Chapter 12
Mapping an Entrepreneurial, Innovative and Sustainable Ecosystem Using Social Network Analysis: An Exploratory Approach of Publicly Funded Innovative Project Data

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Abstract The innovative dynamics of a region largely depends on existing actors and their connectivity, so the resilience of a particular innovation system can be analysed through the study innovation networks. Starting from the Algarve's case study, this analysis uses methods of social network structural analysis to map actors and centralities regarding cooperation and innovation in regional development. The chapter uses data collected through web content mining, starting from the list of organizations that have benefited from public support to innovation. The mapping of the innovation network in the Algarve is compared to theoretical models of resilient networks with the statistical indicators of hierarchy and homophily. The results facilitate the identification of gatekeepers, clusters of activities and constraints and potentialities to the enhancement of the regional entrepreneurial, innovative and sustainable (EIS) ecosystem. This approach has high potential for replication in other regions. The chapter concludes with policy implications for the EIS ecosystem's resilience and dynamics.

Keywords Crisis • Innovation • Regional policy • Network • Resilience

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12.1 Introduction

High volatility and economic turmoil; increasing technological, social and environmental risks; and the successive shocks in the socio-economic systems have grown interest in the concept of resilience in social sciences, particularly in regional studies. The most common conception of resilience refers to the ability of a given system to return to a steady state after a shock. This is an approach, which is mainly used in engineering and related to the idea of *bouncing back.* A second conception of resilience emerges from the ecological studies and focuses on how a system resists without changing its essential characteristics and without exceeding a certain existing load capacity. A third concept of resilience, which has become particularly relevant in regional studies, is concerned with the processes of selection, adaptation and generation of alternative growth trajectories in systems (the idea of *bounce forward).*

This last approach refers to an evolutionary perspective of socio-economic systems by proposing an analytical framework that internalizes change and allows not only the possibility of returning to a given equilibrium or resisting an internal shock (e.g. a structural failure) or an external shock (such as a recession in the economy) but also the opportunity of creating new paths (Boschma 2015). However, the concept of resilience remains to be clarified.

Several authors have devoted attention to the concept, by trying to delimit it and to implement it at the regional level (Christopherson et al. 2010; Davoudi et al. 2012; Dawley et al. 2010; Martin and Sunley 2014; Martin and Tyler 2015; Boschma and Pinto 2015; Simmie and Martin 2010; Simmie 2014). Attention has been given to resilience as a region's ability to adapt to shocks in production and employment (Davies 2011). Regional resilience depends on productive specialization and related variety, actors and network capacities, path dependencies and *lock-ins*, specific institutional architectures and different other factors such as social capital, systemic services or the innovation ability of a territory.

One of the limits in the implementation of the concept of resilience has been choosing an adequate level of analysis. Resilience is a phenomenon that can be studied on multiple scales, from the individual, to organizational, to aggregate levels such as a region or a country. The innovation system can be a useful scale to analyse resilience (Pinto and Pereira 2014). In the systemic perspective, the innovative dynamic largely depends on the existent actors and their connectivity, and so the resilience of a certain innovation system can be analysed through the study of innovation networks. Innovation networks regard, in their essence, to groups of relations, bonds or connections, between the nodes that represent the innovation actors that exist – people, companies, and organizations – interacting in the generation, utilization and diffusion of new knowledge and allowing the collective to learn and innovate (Pinto et al. 2015).

Among other options, it is possible to consider the regional innovation system (RIS) (Uyarra and Flanagan 2012) as a unity of analysis in the study of regional resilience. In this way the attempt is to understand the capacity of a RIS to deal with a shock and be able to maintain or improve its innovative dynamic. The benefits of this choice are relatively easy to identify. Conceptually, the components of a RIS are identified as actors and existent relationships. A RIS has a specific spatial configuration related to a certain territory but rarely runs out in the territorially bounded relations. A RIS has a clear function: promoting innovation, with a broader objective – the regional development. It is relatively accessible, in empirical terms, to identify the set of central actors in a specific RIS and start the research based in these elements. Many of the problems related to innovation activities in the region are directly related to the existence of systemic failures. The RISs are objects of public policies, and it is frequent to identify an overlap between what is the RIS and the intervention territory of regional policy for research and innovation (for a reflection on the concept of RIS cf. Pinto et al. 2012). Structural network analysis (SNA) can thus be a relevant method to study knowledge and innovation networks in the region.

SNA has become a very popular approach in social sciences in recent years. From the 1990s onwards, increasing attention was being paid to social contexts. The study of networks and their structural patterns grew at a rapid pace boosted through the use of computing means (Newman 2010). Although this increase is far from recent, in some fields such as the regional economy and economic geography (Ter Wal and Boschma 2009), these analyses have not yet been consolidated. Only in the last few years has SNA begun to be applied in the study of interaction between actors in regions in a systematic way.

The present chapter is an incursion into this theme, seeking to carry out the study of a regional innovation system through the analysis of networks to generate clues about regional resilience. This study focuses on the region of Algarve (Portugal), as a case study, to, through official information on public support for innovation and a qualitative collection following an innovative approach with web content analysis, map the innovation network. This case is particularly interesting in the Portuguese context because it presents common aspects with the national reality but in an exacerbated way. It is a region based on services of low technological intensity, particularly linked to tourism, with low critical mass and a limited range of innovation actors. In addition, it was one of the territories that most felt the impact of the crisis of 2008, with a sharp fall in regional production and an explosive growth in unemployment. On the other hand, it is a region that recovered promptly with the acceleration of the economy, especially since 2015, with the introduction of new competitive sectors anchored in scientific knowledge and more sophisticated tourist products.

The chapter is organized in four parts. Firstly, the text debates the relevance of systemic perspectives of innovation to comprehend regional resilience. We debate the entrepreneurial, innovative and sustainable (EIS) ecosystems, suggested in the current volume, and compare it with the RIS approach. We tend to agree with a practical vision that suggests that even if both approaches gave more attention to some specific aspects, they are extremely related, with many overlapping elements, and almost can be used interchangeably. Then the article argues for the relevance of applying the SNA to the study of the resilience of a particular system. Next, the methodology is explained, highlighting the data collection process and the organization for the relational matrix. The main results of the SNA are presented in Sect. 4. The text ends with a set of conclusions and some implications for regional policies in order to promote innovation.

12.2 EIS Ecosystems and Network Structure

12.2.1 Entrepreneurial, Innovative and Sustainable (EIS) Ecosystems

The increase of multilevel study regarding innovative dynamics as a path for fortifying the economic fabric, expanding productive capacity and creating employment has led to the attempt to construct methodological and conceptual frameworks to respond to this need. As a result, a number of approaches to innovation systems have emerged which, although some authors identify as overlapping, they can be complementary and contribute together to the creation of frameworks with similar heuristic values.

Priority has been given to the potential of integrated policies that aim to promote entrepreneurial activities in order to foster innovation capacity and address societal challenges (Ács et al. 2015; Foster and Shimizu 2013). One of the emerging frameworks recurrently mobilized is anchored in the concept of entrepreneurial, innovative and sustainable (EIS) ecosystems, which has been receiving increasing attention over the last years (Simatupang et al. 2015) and is the motivation of this manuscript.

There are several forms to define entrepreneurial, innovative and sustainable ecosystems, which are related to the context under analysis. The innovation ecosystem encloses two different economical fields: 'the research economy, which is driven by fundamental research, and the commercial economy, which is driven by the marketplace' (Oh et al. 2016: 2). This concept tries to complement previous approaches by filling the gap between intention and result once it focuses to portray the conditions in which the key regional agents aggregate efforts to support entrepreneurial activities engaging to generate economic and social wealth (Prahalad 2005; Cohen 2006).

The regional actors or entities involved in the collective goal of cocreating and developing technology and innovation establish complex relationships resulting in a network that promotes interactions aimed to stimulate and promote entrepreneurship, innovation and regional development driven through a sustainable path within a specific environment (Jackson 2011; Simatupang et al. 2015; Brekke 2015). This network of relations within a sector or a territory, as stated previously, has the capacity to strengthen or limit the evolution of innovative ecosystems (Hage et al. 2013) once knowledge and technology compete and co-evolve through formal and informal transfer in the sector network, based on multi-stakeholder collaboration (Simatupang et al. 2015).

Despite the stated focus on technological aspects of EIS ecosystems, there are several actors who widen the concept dimensions and analyse the importance of contextual elements, such as the strategies, cultures and organizational and institutional environment, as structural factors when building up the competency and effectiveness of EIS ecosystems (Brekke 2015; Phillips 2006; Carayannis and Campbell 2009). Thus, an efficient EIS ecosystem should rely on the integration of agents' activities at three different levels, namely, the strategic level (policymaking), the institutional level (support institutions) and the enterprise level (entrepreneurs and business entities) (Simatupang et al. 2015:391).

An EIS ecosystem is a social and economic construction that operates in several co-related and interdependent levels. This multilevel nature implies the generation of synergistic effects of the system layers along with cross-level interactions (Prahalad 2005; Spigel 2015). Methodologically it implies a highly complex multilevel construct that needs to give voice to the actors involved and their connections. The context layer implies the environmental outlines of the system, such as the cultural and organizational factors and geographical characteristics (Oh et al. 2016). At the regional level, it includes stakeholders, such as political decision makers, governance bodies, business and technological organizations, R&D agencies and the networks by which they are connected (Isenberg 2011). At the niche level, it is important to underline the group and individual actions, who are engaged in micro level activities that determine posterior outcomes (Oh et al. 2016) working as micro mechanisms from where the actions are formed and emerge. This methodological and theoretical proposal can help to understand the innovative dynamics and capacities of a specific system. However, despite that it still is a concept that, per se, is not able to explain comprehensively the innovative capacity of socio-economic systems as a structural, social and economic construction (Simatupang et al. 2015). One of the reasons most referenced in the literature is because there are different types of innovation ecosystems that arrogate different explanations and analytical frameworks (Oh et al. 2016).

The innovation ecosystems are typified according to its geographical endowment, innovation processes, trigger actors and prime focus (Oh et al. 2016). Based on these features, it is possible to identify innovation ecosystems that differ from the city-based unit to hyperlocal systems (Cohen et al. 2014); that vary according to the actors that trigger it (universities, digital sector, enterprises); the type of innovation focus – usually ecosystems are engaged with processes of open and collaborative innovation (Zhang et al. 2014); and that rely on the same theoretical basis as regional and national innovation systems (Morrison 2013).

If we compare the EIS ecosystem and RIS concepts, we find that they are very similar when analysed together, although there are some differences. Regarding limitations, both concepts present fragile theoretical frameworks and methodological options. However, a great work has been done, through these approaches, trying to comprehensively analyse the innovative dynamics, capacities and outputs of a system. The similarities mainly rely on the importance given to knowledge transfer, stakeholders' collaboration, presence of intention and the acknowledged importance of governance (Oh et al. 2016). The differentiating factors of EIS ecosystem are greater reference to the evolution of systemic connections among innovation actors, focus on open innovation, a central role of information and communication technologies along with a greater impact on the media, larger emphasis on differentiated roles (niches) occupied by organizations and industries and the importance of market forces, relative to government (Simatupang et al. 2015).

However, compared with the RIS approach, the EIS ecosystem concept is still underdeveloped as the related empirical research is still under theorized. Therefore, opportunities persist for a better integration not only with the promptly accumulating research but also with general organizational theory and research. The knowledge produced slightly explains what factors and especially interactions of factors at various levels of analysis lead to desired economic development outcomes (Simatupang et al. 2015). Thus, there are some challenges to overcome, mainly a more effective distinction from national and regional innovation systems, assessing the system performance and a clear definition of the levels at which the term is used (Oh et al. 2016). We consider that the research agenda may benefit more if EIS ecosystem literature is developed in collaborative effort with the more consolidated studies about systems of innovation.

12.2.2 *Network Analysis and Typologies of Resilience in Innovation Networks*

From a modelling perspective, networks are relatively simple to understand since they consist of two essential elements: nodes and links. SNA is an approach that assumes that these nodes and links reflect the implicit structures between actors and institutions in society, the existing relations and the role of these actors at the individual level in the network. It is a perspective that connects micro and macro levels of analysis, resulting in a flexible tool that can also be used to study the meso level – something that is not abundant in the social sciences. SNA transcends quantitative-qualitative dichotomies, as it relies on robust statistical analysis and, at the same time, is based on data collected on actors and institutions that, in most cases, can be observable and studied regarding qualitative information. SNA can be categorized as a situated case study with an explicit temporal and spatial reference (Breiger 2004).

Research that uses SNA tends to adopt one of two approaches: the design of an egocentric network or mapping the entire network in a given domain (Marsden 2005). In the first case, the analysis focuses on studying the set of relations with other actors and objects of a certain central actor – the ego – the starting point of research. In the second case, the aim is to map the global network, finding actors and interrelated objects considered as delimiters of a certain social group. It should be stressed that in this type of analysis, the term actor can represent an individual, company or particular collective social unit (Rivera et al. 2010).

SNA seeks to study social phenomena as groups of standardized relationships between actors. The basic structure of the network retracts the relationships and interactions, as well as affiliations between the actors and certain attributes in the network. The type of association between the actors is fundamental to the definition of research. Relationships in the context of SNA represent the set of social bonds of a certain type (e.g. 'interacts with', 'negotiates with', 'collaborates with') that binds pairs of actors. Connections in SNA are usually described using two dimensions: symmetry (refers to mutual or reciprocal relations, when a relation is established between two actors and works in both directions) and homophily (refers to relations between actors with similar characteristics). These characteristics are related to the resources of the actors (Jackson 2010). Relationships are also described by their intensity. This dimension is usually associated with the debate about weak or strong ties, as a result of Granovetter's analysis (Granovetter 1973, 1983) which concluded that strong ties are structuring of networks but weak ties are essential in the search for opportunities, by introducing novelty and innovation in the network, and to the integration of new actors in certain subgroups of the network.

When connections between two subgroups within a network are dependent on a limited number of intermediaries, a structural hole can be created, resulting in isolated groups or actors within the network if the actors connecting them are removed. These structural holes give power to those actors whose relationships eliminate holes (Burt 1995, 2000) because they represent opportunities to mediate information flows, coordinate and mobilize other actors according to their own objectives. The actors between structural holes gain centrality in intermediation allowing to reveal the hierarchical structure of the network and to identify influential nodes. It should be noted that the existence of a gap between two groups does not necessarily mean that the members of one group are not aware of the other group. It simply means that they do not engage in joint activities.

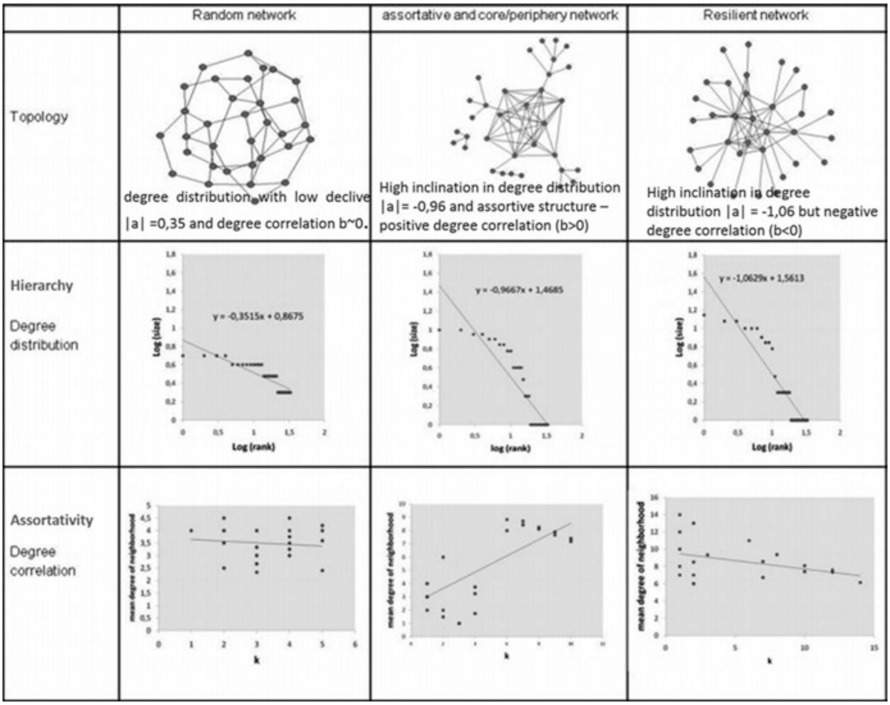
A common strategy in the study of limited scale social networks has been to identify all members and track their connections. But this is far from a simple matter. Social relationships are social constructs, based on situational definitions made by the members of the group. Data in SNA is collected normally with the use of questionnaires, especially when the actors are people. These usually inquire about the relations of the respondent with other actors. Another option is the direct observation that favours an ethnographic research approach. Interviews are also a particularly suitable option for collecting data from individuals in high positions within organizations and who tend to avoid questionnaires. Archive data and official records can also be used to obtain relational information. Any study using SNA should be cautious in defining the relationships that will be analysed and make sure that the data collection techniques are appropriate for the intended level of analysis.

Recent studies have attempted to cross SNA with regional studies. This is a field which remains unexplored (Ter Wal and Boschma 2009) since networks have been viewed as a territorial phenomenon although the localized nature of social capital has been emphasized several times (Rutten et al. 2010) and the distinction between localized networks and nonlocalized networks has already been addressed in the literature (Karlsson 2011).

Recent research has attempted to perceive the essential characteristics of a given network of regional actors to structure a 'resilient network'. One of these studies is the proposal of Crespo et al. (2013) that presents three types of network as a result of statistical indicators of homophily and hierarchy: 'random network', 'resilient network' and 'core-periphery network'. Table 12.1 summarizes the topology and the essential factors in each type of network.

The existence of networks of each of these types has important consequences for public policies. Table 12.2 summarizes some of these implications in terms of the structural change that policies must promote in order for the network to become more resilient.

Table 12.1 Resilience of different types of network



	Random network	assortative and core/periphery network	Resilient network
Topology	degree distribution with low declive |a| =0,35 and degree correlation b~0.	High inclination in degree distribution |a|= -0,96 and assortive structure – positive degree correlation (b>0)	High inclination in degree distribution |a| = -1,06 but negative degree correlation (b<0)
Hierarchy Degree distribution	y = -0,3515x + 0,8675	y = -0,9667x + 1,4685	y = -1,0629x + 1,5613
Assortativity Degree correlation			

Source: Crespo et al. (2013)

Table 12.2 Implications for policies in different types of network

	Hierarchy: Δ|a|=0	Hierarchy: Δ|a|>0	Hierarchy: Δ|a|<0
Homophily: Δb=0	*Laissez faire*	Reinforce the up part of the hierarchy of knowledge networks	Reinforce the down part of the hierarchy of knowledge networks
Homophily: Δb<0	Promote structural heterophily and disassortativity	Reinforce the up part of the hierarchy of knowledge networks	Reinforce the down part of the hierarchy of knowledge networks
		Promote structural heterophily and disassortativity	Promote structural heterophily and disassortativity
Homophily: Δb>0	Reinforce the structural homophily and assortativity	Reinforce the up part of the hierarchy of knowledge networks	Reinforce the down part of the hierarchy of knowledge networks
		Reinforce the structural homophily and assortativity	Reinforce the structural homophily and assortativity

Source: Crespo et al. (2013)

12.3 Methodology

Based on the Algarve's case study, this research uses methods of structural analysis of social networks to map actors and centralities in cooperation and innovation in regional development. The analysis uses data collected through *web content mining* from the list of organizations benefiting from public support for innovation through the regional Operational Program (OP) 2007–2013.

The official list of support/beneficiaries of the regional OP in innovation incentive systems was obtained directly from the Algarve Regional Coordination and Development Commission (CCDR Algarve) and is currently available on its institutional website. With this collected list, the next objective was to create a relational data matrix to perform the SNA. The first group of nodes and relationships collected included organizations involved in innovation projects with funding through the OP. Based on this initial listing, the websites of all beneficiary entities were gathered. The *content mining* analysis of the websites ran from March to May 2016, looking for expressions such as 'partnership', 'network', 'project' and 'protocol' to identify a second group of nodes and relationships. These new nodes and relationships have been added to the initial listing. Then it was tried to identify the websites of the new entities, and a second round of *web content mining* was executed.

The identified actors were characterized in terms of:

- Typology - 1, company; 2, governance entity; 3, innovation intermediary (business association, technology transfer office, among others); 4, university or public entity of R&D.
- Five-digit main economic activity code.
- Location in the Algarve.

The relationships identified were characterized in terms of:

- Innovation - 1, relation explicitly related to innovative activities vs. 0, other types of collaboration.
- Depth - 1, low deep (project, activity); 2, deep (partnerships, networks, projects, protocols); 3, consolidated (if collaboration was repeated among the same entities).

Based on this information, it was possible to develop the structural network analysis. In the following section, we present the main results of this study.

12.4 Results of Structural Analysis of Social Networks

12.4.1 The Algarve Innovation Network

The SNA was carried out based on the information collected, using the software NodeXL (Smith et al. 2010) and Cytoscape (Shannon et al. 2003). The final network presents a total of 929 nodes and 726 relations, with 639 not being repeated. This result has an interesting aspect. The fact that there are more nodes than links is suggestive of a large number of innovative projects funded publicly that have a single beneficiary that does not present any online information of collaboration with other actors.

The different typologies of actors were represented with the following logic in the figures: squares represent companies (COMP), lozenges are innovation intermediaries (INT), circles are the actors of governance (GOV), and triangles are universities and other public R&D entities (UNIV). Using the Fruchterman-Reingold algorithm, Fig. 12.1 presents the global network. This image represents a sparsely populated network core, where the vast majority of actors concentrate on the periphery of the network.

An alternative representation using the Harel-Koren fast multiscale algorithm, Fig. 12.2, presents the global network but allows clarifying the subgroups in the EIS ecosystem. This image presents two crucial clusters with an important variety of actors and some peripheral communities dominated by companies. There are several subgroups linked by a very limited number of actors, which on the one hand give added power to these nodes and on the other hand they are a catalyst for the creation of structural holes if these actors disappear or for some reason begin to not perform their function properly within the network.

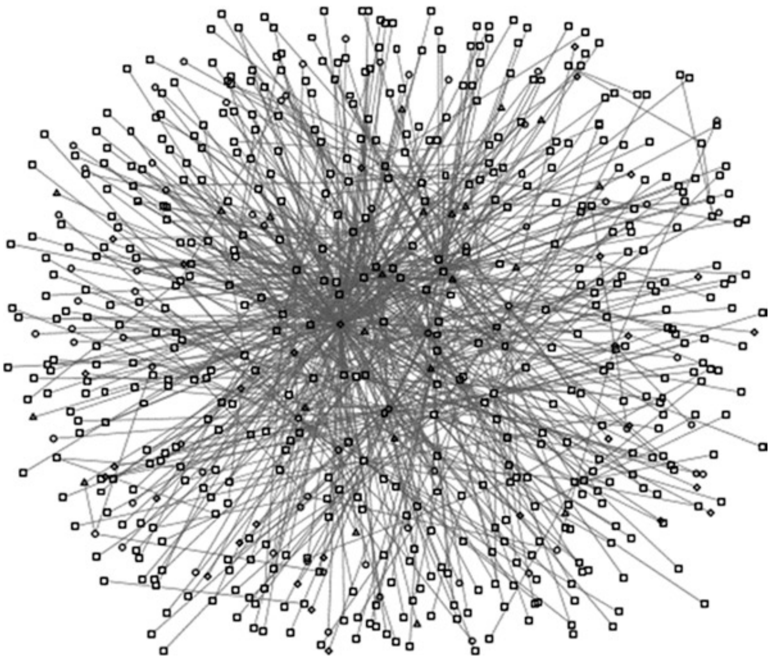


Fig. 12.1 Actors and relationships in the Algarve innovation system (Source: Own elaboration using the NodeXL, Fruchterman-Reingold algorithm)

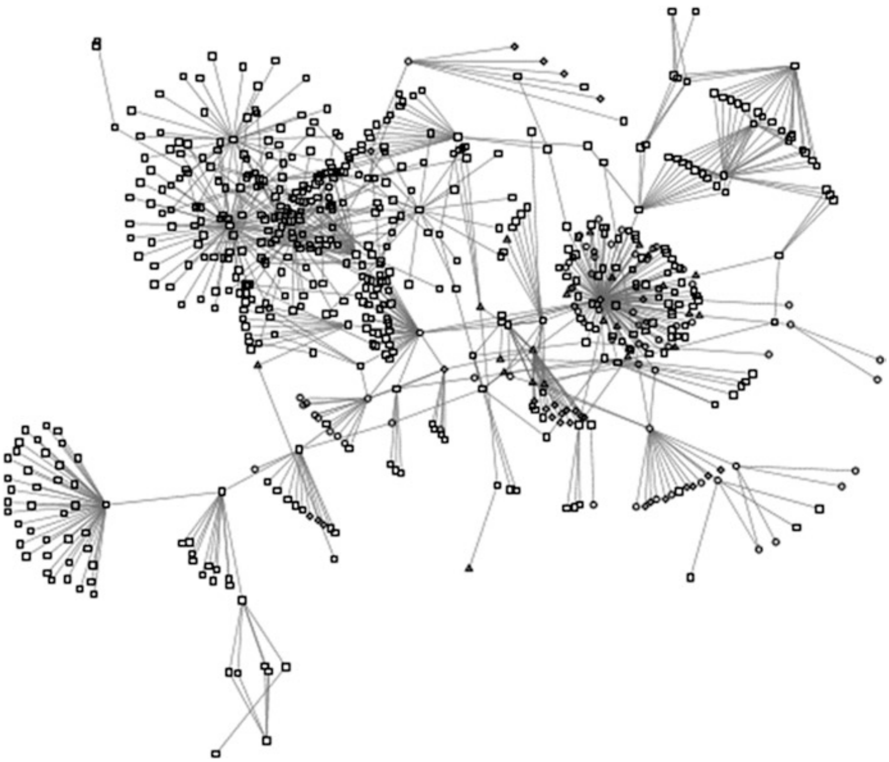


Fig. 12.2 Structural holes in the innovation system of the Algarve (Source: Own elaboration using the NodeXL, Harel-Koren Fast Multiscale algorithm)

The number of relationships is one of the main indicators of the importance of an actor in the network. An analysis of this measure, the so-called degree, the total number of connections – in and out degree – shows that the actors that concentrate the most connections are few; there are only 21 nodes with more than 10 connections (Table 12.3).

After these 21 entities, the number of relations sharply decreases. As a reference the average number of connections per actor, in this network, is 2.2. Several organizations, the CRIA – Technology Transfer and Entrepreneurship Division of the University of Algarve, CCDR Algarve, and UAlg – University of Algarve (Rectory), populate the nucleus of the network. AMAL – Intermunicipal Community of Algarve and Tourism of Portugal are also crucial entities in network connectivity.

It is worth giving some attention to the particular case of CRIA, which assumes a high relevance, with more than double the relationships identified by the second most connected actor. The creation and development of this entity has already been analysed in previous studies (namely, in Pinto and Pereira 2012). The role of this UAlg Division in the region has transcended the mere technology transfer office,

Table 12.3 Number of relationships identified of most connected entities

Actor	Degree (total number of connections)
INT1 – CRIA	119
COMP103	52
COMP60	40
GOV3 – CCDR Algarve	39
COMP187	31
COMP26	29
COMP109	25
UNIV3 – UAlg (Rectory)	25
COMP102	21
COMP248	19
COMP5	19
COMP194	18
GOV4 – AMAL	18
COMP40	17
COMP34	16
GOV2 – Institute of Tourism	15
COMP43	14
COMP9	14
COMP242	13
COMP1	12
COMP168	10

Source: Own elaboration using the NodeXL

mainly due to the lack of other intermediary actors specialized in innovation. This actor has played a catalytic role in promoting innovation in the region and has also been an instrument of regional actors, in particular the CCDR itself, when they wish to intervene in this area, with recurrent support and funding through specific projects under the regional OP.

12.4.2 Hierarchy and Homophily in the Innovation Network

The mapping of the innovation network in the Algarve can be compared with the theoretical network models previously presented through hierarchy and homophily indicators.

As stated, the hierarchy is measured by the number of relationships with other actors. In this case we use the *degree distribution* to understand if actors that have more relations are few, dominating the network, or if the relations are distributed in a balanced way by the nodes of the network. Figure 12.3 shows a scatter diagram illustrating the number of nodes with a particular degree. A very high number of nodes present a low degree, while only a very low number of nodes have a high number of relations.

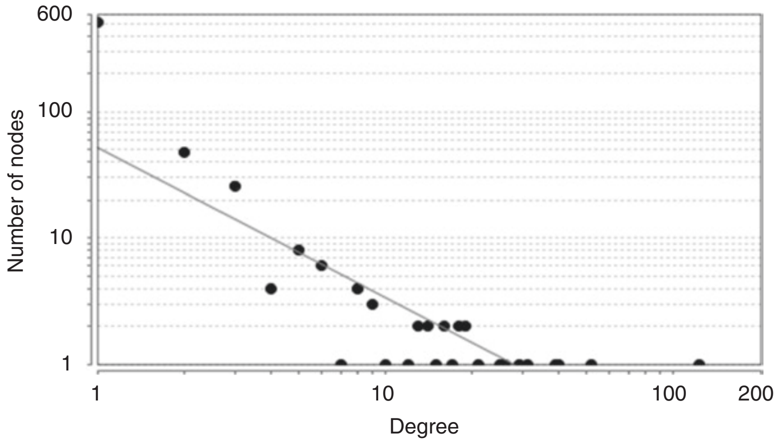


Fig. 12.3 Hierarchy in the network (Source: Own elaboration using Cytoscape)

This graphical intuition can also be confirmed, following the proposal of Crespo et al. (2013), estimating a representative function of this relation and analysing the associated coefficient (a).

$$\mathrm{Log}(Y) = C(x)a \tag{12.1}$$

$$\mathrm{Log}(Y) = \log(C) + a\log(x) \tag{12.2}$$

$$\mathrm{Log}(y) = 52{,}160 - 1185x \tag{12.3}$$

In this case (cf. Eq. 12.3), the coefficient is negative, which is illustrated by the negative slope line shown in Fig. 12.3. This result translates to a high level of hierarchy, an outcome that would be expected given what was stated in Table 12.3.

The other measure of network analysis refers to homophily. It should be noted that homophily refers, as discussed above, in general terms to the fact that certain actors privilege relationships with actors that are similar to themselves. There are, of course, a number of possible perspectives on homophily (whether business entities deal more with other companies, if R&D actors relate to other R&D entities, if entities in a particular sector/economic activity relate to entities in their sector, if entities with a high number of employers and/or high business volume relate with small- and medium-sized enterprises or not). All these dimensions are possible to analyse with data collected for SNA. In our particular case, these analyses are possible to carry out. However, homophily will be studied in this article in a very particular aspect, probably the most studied by the literature: the fact that more connected entities relate to more connected entities. Homophily can thus be measured by the linear association between the number of relations of an actor and the average number of relations of its neighbours. This indicator is called *degree correlation*. Figure 12.4 shows the dispersion diagram between the number of neighbours and the average

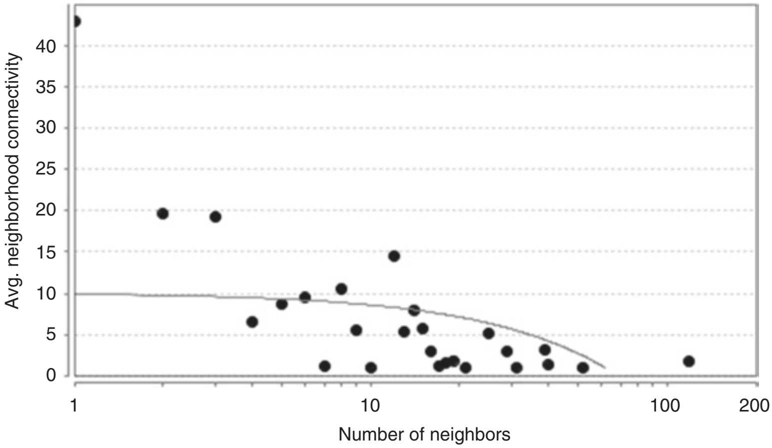


Fig. 12.4 Homophily in the network (Source: Own elaboration using Cytoscape)

number of neighbours' connections. The fact that this distribution is *flat*, having an unclear pattern, suggests that there is no obvious trend. That is, actors with a higher degree do not necessarily relate to actors with a higher degree.

This graphical intuition can be confirmed, following the proposal of Crespo et al. (2013), estimating a function of this relation and analysing the associated coefficient (b) and calculating the correlation coefficient.

$$Y = 10{,}049 - 0146x \tag{12.4}$$

In this case the trend curve (cf. Eq. 12.4) is almost horizontal (practically with no defined slope pattern), and the correlation coefficient is relatively low ($c = 0.385$).

Thus, the intense negative slope of the degree distribution and the flatness of the degree correlation result in a network that characterizes the regional innovation system in the Algarve, close to the theoretical model of a 'random network'. A 'random network' is, from the structural point of view, a relatively resilient network to shocks, which dissipate by several nodes, destroying parts of the network but which tend to renew rapidly or to be replaced in their functions by other nodes. But from the point of view of effectiveness, a 'random network' has a lack of cohesion and of internal density and usually has a disconnected central structure. In order to be effective, a real social network should not over-approximate the characteristics of a 'random network', at the risk of creating rapid contagion, and transfer shock impacts through the network, from the periphery to the centre, leading to the destruction of the essential structures of the global function of the network. A innovation system should rather reveal patterns that suggest a privileged association between some of the nodes in order to structure a core of actors, varying in typology and number, densely connected to each other, approaching the theoretical model of 'resilient network'.

12.5 Conclusion

The last few years were of high economic and social turbulence. It has become fundamental for the social sciences to find concepts and methodologies capable of fostering an understanding of how socio-economic systems, at different levels, resist and recover from certain structural shocks and failures.

In this context, the concept of resilience has been used to analyse the impacts of shocks, particularly those resulting from the economic crisis. Increasingly, an evolutionary approach to resilience has been presented in regional studies, which allows not only to understand the capacity to return to certain development paths but also the capacity to construct new paths and opportunities.

In this text it is suggested that the resilience capacity of a specific territory can be analysed using the SNA. One of the limitations of the concept of resilience is the choice of the unit of analysis. Used ambiguously it can be applied from people to countries. The chapter suggested that focusing a specific system – as an EIS ecosystem or a RIS – may help to provide some precision to the comprehension of regional resilience. The exploratory study in this chapter presented a novel methodology to gather information to create a relational data matrix. This methodology consisted, in a first phase, in the creation of a list of entities and relationships in innovative projects supported by public resources and in a second phase, through web content mining, a transversal online identification of entities and collaborations for innovation in the region. Certainly, this methodological approach presents weaknesses, mainly because the information online does not necessarily reproduce the real situation of the actors but rather what they intend to make more visible. This approach of gathering relational information in two phases is useful to fill the problems of completeness that are quite common in SNA if the data is limited to use information from official public records.

The Algarve's case study pointed to an innovation system close to a 'random network', with limited internal density and excessively dependent on a very small number of intermediaries. The text suggested that the use of two indicators (degree distribution and degree correlation) provides important clues to innovation policies and the structure of EIS ecosystems. The degree distribution – which measures the hierarchy by the number of links of each actor – has impacts on the policies at the actor's individual level. In the case under study, it is necessary to connect actors with fewer connections, for example, promoting links between actors beyond market (supplier-consumer) relations or by developing collaborative activities for innovation. The degree correlation – which measures homogeneity – is a key indicator for policy design at the system's level. In this case study, the low level of connectivity between more central actors suggests the need for the promotion of more collaborative activities at the centre of the network to be accompanied by a reinforcement of the role of mediation and translation by a broader range of actors that will constitute a denser and more populated nucleus. Public policies should make efforts to stimulate cooperation for innovation by avoiding excessive weight of some actors and an exacerbated concentration of resources.

Future research using this kind of relational matrix may explore topics such as the spatial location of relations, the sectoral specialization of the actors and the related variety or specific clusters within the network.

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