, 2015). Developing innovation capabilities by leveraging the regional innovation network takes on greater importance for actors in marginal southern regions because they have few prospects for development and growth all alone in an environment more hostile to perform technological activities and develop innovation capabilities (Doloreux and Dionne, 2008; Varis et al., 2012).

We assessed the improvement in actors' innovation capability coming from each relationship they established in the network and found that some groups of actors gain higher level of innovation capability when assuming more prominence positions, while some others increase their innovation capability when assuming a more brokering one. As such, this paper adds to the previous literature of regional studies (e.g. Van Looy et al., 2003; Fritsch and Kauffeld-Monz, 2010; Levén et al., 2014; Alberti and Pizzurno, 2015) by suggesting that the innovation benefits of assuming brokering and prominent network positions in a regional innovation network depend on the actors' nature. From one hand, we found that in the Sicilian innovation network private firms are those actors assuming more prominence positions in the network. This result is specific to the Sicilian territory because of all the Sicilian private firms in our sample are SMEs. SMEs have less ability to access external resources and fewer exchangeable technological assets than larger firms do, so they tend to establish many relations with regional partners (Lin and Lin, 2016). Cooperating with numerous partners, SMEs assume more prominent positions in the regional innovation network than the others regional actors. Specifically, because of the heterogeneity nature of regional innovation network to be prominent, SMEs need to establish several collaboration with partners with different natures. This kind of position and the variety of the portfolio relationships allow SMEs to gain higher

volumes of information from network and sustain their innovation activities (Kaufmann and Tödtling, 2002; Lin and Lin, 2016).

From the other hand, we found that Sicilian research centers and universities are those actors assuming more brokering positions in the network. This finding is not specific to the Sicilian context since results from previous regional innovation studies have highlighted the knowledge intermediaries role of universities and research centers in other regional contexts (e.g. Kauffeld-Monz and Fritsch, 2013). Notably, because of their ability in creating, storing, codifying, translating and transferring knowledge from different knowledge domains, research centres and universities tend to establish relations with different kinds of regional partners (Etzkowitz, 2003; Ardito et al., 2018). Linking unconnected regional actors, they span structural holes and assume more brokering positions than the others actors of the network. This kind of position allows them to access flow of non-redundant knowledge from different domains to sustain their innovation activities (Huggins et al., 2008).

Findings from the empirical analysis suggest that the Sicilian case is an interesting test-bed to show the importance to assume different network positions in the regional innovation network to strengthen the innovation capabilities of a territory. Moreover, they also contribute to the literature on regional innovation studies (e.g. Krätke and Brandt, 2009; Alberti and Pizzurno, 2015; Park, 2016). This study suggests that investigations on innovation capabilities of regional innovation networks should not only consider the policy implications and the knowledge sharing aspects of these networks (e.g. Van Looy et al., 2003; Fritsch and Kauffeld-Monz, 2010; Levén et al., 2014; Alberti and Pizzurno, 2015) but also the positions that different types of actors can get within the network. Actors cannot be considered as a homogeneous group regarding their level of prominence and brokering in the regional innovation network since, depending on their nature, they deliberately choose different positions to improve innovation capabilities. For example, this finding may imply that for some actors embedded in

a regional innovation network having access to non-redundant and diverse information can be more advantageous than accessing high volume of information. Thus, this paper contributes to previous regional network literature suggesting that differences in the innovation capability of actors are related to the network strategies they decide to adopt in the regional innovation network (Fritsch and Kauffeld-Monz, 2010; Alberti and Pizzurno, 2015).

The results have clear practical and policy implications for the Sicilian region under analysis, but, in our opinion, they are also useful for regions facing similar circumstances, such as many peripheral regions across Italy and Europe. First, this paper suggests actors in a regional innovation network to design their positioning by considering their nature in order to improve their innovativeness. Particularly, SMEs' managers need to establish numerous relationships with IFCs operating in the geographical area to receive appropriate business supports and with universities and research centers to gain knowledge from beyond the regional boundaries. In line with this implication, this paper also suggest policy makers to create ad-hoc public policies fostering the cooperation between actors of peripheral regions to increase their innovation intensity and technological activities. Second, research centers and universities need to assume peripheral positions in the regional innovation network to simultaneously maintain relationships with actors within the regional network and actors operating outside the boundaries of the network in order to benefit from both regional and global knowledge flows. Accordingly, policy makers should spur public policies aimed at encouraging collaboration between universities/research centres and all the different actors that constitute the regional innovation system.

The results of the present paper should be considered in light of some limitations that could be overcome by future studies. First of all, the analysis focuses on the innovation network of a specific region, i.e. the Sicilian regional innovation network, which is characterized by the under-representation of large firms. Thus, future comparative analyses with other regional

innovation networks may provide further insights eliminating geographical-specific biases. Second, the Sicilian regional innovation network actually comprises a plurality of service and manufacturing firms ranging from medium-sized to small-sized, however, this paper does not discriminate among them. As such, future research avenues may also distinguish among different types of SMEs that in our study were treated as a homogeneous body. Additionally, future studies addressing the role of actors with different natures in the regional innovation network may consider other attributes of network actors (e.g. the educational background of managers, and the actors' experience in establishing relationships) to better discriminate among them in their positioning decision process.

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