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Knowledge Network Structures and Dynamics in Local Systems:

Evidence from the Wine Industry.

A dissertation submitted in partial fulfillment of the requirements for the doctoral degree in Development Economics and Local Systems.

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Table of contents

Figures

Introduction – Figures

Chapter II – Figures

Chapter III – Figures

Tables

Introduction - Tables

Chapter II - Tables

Chapter III - Tables

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Introduction

1 A short introduction to the local foundation of economic development

An investigation on the reasons of the existence and reproduction over time of local agglomerations comprised of proximate organizations may seem paradoxical or out of date in a World so increasingly relying on information technology, transport speeding up, and virtual communication that Cairncross (2001) argued to be characterized by the "death of distance". However, different scholars belonging to several disciplines are increasingly investigating features, structures, and mechanisms leading economic actors to co-locate in *places* into *local systems*; particularly, when they reach successful and sustainable performance.

The two words in italics need a brief explanation due to the fact that other words might be chosen to explore similar concepts[1].

Regarding the former, we refer to the debate involving several scholars, especially from geography, about *place*, *space*, and *region*. We focus on places following Agnew (2011)'s claim that a *place* "contains its own special qualities" (p. 2), while *space* is a location with the consequence that a "place becomes a particular or lived space" (p. 6). Moreover, we focus more on relational places (Amin, 2004), than on territorial places, where connectivity among heterogeneous agents plays a critical role in designing places' structures and evolution. Accordingly, we aim to follow the dimension of place that Agnew (2011) calls "sense of place" as the identification of a place "as a unique community, landscape, and moral order. In this construction, every place is particular and, thus, singular. A strong sense of belonging to a place, either consciously or as shown through everyday behavior such as participating in place related affairs, would be indicative of *sense of place*." (p. 24)[2] and of Paasi (2002) that argued "if regions are conceptualized as multiscalar institutional structures, places can be conceptualized as cumulative archives of personal spatial experience emerging from unique webs of situated life episodes. Place is

[1] For example, in a recent contribution, Torre and Wallet (2016) distinguish among three main approaches for the analysis of the development of places where economic activities agglomerate. First, they argue that the term "local" is used to identify places that are moderately extended and where bottom-up processes tend to drive their development. Second, they recognize that; on the one hand, the term "regional" can be used to detect places from an administrative point of view; on the other, it can represent the economic development of places (in terms of employment, wealth, productivity, or competitiveness) from a geographical point of view. Third, they recall also the term "territorial", as a place with identifiable boundaries where local actors and/or groups of them follow common plans on a relational basis. Following this categorization, our study should relatively fit into the interveawing between their use of "local" and "territorial".

[2] This does not deny that other terms than *local systems* (e.g. business clusters, industrial districts) can be used once they fit better with characteristics of the place under investigation.

thus not bound to any specific location but conceptualized from the perspective of personal and family/household histories and life stories" (p. 807). In other words, places are "locations with meanings" (Creswell, 2008, p. 134).

In this vein, we follow Hassink and Gong (2017) when they argue that they "pay special attention to the social, cultural, and economy relations of specific places investigated by economic geographers. Such an attention to the specificity of certain places is particularly conducive to an inclusive development of the economy, as it stresses not only economic relations (which economic geographers have paid attention to) within and beyond a place, but also cultural and social relations, which are key to a socially inclusive development" (p. 21). Consequently, this study aims at avoiding the risk of investigating an uncontextualized portion of a territory where places are dissolved in placeless spaces (Marston et al., 2005).

Regarding the latter, we follow Moulaert and Sekia (2003) overview of *territorial innovation systems* and we focus on those where a local context and organizations there embedded play a fundamental role for their existence and reproduction over time. Thus, with *local systems* we refer to different concepts that the literature of several schools of thought used to identify socio-economic systems where clustered organizations (especially, but not exclusively, firms) play a critical role as – among others - Industrial Districts (Brusco, 1990; Becattini, 1991), Business Clusters (Porter, 1998), Innovative Milieus (Camagni, 1995; Maillat, 1995), Regional Innovation Systems (Cooke et al., 1997; Asheim and Gertler, 2005), Flexible Production Systems (Scott, 1988b), Learning Regions (Morgan, 1995). Needless to say, scholars belonging to different schools of thought sometimes use the same term for different phenomena, or they use different concepts as synonyms (Eriksson, 2009), leading the debate far from a unique interpretation (Martin and Sunley, 2003; Feldman et al., 2005). Several established definitions are presented in Table 1.

Moreover, this debate is strictly linked to the role of knowledge and its diffusion among different actors, because knowledge creation and circulation is still located somewhere (Schatzki, 1991) and "beyond mere location in space, therefore, from this perspective places really matter for what we think abstractly as well as what we do practically" (Agnew, 2011, p. 27). Also, Alfred Marshall (1920) pointed out the central role played by knowledge and by exchange of knowledge, when he argues that "*Capital consists in a great part of knowledge and organization … Knowledge is our most powerful engine of production; it enables us to subdue Nature and force her to satisfy our wants.*

Organization aids knowledge; it has many forms, e.g. that of a single business, that of several businesses in the same trade, that of various trades relatively to one another" (p.84).

Table 1: Relevant definitions for local systems

Concepts	Definitions	Key features
Industrial District (Becattini, 1990, p. 38)	A socio-territorial entity which is characterized by the active presence of both a community of people and a population of firms in one naturally and historically bounded area. In the district, unlike in other environments, such as manufacturing towns, community and firms tend to merge.	Formal and informal social, economic and political relations. Local community and population of firms. Cooperation and competition. Industry specialization.
Business Cluster (Porter, 1998, p. 199)	A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. The geographic scope of a cluster can be a single city or state or a country or even a network of neighbouring countries.	Productive, geographical and institutional environments. Relationships among actors.
Innovative Milieu (Camagni, 1991, p. 4). See also Maillat, 1998 and Crevoisier, 2004)	The set, or the complex network of mainly informal social relationships on a limited geographical area, often determining a specific external 'image' and a specific internal 'representation' and sense of belonging, which enhance the local innovative capability through synergetic and collective learning processes.	Local business culture and educational system. Role of infrastructures, quality of production, and local learning.
Regional Innovation System (Doloreux and Parto, 2005, p. 134-135). See also Cooke, 2001; Doloreux, 2002; Asheim and Gertler, 2005.	A set of interacting private and public interests, formal institutions and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge.	Critical role of knowledge and collective learning. Regions as locus for innovation.
Learning Region (Florida, 1995, p. 527). See also Morgan and Cooke, 1998	Learning regions function as collectors and repositories of knowledge and ideas, and provide the underlying environment or infrastructure which facilitates the flow of knowledge, ideas and learning.	Co-evolution of technology and institutions. Critical role of knowledge and idea.
Flexible Production System (Scott and Storper, 1991, p. 107)	Forms of production characterized by a well-developed ability both to shift promptly from one process and/or product configuration to another, and to adjust quantities of output rapidly up or down the short run without any strongly deleterious effects on levels of efficiency.	Technical innovation, industrial organization, and location. Role of R&D. Social regulation and production system.

Source: our elaboration

In fact, several contributions shift their focus on knowledge related issues (Malmberg and Maskell, 2002; Boschma, 2005), finding that knowledge creation is a critical determinant of regional competition (Boschma and Frenken, 2006). Indeed, even if it is true that the cost of codifiable information diffusion may be independent of distance, the cost of knowledge diffusion increases with distance (Feldman and Audrestsch, 1999), and "sticky knowledge" (Von Hippel, 1994) is better transferred through face-to-face and frequent meetings that often occur in local systems like places (Asheim and Isaksen, 2002).

In this vein, several scholars investigated the geographical dimension of the spread of knowledge proving to what extent it can be territorially localized (Jaffe et al., 1993) and they identified that a critical role in local development is played by localized knowledge spillovers as knowledge externalities bounded in space (Breschi and Lissoni, 2001). Furthermore, the spread of knowledge is also the phenomenon for which knowledge about novelties spreads more easily among co-located actors thanks to (local) social rules that foster trust and face-to-face interactions; thus, leading to faster innovation diffusion (Breschi and Lissoni, 2001).

In a few words, investigations on the local foundation of economic development have attracted the attention of several scholars in the past because economic activities still tend to agglomerate across different places all over the World (Scott and Storper, 2003), and several scholars argued and proved that market opening and technological progress may also reinforce a local agglomeration process (Eaton and Eckstein, 1997; Glaeser, 1998). Moreover, an investigation on local systems and their development is at the core of an economic debate more and more embedded in knowledge societies and their related economies where knowledge moves within (industrial) agglomerations (Tallman et al., 2004). However, some studies have questioned that knowledge is always distributed across local actors (i.e. firms) in extensive and even ways (Giuliani, 2006) and several of them recently studied determinants at the basis of their irregular architectures and dynamics (Fitjar and Rodriguez-Pose, 2017).

Therefore, this thesis aims at investigating relevant structures of knowledge networks in local systems and significant determinants of local development dynamics.

1.1 Network studies and local development from a knowledge network perspective

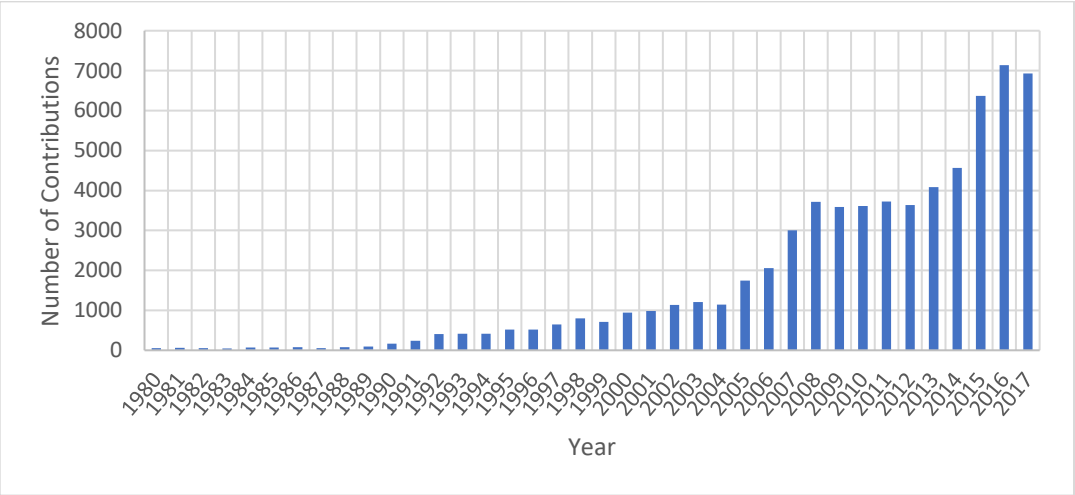
"Network" is more and more a common word in everyday language since relationships are at the very basis of a World increasingly interconnected. For example, virtual social networks like Facebook, Twitter, or Instagram are present in our everyday life. We live in Countries that are administratively connected to other Countries within supranational unions like the United States of America, or the European Union. Multinational corporations, joint ventures, merger and acquisition operations are forms of relationships increasingly affecting our work possibilities and societies.

Over the last three decades network-related studies are attracting the attention of many scholars belonging to different disciplines in economics (Shy and Oz, 2001), to such an extent that some of them claimed that there has been a *relational turn* in which scientific investigations are increasingly focused on the analysis of relationships between different components (Bathelt and Glückler, 2011). Moreover, others argued that networks are critical elements at the basis of the economic performance of organizations (Uzzi, 1996) and a branch of the economic literature (for example, Carlsson and Jacobsson, 1997) has stressed the vision of networks as the third way of coordination other than markets (competition) and firms (hierarchy). In this vein, Bradach and Eccles (1989) identify trust, price, and authority as the three main mechanisms for – respectively - the three main forms of coordination. Following Powell (1990, p. 301), networks have complementary strengths as normative basis, a relational mean of communication, norms of reciprocity (based on reputational concerns) to face conflicts, a medium degree of flexibility, and they operate in an open-ended climate with mutual benefits where actor preferences and choices are interdependent on the others. Basing on these characteristics, trust within network contexts plays the critical role of being a pre-condition to mitigate risks due to opportunism, uncertainty, and ambiguity between two independent actors as recalled by the literature on transaction costs (Williamson, 1985) and it may help in overcoming or minimizing losses due to adverse selection and moral hazard (Arrow, 1985) between two independent parties (Dei Ottati, 1994). Focusing on organizational settings typical of local systems, networked actors are characterized by a combination of competition and cooperation (Becattini, 1990; Sako, 1992). In fact, on the one hand, cooperation makes exchanges among independent actors easier and it helps in maintaining the quality of production; on the other hand,

competition reduces rigidities and fixed costs typical of hierarchical organizations and it encourages innovation (Dyer and Singh, 1998; Deakin et al., 2008).

Figure 1 shows an increasing number of publications on networks within economics over the last three decades.

Figure 1: Evolution of contributions on networks in economics over time (1980-2017)



Note: we searched for articles with "network*" as topic in business, management, economics, geography, social sciences other topics, as research areas. We obtained 45320 records over thirty years. Source: our elaboration on ISI Web of Knowledge database.

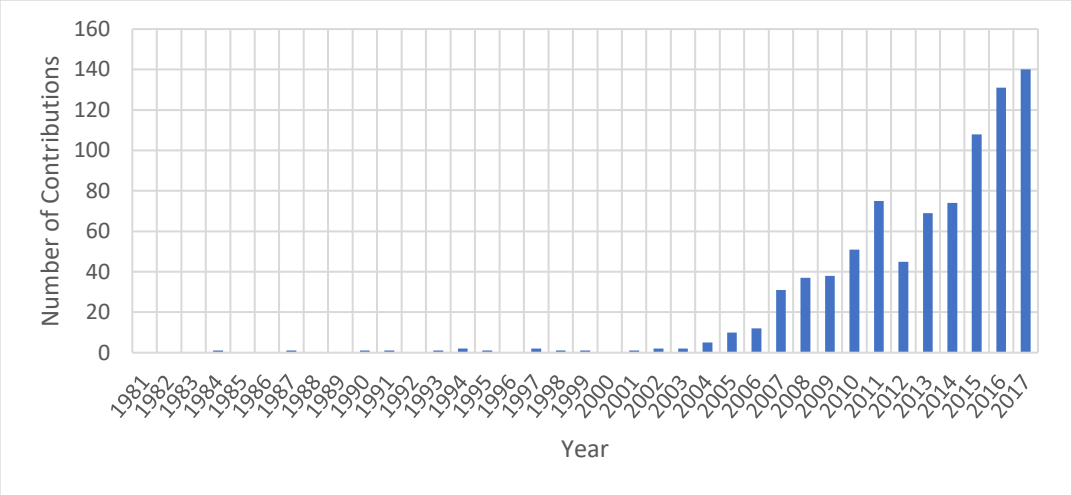
In this research area, Social Network Analysis (SNA) (Wasserman and Faust, 1994; Scott, 1988a) has emerged as a coherent and promising methodology for the study of network architectures and, more recently, for the investigation of network dynamics and changes over time. Figure 2 offers a picture of the increasing attention of scholars on SNA as one of the main structured methodology to investigate networks.

Particularly, an investigation of relationships transferring parts of knowledge within places is a relevant approach to interpret reasons of a local system's structure, dynamics, and performance (Ter Wal and Boschma, 2009).

In this vein, there is a shift from independence to interdependence, thus, we need a shift from a study about autonomous actors to an investigation of relations among them. In fact, taking a knowledge network-based perspective, local systems' structures can be represented as networks of heterogeneous agents, where actors are likely to share knowledge since they operate into a mutualistic environment where relationships are often reciprocal (Morrison, 2008). This means that they can seek advice from others and they are

likely to exchange knowledge since they are likely of being reciprocated in the future (Dahl et al., 2004).

Figure 2: Evolution of contributions on SNA in economics over time (1984-2017)



Note: we searched for articles with "social* network* analysis*" (in this order) as topic in business, management, economics, geography, social sciences other topics, as research areas. We obtained 1764 records over thirty years. Source: elaboration on ISI Web of Knowledge database.

However, even if in local systems like contexts, several contributions in the past assumed that knowledge is a local public good at disposal of a large number of local actors (e.g. managers, technicians, entrepreneurs, etc.) that appeared to benefit from that almost without effort or by chance (Gertler, 2003), adopting a network perspective, this view can be challenged. In fact, taking a network perspective as a scientific paradigm to investigate a local system allows us to explore to what extent they are the locus for knowledge emergence (as well as, its maintenance or transformation), and it can be useful in exploring what are the different roles played by different actors in this process at the basis of local learning activities.

Particularly, in organizational settings and in local systems like areas, individual aspects (e.g. firm-level characteristics) impact on exchange of knowledge, as well as relational features (e.g. proximities) and structural mechanisms (e.g. tendency to form triads following the rule that "a friend of a friend is more likely to be a friend of mine") (Ahuja et al., 2012). All those aspects can be investigated with instruments provided by a network approach, thus, interactions among actors where knowledge is shared can be interpreted as one of their fundamental units of analysis (Dyer and Singh, 1998).

Since knowledge is more and more complex and it changes over time, places where it plays a relevant role for the economic performance will be more (or less) successful for several reasons. For example, if agents belonging to local systems are more (or less) capable to discover differences among them in terms of knowledge bases, capabilities, and skills; or, if they are more (or less) able to exploit these differences in terms of learning and innovation; or, if they are more (or less) inclined to transform it in economic value. In other words, also within specialized economies, industries, or places, economic actors (i.e. firms) are heterogeneous and some of their differences may be complementarities and/or may be exploited as synergies. In this way, considered this critical role played by variety, specialization is still a driver of a local economic performance, because if it is possible to exploit (and to investigate) variety within specialization, it is also possible to exploit specialization within variety.

This point needs a few brief clarifications. First, we need to distinguish between heterogeneity among actors (for example, firms) and heterogeneity among industries once we follow a local development perspective. A place may be specialized in one (or few related) industry(ies) or it may be the locus for different (both related or unrelated) industries, but, both specialized and diversified places should be the home of heterogeneous actors (related, as well as isolated) and they can (or not) share parts of knowledge. Second, shrinking the level of scaling, every diversified place can be specialized in one production or sector, and at the same time, broadening the level of scaling, every specialized place can be considered diversified in comparison to more focused local level. Third, specific productions and goods are more likely to exist in diversified places (for example, but not exclusively, hi-tech components), as well as others are more likely to be produced in specialized ones (for example, but not limited to, high-quality and luxury goods or productions embedded in cultural and traditional environments)[3].

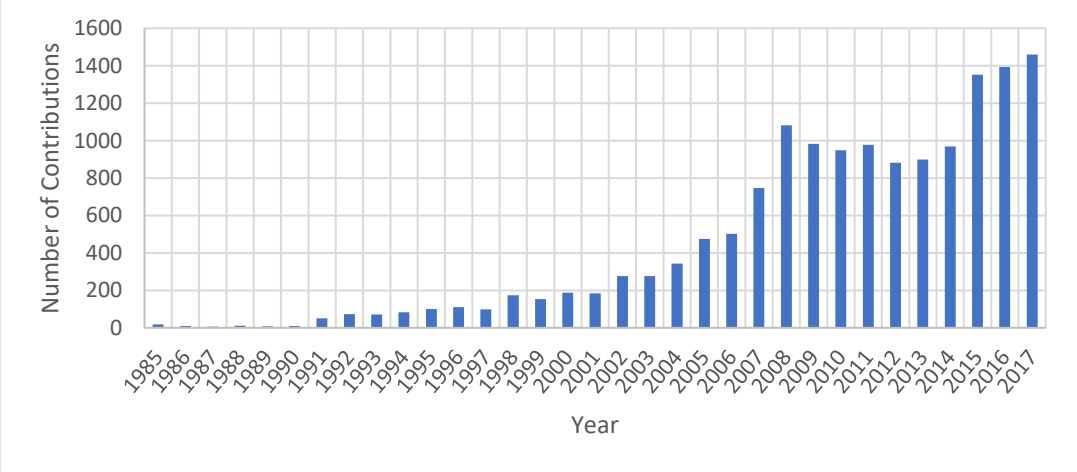
In a system composed of differentiation and integration of functions, such as a local system, networks are a critical organizational form. In this vein, explicitly taking a relational perspective, it might be assumed that actors are likely to belong to a local system once they are nodes in networks, that is equivalently to say that they need to be related is

[3] The traditional way of analysing local systems from an economic point of view dates back at least to Marshall (and von Thünen) and it stressed – among other aspects – benefits of specialization. More recently the debate shifted on impacts of heterogeneity at several scales, from capabilities to economic agents' attributes, to ways in which they interact, etc., fostering a rich debate between specialization and diversification (for a detailed investigation, see Beaudry and Schiffauerova, 2009).

some way at least to another actor within the system. However, the role of geography is not only to identify static spatial boundaries, since it possible to have actors isolated in the same place where a network is interpretable as the structure of a local system, as well as actors entering or exiting the system over time, but, it is to identify a place where also a production system, a cultural tradition, and an institutional framework is based. Contextual norms are values that avoid (or give the opportunity) to an actor to belong to a local system. From this point of view, networks' rules can also play the role of institutions. Then, the economic performance is affected by the interrelations between organizations with the economic context and the related place.

Picture 3 shows an increasing attention by local development scholars to knowledge networks over the last fifteen years.

Figure 3: Evolution of contributions on knowledge networks within local systems over time (1985-2017)



We searched for articles with terms like "cluster*", "industrial district*", "innov* milieu*", "region* system* innov*", "learning region*", "flexibl* innov* product* system*", combined with "knowledge network*" as topics obtaining 15889 records over 26 years. Source: elaboration on ISI Web of Knowledge database.

Once a system of relationships is recognized to be a source of knowledge creation and diffusion, it is important to focus the investigation on understanding the dynamics of productive knowledge. Following Andreoni (2014), productive knowledge may be viewed as the passage from learning to a real production process and all those categories are intrinsically intertwined. If an economic system is explored from a knowledge-related point of view, its diffusion patterns can be one of the most strategic resources at the basis of learning processes and they become one of the critical factors to understand economic

structures and mechanisms (Morgan, 2007). Once considered that one of the most relevant sources of knowledge generation is the sharing of ideas among several kinds of actors, an approach focused on knowledge networks may be a relevant tool for an investigation on local systems that aims to reach a representation as broad as possible.

Table 2 presents the first 10 publications considering knowledge networks as fundamental features of local systems in terms of citations.

Table 2: First ten contributions on knowledge networks within local systems for citations

Contribution	Citations
Porter, M. E. (1998). Clusters and the new economics of competition, *Harvard Business Review*, *76*(6), 77-90.	15395
Bathelt, H., Malmberg, A., and Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in human geography*, *28*(1), 31-56.	4558
Porter, M. E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic development quarterly*, *14*(1), 15-34.	5550
Inkpen, A. C., and Tsang, E. W. (2005). Social capital, networks, and knowledge transfer. *Academy of management review*, *30*(1), 146-165.	3623
Martin, R., and Sunley, P. (2003). Deconstructing clusters: chaotic concept or policy panacea?. *Journal of economic geography*, *3*(1), 5-35.	3140
Morgan, K. (2007). The learning region: institutions, innovation and regional renewal. *Regional studies*, *41*(S1), S147-S159.	3267
Markusen, A. (2002). Sticky places in slippery space: a typology of industrial districts. In *Economy* (pp. 177-197). Routledge.	3702
Storper, M., and Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of economic geography*, *4*(4), 351-370.	2624
McEvily, B., and Zaheer, A. (1999). Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic management journal*, *20*(12), 1133-1156.	2437
Gertler, M. S. (2003). Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). *Journal of economic geography*, *3*(1), 75-99.	2037

Source: elaboration on ISI Web of Knowledge database and Google Scholar. Data collected in October 2018.

Thus, journals about management, organization, strategy, and geography seem to seriously take the network perspective as a fundamental tool to understand patterns of knowledge creation and diffusion within local systems over the last twenty years. Recently, some of them adopted a dynamic network perspective to explain structures and mechanisms of innovation within local systems. Innovation seems to be one of the most relevant arguments (Caloffi et al., 2018) since it is usually assumed that it leads to sustainable economic performance and growth; while, other elements of local systems like the traditional productive side seem to attract less attention.

Different network mechanisms play fundamental roles in the spread of knowledge. For example, previous network investigations analysed the impact of closure (Coleman, 1988), the role played by centrality (Ibarra and Andrews, 1993), patterns as preferential attachment (Barabasi and Albert, 1999), network architecture with structural holes (Ahuja, 2000), relational mechanisms due to asymmetric access to information (Burt, 2009), tendency towards homophily/assortativity (Kossinets and Watts, 2009), or heterophily/disassortativity (Newman, 2002), to mention just a few of them. Once they are individuated within local system contexts, several contributions demonstrated that knowledge network architectures and dynamics follow more uneven (Markusen, 1996) and selective (Giuliani, 2006) trajectories than expected. In fact, they are often characterized by hierarchical (Markusen, 1996), core-periphery (Asheim and Isaksen, 1997), and clique-like (Giuliani, 2007) network structures.

Three critical points arise from this picture. First, a static investigation of a local system is a partial representation, since a local system is a complex system composed of several parts that continuously act and react to other actors' decisions, to changes in the cultural and institutional scenes, and it is affected by the external environment. Second, the plurality of actors and their evolutive behaviours imply that local systems can follow different patterns of development, as many as their possible combinations. Third, a geographical approach is still critical to have a representation of a local system, since the more actors are proximate in space, the more they can interact both deliberately and accidentally. This idea is so much essential for knowledge creation and diffusion that it may be possible to argue that they still find one of their main sources within local places. Mixing evolutionary and institutional economics, scholars discovered that a critical role for the production process and the cognitive aspect of the learning process is played by capabilities, in a dynamic identification of creation, diffusion, adaptation, and accumulation of knowledge over time (Cohen and Levinthal, 1990, Lundvall, 1992). Furthermore, once a local system perspective is taken, knowledge has a localized and cumulative behaviour since local actors have a limit in individual knowledge capacity and capacity to understand meanings of knowledge (Zucker et al., 1998).

Finally, the shift towards a knowledge-related relational interpretation of local systems is nowadays a fundamental element of a big discourse that was originally and mostly discussed in western Countries both from the conceptual point of view (particularly, within European and North American universities) and the political point of view (at local scales, as well as at extra-national scale, e.g. the cluster policy by the European

Commission) and recently it has spread within less economically developed Countries. For example, the Lisbon Agenda introduced cluster policies to bring Europe to be "the most competitive and dynamic knowledge-based economy in the World" (CEU, 2000, paragraphs 1, 5, and 8) and it led to the creation of the European Clusters Observatory (European Commission, 2014).

2 Selecting the wine industry between local and global dimensions

Consumers purchase bottles of wine for several reasons. First, wine consumption (and production) is embedded within different cultures around the World; second, drinking a glass of wine is not only a way to satisfy nutritional needs, but it is more and more a form of social entertainment; third, some high-quality wines are excellent products and symbol of high-status; fourth, wine has also health benefits. Moreover, wines are sometimes perceived as cultural goods and the wine production process is increasingly interpreted as a cultural one since bottles are often produced within places where production techniques are inherited by past generations, thus, they are the heritage that leads external actors to label a place as a wine region. From this perspective, the wine industry is shifting from a perception of being an industrial sector to an interpretation as an artisanal-based cultural industry, so long that the Scottish writer Robert Luis Stevenson described the quest for perfection by winemakers as "bottled poetry".

This emerging industrial-cultural framework also influences the economic performance; particularly, from a local system's perspective, since the final value of the bottle (and consequently, the final price), among other things, is also affected by this individual (sometimes artistic) reputation and by the regional wine tradition. Furthermore, Beebe et al. (2012) represent wine regions as locations of a lived experience, other than just a territory where wine is produced. In fact, a consumer may aim to visit a winery in order to experience a lifestyle during tastings and tours (Brunori and Rossi, 2000) (not coincidentally, more and more wineries are artistic works made by successful architects). Finally, even if over the last decades wines were produced within two main belts (one in the north of the globe and the other one in the south), recently wines are more and more producible almost everywhere because the climate change has moved the climate zones and because technology has progressed towards the possibility of wine production in places

previously unthinkable[4]. Consequently, employment in the wine sector increases across several places all over the World (Smith, 2007).

The influence of the local environment on the wine production is extremely critical, so long that professionals coined the term *terroir*, a concept uniquely adopted for wine-related productions that identifies all the local special features of a place of wine production in an evocative way (e.g. altitude, soil, drainage, climate, and also the local history and tradition). These features imply that the wine industry is often labelled with the geographical location of production by necessity and it also restricts the human manipulation on the growing environment (the opposite often happens for other types of crops). Therefore, the fact that wine bottles are extremely influenced by local environmental features makes consumers aware of the fact that different wines possess different characteristics and winemakers aware that their success will be critically influenced by how their products and the place where they are located are perceived. Moreover, the globalization process has not put on a side the role of places and; particularly, the impact of heterogeneity of environments, but it has driven the process through a deep focus on context specificities all over the (wine) World. In this vein, it is possible to assume that the globalization process, at least over the first twenty years of its existence, has led two main effects (Demossier, 2012). On the one hand, it has partially led a few wine regions towards homogenization in terms of tastes; on the other hand, it has pushed to a re-emergence of the role of local uniqueness, but, on a wider (more and more global) scale.

In a few words, the wine industry is an excellent case of a globally competitive sector, as well as an ideal example of local development of a natural resource-based industry. In some of those places the wine production process is perceived as the critical local image and it may foster the emergence and the reproduction of a local system basing on a wine-related local identity.

2.1 The wine industry from a local development and network-related perspective

The European Commission (2006, p. 36) claimed that the wine industry has economic and social impacts on local development of places for several reasons:

- It plays a fundamental role in the level of activity and employment in rural areas with a smaller average farm size than other sectors.

[4] The only remarkable exception is for Countries where alcohol consumption is against the law for religious or cultural reasons.

- "The family labour force strongly prevails", and "compared with other types of farms, wine holdings typically have a higher proportion of older farmers".
- This sector presents both "permanent jobs in the vineyard" and "seasonal employment in the harvest". Moreover, it motivates jobs within industries related to wine-making.
- "Wine is either made directly on the holding, in cooperative cellars or by a private enterprise".
- The economic value is always "near to the production area, for both technical and legal reasons" ("the added value remains in the production region"). Also, this industry favours indirect economic activities because there are effects in terms of employment, for example, linked to wine distilleries, or tourism.
- "Wine production fulfils non-commercial functions since its structuring effects have a (negative/positive) impact on the countryside, villages, rural communities", and the environment.

Despite the recent re-emergence of interpretations of wine regions as local systems, only a few contributions over the past few years depict such industry as networks of interconnected and interacting winemakers. For example, Porter (1998) investigates the California wine region as "an extensive complement of industries supporting both wine making and grape growing", composed of "a host of local institutions... in wine, such as the world-renowned viticulture and enology program at the University of California at Davis", and where linkages operate with "other California clusters in agriculture, food and restaurants, and wine-country tourism" (p. 78), and Becattini and Omodei Zorini (2003) argue that wine regions are "interrelated combinations of commodities, services, values and institutions rooted in specific rural areas" (p. 3).

Over the last few years, a few scholars discovered that the wine industry is likely to cluster in space and they depicted such industry as comprised of networks of interconnected and interacting winemakers that often take advantage of local wine-related institutions such as local consortiums (Brunori and Rossi, 2000; Giuliani, 2006). In this vein, local networks may enhance the impact of the wine industry on the economic performance of certain rural regions and on its related sectors (Porter, 2000). In several cases, local wine consortiums play a leading role in forming and maintaining relationships among wine producers with the aim of increasing cooperation among them. They are critical also from the institutional point of view since they regulate the winemaking production and the commercialization of bottles (only certain varieties and percentages of wine grapes can be used, firms need to

adhere to specific production methods and they should adopt the indicated bottles and labels, etc.). Moreover, as assumed by Tirole (1996) and, specifically for the wine industry by Gergaud and Livat (2010), they produce and sustain a common reputation over time that is important both for local and external actors and this is strictly related to the individual reputation as well. In fact, wine-related agents operate within an environment of imperfect information once they need to take relational decisions and a firm belonging to a wine association may be seen as less risky in term of quality; and, in turn, less risky to build a relationship with. Moreover, such forms of formal organizations may lead isolated wineries to establish forms of relationships that they were not able to make on their own, thus, they might force the emergence of knowledge sharing through network agreements in the case of a partially presence or absence of an efficient knowledge externality.

In addition to this, also informal networks operating within wine regions are critical for the spread of knowledge and for the diffusion of informal rules. On the one hand, workers of proximate wineries have many opportunities for accidental and face-to-face meetings that lead to an unplanned spread of knowledge; on the other hand, those firms can rely on a system of unwritten rewards and penalties regulated by the functioning of trust. In fact, trust plays a fundamental role because it persuades people to share information in context of uncertainty and it induces reciprocity and coordinates action (Madhok, 1995). This is particularly important in an industry like the wine sector, affected by high degrees of uncertainty due to its dependence on natural factors (e. g. climate change), in addition to the traditional features of business uncertainty. More specifically, trust seems to be very important, especially in the wine industry (Morrison and Rabellotti, 2005), because it facilitates the first phases of a relationship, it allows to remain efficient over the time and it is encouraged by the establishment of institutionalized forms of networks and common labelling (e. g. above mentioned consortiums, as well as protected designation of origins and protected geographical indication or traditional specialities guaranteed).

This hypothetical system may lead a wine region to the following process. Firstly, proximate wineries form an informal network of relationships; secondly, a process of formalization begins to create, encourage, and sustain useful relationships; thirdly, formal institutions settle the formalization process with a formal network, without which the wine local system would lose specific knowledge capital and innovation capacity. It is important to note that; on the one hand, the formalization process (as well as the formal network) does not negate the continuing function of the informal network in term of exchange of knowledge; on the other hand, local actors can belong to both the formal and the informal

network, or only to one of these, or none of these. Moreover, every typology of network is a critical instrument to elaborate and share a common technical language among wine producers (White, 1992).

Furthermore, following Sabel, 1993, Asheim and Coenen, 2005, three main individual ways of learning emerge once the wine industry is interpreted with a network perspective: learning by doing, learning by observing, and learning by monitoring. All those three learning typologies lead to a collective learning process, where learning is driven by rules or practices to coordinate economic activity between involved actors, often enhancing the conditions for individual and collective learning, and potentially innovation. In fact, a few contributions argue that clustering processes are a critical factor for the existence and competitiveness of the wine industry, mostly because knowledge and innovation spread easily within an industry that much specialized where the co-location of firms sharing similar issues opens the door to frequent encounters and possibility of imitation (for example, see Marsh and Shaw, 2000, Porter and Bond, 2004). Thus, also non-market networks are fundamental, and they can replace market relations, leading a group of firms to a shift towards a cluster of related actors with common practices and continuous exchange of knowledge (Kunc and Bas, 2009).

Local knowledge networks within wine regions and wine-related local associations also play a fundamental role from a sociological point of view, since they affect the creation of local communities and local identities (White, 1992). In other words, they play a critical role in building a local wine-based identity. The local identity is a characteristic encompassing wine firms that is inherited from the past and it is localized within the wine region's boundaries. In other terms, a local identity is a social construction that presents the wine region as whole in front of external actors, thus affecting regional competitive advantages and success, but, it is both internally (individual and relational actions of local wine firms) and externally (how the local system is externally perceived and, consequently, how external actors present and report the wine local system) created. Beebe et al. (2012) argue that a local identity is a critical feature as well as Marshallian externalities. Moreover, the wine industry in several Countries (as in Italy) is dramatically affected by a local identity since it is related to its *terroir* and to a sense of belonging. In this vein, a local wine system may create a wine-driven identity that becomes a label of the specific region in which local actors are reflected and that external actors interpret as a guarantee of quality and authenticity. A process that for the most successful cases may lead to build a regional wine-related brand over time and this is a unique feature of an industry that differs from

many other sectors because that identity is inextricably linked to a spatially determined location (Charters, 2006; Aylward and Zanko, 2008).

On this basis, SNA is a fundamental methodology for an in-depth exploration of networks operating within wine regions. In fact, it offers several instruments to investigate relational systems among wine producers potentially detecting – among others - typologies, strength, amount, frequency of relations as well as it is useful to identify isolated ones. There are several possible forms of isolation of firms since there are several kinds of networks from which it is possible to be excluded. For example, Giuliani and Bell (2005) find that a winemaker can be excluded from the local knowledge network because she/he is not able to understand concepts from others, even if they can be related to the same others through productive channels (for instance, in the case of trade of grapes and wine).

Moreover, it is a powerful methodology to study changes in relational structures over time. This is particularly helpful in the wine industry since it allows us to try to face the boundary problem typical of SNA; in other words, a distinction between actors belonging to such a system and actors outside that may be difficult. Wine industries overcome this problem in most of the cases for the presence of borders regulated in conformity with rules of local wine associations (e.g. producers' associations, protected consortium, protected traditional terms, protected designations of origins, geographic indications, etc.). This form of organization does not imply that all the economic actors within the boundary are nodes of a local wine network, since they are formal organizations but on a voluntary basis; thus, it is possible to have actors located into the formal boundary that are isolated from the network, as well as actors outside it that are related to other network nodes.

3 Research gaps

However, the research on local systems needs to follow some new rules. With a critical assessment of knowledge networks within local systems, we individuate several aspects that – at the best of our knowledge – are underdeveloped and a few streams for new research.

3.1 Knowledge networks as a representation of complexity within local systems

We need to take into account all different sources of the spread of knowledge or, in other words, heterogeneous ways in which actors interact for knowledge diffusion and creation. This means exploring both local and external interconnections at different multi-scalar perspectives, considering different processes affecting knowledge networks

structures and dynamics over time as knowledge-based link formation, maintenance, and elimination; tie content changes; multiple interactions among relational sets. In turn, these mechanisms may change actors' attributes and behaviours, and network structures. In this way, if the majority of scientific contributions considered network dynamics as exogenous mechanisms within local systems, there is a need for exploring their impacts and consequent feedbacks in a more encompassing way. This is especially challenging in local systems' environments comprised of heterogeneous actors, random elements, indirect effects, some unobservable characteristics, and where there is a never-ending succession of micro, meso, and systemic changes. In this vein, we need to disentangle cause-effect mechanisms of knowledge network dynamics in order to clarify what typologies of resources local systems really benefit from, which kind of processes leads from sources to positive effects, which others stimulate these mechanisms, and also take into consideration feedbacks. The literature recognized a few factors that may enhance positive results (for example, the presence of research centres and universities, or industry-related institutions, or external sources of novel knowledge, tendency towards cooperation and competition, or the role played by trust, etc.), but, they are often taken for granted and implicitly assumed without direct field investigations (for an exception, see Belussi, et. al, 2010). However, disentangling causes and effects is not easy because different elements are co-evolving, they are often intertwined, random elements may influence structures and mechanisms, and they continuously change and influence each other's. An exploration of all those elements and their dynamics is a matter both for theory and empirics to discern.

3.2 The relevance of network multiplicity

Stability of networks, and particularly of knowledge networks, over time may be based on opposite dynamics of different typologies of relational settings. For example, the dissolution of a few ties may be compensated by the creation of structurally equivalent new ones. Although there is a long tradition of studying different kinds of relationships, many authors investigated them separately. For example, labour mobility, alliances, advice sharing, associations, client-suppliers interrelations, research collaborations, transfer of funds etc. are identified as critical tools for knowledge diffusion, but, only a very few contributions have attempted to analyse the influence of the co-existence of multiple relationships within local systems even if actors are embedded in multiple types of network at the same time by their nature. This empirical effort especially studied to what extent social and economic ties – even if heterogeneously defined and identified – affect local

systems' advantages and economic performance through knowledge diffusion, innovation sharing, mutual problem solving via advice, etc. (for example, Ferriani et al., 2013; Capone and Lazzeretti, 2018, Contreras Romero, 2018). Within this multiple network contexts, also a definitory effort is needed in order to distinguish by multilevel, multiplex, and simultaneous networks structures and dynamics.

This is also particularly interesting from a methodological point of view, since statistical implementations of network analysis (Snijders et al., 2013); specifically, into economic geography (Broekel et al., 2014), may open a new way to empirically test multiple networks co-existence and interactions. In fact, if traditional structural mechanisms like reciprocity or triadic closure are critical patterns within a single network, they may have important implication also in a multiple setting. For example, one typology of relationship between two actors may be likely to be reciprocated by another specific typology between the same two agents; or, it is possible to think about triangular structures comprised of different categories of relations.

3.3 External validity concerns and the importance of a comparative perspective

It goes without saying that a knowledge network comprised of one kind of relationship may have a different impact in terms of direction and magnitude in a place rather than another; in fact, local values, traditions, rules, institutions etc., highly affect economic performance. For instance, urban, rural, or peripheral systems, or local systems based in laboratories or in natural settings, have different needs and present different opportunities for economic activities, as well as different financial and fiscal structures. Moreover, history plays a critical role, because certain networks may emerge, dissolve, interact with others in different ways and with heterogeneous impacts in certain periods of time; and this is critically important within local systems, where path-dependency on the past highly affects new development paths. Also, different industries are more influenced by one kind of relations rather than others; for example, research collaboration networks highly focused on innovation can impact more on high-tech sectors, than in low-tech ones. Even though Phelps et al. (2012) argued that other than social embeddedness, also cultural embeddedness comprised of both formal and informal systems, plays a critical role, knowledge network research is still under-contextualized. On this basis, comparative studies across several cases should help to overcome generalizability bonds through an

avenue of research that studies similarities and differences between heterogeneous contexts and historical contingencies, rather than static pictures that hardly work for all.

Broadly speaking, roles of context and history, even if they have been often theoretically recalled, are more descriptively presented than analysed with an explanatory aim. In this vein, studies of knowledge networks, particularly if they are explored paying attention to individual features of involved actors, their similarities and dissimilarities, and the most common relational mechanisms, may be critical instruments to a better understanding of the roles played by actors' embeddedness in places and to what extent they affect the performance of a place and not another.

From the scientific point of view, this approach may help to explain conflicting results in present knowledge networks and local systems' research; while, from the political point of view, this discourse is strictly related to critics to one-size-fits-all local policies, in favour of strategies planned on evidence-based cases (Tödtling and Trippl, 2005).

3.4 Network related policies and impact evaluation within local systems

In several local systems, policies are critical tools influencing the spread of knowledge, its creation, and its maintenance, since political decisions of local and non-local institutions may stimulate or hamper the networking level of the environment where different actors transfer several kinds of knowledge. In this way, policies may operate to decrease the level of uncertainty and to increase the level of trust among actors, in order to facilitate or accelerate learning processes and spread of useful and collaborative knowledge. Particularly, policies may directly impact on the potential benefits of institutional proximity, increasing the level of similar rules among actors (creating a common institutional framework) and the extent to which they are shared; and indirectly on other categories of proximities due to their strong interweaving (Boschma, 2005). Despite this, at the best of our knowledge, the relation between policies and different kinds of proximity and networks is still an underdeveloped field of study.

If one-size-fits-all local policies are more and more ex-post criticized, an ex-ante implementation of impact evaluation methodologies may be efficient to understand potential impacts of a program on involved actors and the system as a whole, in terms of performance, productivity, and sustainability. In this vein, the size of the impact, how long it takes to produce effects, efficiency and effectiveness concerns may be critical points to be faced; particularly, from a network perspective, instruments fostering coordination among cooperative and competitive actors are at the very core of the argument. At the best

of our knowledge, this research stream is underdeveloped and only applied in less developed Countries with mainly top-down programs (Boneu et al., 2016), even though measures of SNA and dynamic statistical methodologies offer several interesting instruments to deal with this issue. For example, randomized experiments and non-experimental methods (e.g. propensity score matching, difference in differences, instrumental variables, regression discontinuity design, etc.) may be chosen to evaluate impacts on both the individual and systemic level basing on different local characteristics and taking into consideration that programs heterogeneously affect different actors within the same region. Stressing potentialities given by a relational approach, an empirical analysis still has to put more effort in exploring which kind of institutions and to what extent are linked to specific knowledge networks, and once investigated in an evolutionary perspective, scholars need to focus on a dynamic institution-based study. Moreover, once a program is evaluated, the shift to implementation of (industrial) policies within local systems is a very delicate stage for two main reasons. On the one hand, policies must be planned with strategies that regions can realistically achieve with their present assets and potentialities and taking into consideration historic strengths and weaknesses; on the other hand, once a policy is put into effect, it may incur in local misgivings by actors unwilling to follow long-term plans once new rules are not in line with internal established routines. In other words; first, policies may be designed fostering path-dependence based on elements of continuity; second, considering adaptation based on elements of change; third, sustaining structural regional elements such as local education, entrepreneurial culture, specific governance plans, infrastructures, etc. based on cultural, social, historical, institutional, environmental resources and needs in front of risks and opportunities.

Finally, policies may be planned to increase the level of education of employees (and of citizens of a certain place) to such an extent that they can enlarge their absorptive capacity towards diverse and novel knowledge. In this way, it is possible to create an environment opened to novel ideas, inventions, process and product innovations.

3.5 Quantitative, qualitative, and quali-quantitative contributions

Even if studies on local systems have attracted the attention of many theoretical scholars in the past, recently some empirical efforts have been made to test general assumptions within real fields, also thanks to more powerful data elaboration, easier accessibility to network-related software, and a relatively higher data availability. Even though quantitative contributions are more and more implemented, they are not free of

limitations; particularly, once they are settled in contexts where social issues as trust, friendship, kinship, reputation, status, etc. play a fundamental role since they are difficult to be measured. Moreover, some kinds of relations are often perceived by individuals and are not easily factually representable. In these cases, contents and meanings of ties are critically relevant.

Furthermore, quantitative analysis about local development with a network perspective may suffer from the risk of offering results that are de-contextualised from singular places where they are settled, even if relational possibilities can be highly affected by local conditions (e.g. history, local culture, embeddedness in a community of people, etc.). In this way, following Hassink and Gong (2017) and focusing on local systems, a place-based analysis should reveal issues and describe phenomena (as in a traditional quantitative study), as well as it should aim at understanding and explaining them (as it is common in a qualitative analysis)[5].

Analysis of networks, and particularly, SNA, have its origin in both a quantitative approach based on mathematical graph theory and a qualitative one on a part of network sociology; thus, once both methodologies are available, where one finds its own research limits, the other may get involved to go beyond through a complementary approach.

3.6 The relevance of investigations on sustainability

Finally, the large majority of previous literature mainly investigated successful local systems (for exceptions, see Hassink, 2010; Giuliani et al., 2018), and the few studies on their decline stressed political lock-ins as the main reason of negative effects, as well as contextual historical trajectories made by contingencies, unsuccessful entrepreneurial decisions, negative learning effects, and unpredictability (among others, Suire and Vicente, 2014). However, also an analysis of relational characteristics and; especially, network dynamics over time may be helpful in exploring reasons of local systems' deterioration in terms of job loss, performance decrease, and competitive disadvantages, and to foster resilient responses (Crespo et al., 2013; Boschma, 2015). At the same time, they are

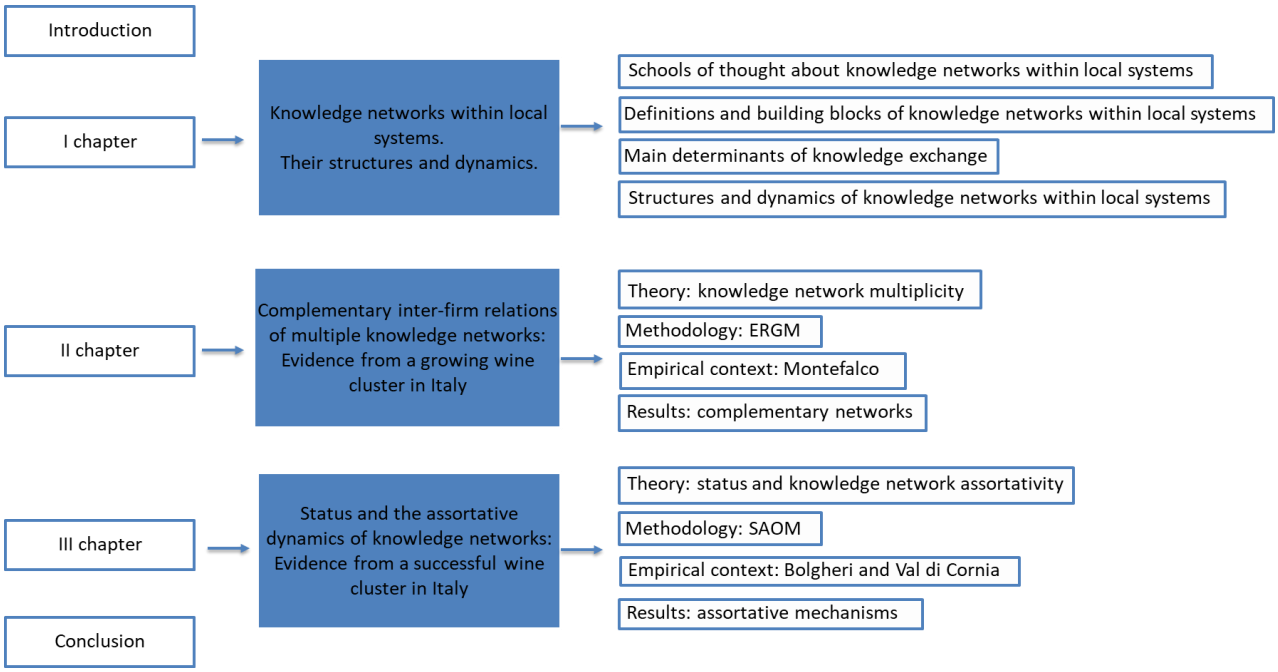
[5] Hassink et al. (2016) discuss complementarities between approaches by economic geographers and geographical economists and, thus, between qualitative and quantitative analysis. Particularly, they conclude proposing four main potential routes for an integrative approach: 1- "qualitative methods can be used initially to help develop quantitative measures" (p. 11); 2- "a predominantly quantitative study can be deepened with qualitative results to help interpret and explain the quantitative findings" (p. 11) ; 3- "quantitative results are used to help interpret predominantly qualitative findings" (p. 12); 4- "research is based on different methods, separately conducted, and the results from each approach are used to cross-validate the study findings ex-post" (p. 12).

complex systems made by interacting and continuously changing components over time; thus, identification of a decline may be difficult, since a downturn may be counterbalanced and hidden by other successful elements. This is particularly true in terms of social and environmental sustainability since almost all local system-based contributions only focus on economic performance and traditional growth. But, as in economics, environmental and social issues are more and more at the centre of the debate, so this point must be taken into account for the exploration of local systems working in long-term perspectives (Krueger et al., 2017). Thus, research should investigate the ways a network approach may contribute to detect or design sustainable development, inclusive growth, intra-generational equity, and responsible production and innovation. In other words, a network perspective may help us at thinking about sustainable places rather than only about firms' competitiveness, and local competitive advantage.

4 Aim and outline of the study

After the introduction, this research revolves around three main chapters and a common conclusion with both theoretical and empirical objectives for which Figure 4 provides an overview.

Figure 4: Overview of the PhD thesis



Source: our elaboration.

All of them can be framed within one common theoretical focus (studies on local development), one common methodological approach (network studies, and particularly SNA), and one common empirical field (the wine industry).

The introduction of the research gaps presented in Section 3 makes emerging the overall aims of this research:

- To identify a framework to study local development in relation to their knowledge network-related structures and dynamics.
- To focus this debate on a relational perspective; particularly, stressing the role that individual heterogeneity and relational multiplicity plays on the spread of knowledge.
- To empirically test the efficacy of the identified framework within the same industry, but, with two different and original databases.
- To implement two different methodologies of SNA for the study of knowledge network structures and dynamics.
- To identify possible policy implications and further research streams.

Particularly, Chapter I aims at answering the specific research question "what is the state of the art on knowledge networks within local systems?". It will provide a literature review on the aspects highlighted as research gaps in Section 3.1. Explicitly taking a network perspective, node-level, dyadic level, and structural level determinants of knowledge exchange and knowledge networks' dynamics are individuated. Starting from several relevant contributions in this literature, an original explanation of local systems evolution with a knowledge network perspective is provided.

Also, Chapter III will focus on the research gaps individuated in Section 3.1 and it aims at answering the specific research question "to what extent does status as the perceived relative qualities of a firm in a given market or organizational field affect knowledge network evolution over time?". Among the several individual characteristics (at firm-level) that affect knowledge network evolution, this part explores the role played by status since it is one of the individual determinants of knowledge networks' dynamics that have received little attention even if it critically affects relational decisions in contexts characterized by uncertainty, like local systems (Giuliani, 2013). Particularly, it analyses the impact of firms' status heterogeneity on the local spread of knowledge with the aim of investigating whether assortative or disassortative mechanisms are more likely to influence the uneven knowledge diffusion across firms over time.

Chapter II will focus on research gaps underlined in Section 3.2 from an empirical point of view and it aims at answering the specific research question "to what extent do multiple ties as different relational sets through which knowledge diffuses impact on the local exchange of knowledge?". Often knowledge networks in local systems are empirically modelled on the basis of one knowledge sharing mechanism while other typologies of knowledge networks that simultaneously may operate within the same local context can be (more) relevant to explain the local spread of knowledge. At the best of our knowledge, network multiplicity has received little attention in the literature (Ferriani et al., 2013). Particularly, this part investigates the role played by heterogeneous channels through which knowledge spreads among the same set of co-localized actors and it aims at exploring to what extent different networks impact on the local exchange of knowledge and to what extent they follow complementary or overlapping routes of diffusion.

Finally, the last part concludes with a summary of the main findings and it shows a few possible policy implications. Also, the main limitations of the study as well as a few future possible extensions are discussed.

We aim to answer these questions with an interdisciplinary approach mainly referring (but not limited) to two streams of the research. On the one hand, the continuous research of the reasons why industries cluster in space and why some places are more (less) successful than others (among others, Martin, 1999; Maskell and Malmberg, 1999); on the other hand, the equally continuous research of the reasons why some industries are likely to emerge and reproduce over time within certain places studied by scholars investigating determinants, structures, and dynamics of local development (among others, Becattini, 1990; Becattini et al., 2003)[6].

About the former, we particularly focus on both relational and evolutionary economic geography (for a comparison between the two, see Hassink and Klaerding, 2009), where the relational one "focuses on a relational understanding of economic action which is analysed in spatial perspective" (Bathelt and Glückler, 2011, p. 6) and the evolutionary one deals with "the processes by which the economic landscape – the spatial organization of

[6] Hassink and Gong (2017) highlighted that Barnes and Christophers (2017) include industrial districts and business clusters in a category that they call *Geographies of Business* (the other categories they identified are *Geographies of Capitalism*, *Geographical Economics*, and *Alternative Economic Geographies*). In this work we assume that economic geography sometimes adopts concepts related to local systems (among others, industrial districts and business clusters) as contexts where it tests its own concepts, while studies on local systems emerge from a different scientific history, they are likely to adopt different concepts, and they often focus on different aspects (for example, industrial organizations, innovation-related studies, production systems, etc.).

economic production, distribution, and consumption – is transformed over time (Boschma and Martin, 2007, p. 539). However, often contributions belonging to these schools do not extensively take into consideration that organizations they are studying are embedded in certain specific places and not in others, nor in a de-contextualized space.

About the latter, we particularly focus on studies about local development (Becattini et al., 2003), particularly in places where not exclusively the industrial organization plays a significant role for local sustainability and performance, but also society, a cultural environment, and an institutional setting. Even if location theories are intertwined with studies on local development, with this work we also stress the (economic and social) relations among different actors embedded in places. However, scholars interested in exploring determinants, structures, and dynamics of local development from this perspective may be less likely to pay attention, also from the methodological point of view, to (knowledge) networks in a dynamic perspective.

Weaving together strengths of the former with weaknesses of the latter and vice versa, but without any pretense of calling for a new all-inclusive paradigm, we draw on this plural theoretical background with the aim of introducing an interdisciplinary study that explores relational structures of knowledge networks and their dynamics in local systems.

Chapter I is a theoretical contribution written in the form of a literature review. Chapter II and Chapter III are empirical contributions based on quantitative analysis and they employ methods (Stochastic Actor-Oriented Model - SAOM and Exponential Random Graph Model - ERGM) that represent the state-of-the-art in the literature on knowledge networks. With the aim of minimizing the risk of de-contextualized analysis, two sections explaining specific contexts under study are provided in the two empirical works (Section 3.2, Chapter II and Section 3.1, Chapter III). Moreover, to have a more realistic picture of places under study, we use primary data directly collected from the field. This implies that surveys are conceptualized to address research questions and aims previously presented.

Chapter I

Knowledge networks within local systems.
Their structures and dynamics.

Abstract

This work reviews the literature about knowledge diffusion within local systems of clustered economic actors and, focusing on the role played by knowledge networks, several fundamental scientific contributions and topics are individuated. Stressing the inter-organizational perspective, scholars have already long recognised that knowledge spreads unevenly and selectively among co-located actors. This work individuated that an irregular knowledge diffusion is due to several intertwined reasons, such as the relevance of economic actors' traits and perceptions, homogeneity and heterogeneity across actors' features (e.g. different proximities), and structural mechanisms of interconnections.

After an exploration of the most important theoretical building blocks of knowledge and knowledge networks within local systems, a knowledge network-based interpretation of local systems' evolution is provided.

Keywords: knowledge network; diffusion of knowledge; industrial cluster; industrial district, local system.

1 Introduction

Recently, various scholars debated the scope of the Marshallian industrial atmosphere, where "*mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them, unconsciously*" (Marshall, 1920, p. 225). Particularly, a few recent contributions challenged this view, arguing that the diffusion of knowledge in a local system is not diffused "in the air" (Fitjar and Rodriguez-Pose, 2017). In this vein, knowledge does not spread uniformly across local actors, but it diffuses within a core group and in a selective and uneven way (Giuliani and Bell, 2005), given the presence of heterogeneity among actors' characteristics (Lazerson and Lorenzoni, 1999; Markusen, 2003) and their different cognitive roles, knowledge bases, and absorptive capacities (Giuliani, 2005, 2007; Asheim et al., 2011).

At the same time, several other contributions found out that a network perspective is a critical approach to analyse knowledge creation, diffusion, absorption, and use (Phelps et al., 2012). This line of research is increasingly investigated within local systems-like contexts (Ter Wal and Boschma, 2009), and a few of them explored reasons why some places are more (or less) successful than others basing on a relational perspective (Crespo et al., 2013). In this vein, for example, Becattini (1991) argued that an industrial district requires "the development of a permanent network of links between the [industrial] district and its suppliers and clients" (p. 38) and Porter (1998) argued that "a cluster is a form of network" (p. 226).

Particularly, firms are entities that can efficiently transfer knowledge and they are more likely to innovate by recombining already functioning capabilities and social relationships (Kogut and Zander, 1992), leading to a "combinatorial knowledge" of specialized knowledge bases of heterogeneous actors (Strambach and Klement, 2012). In this perspective, a firm may be described as the result of a mechanism of integration of individual experts and knowledge (Grant, 1996).

In this work, we review the existing theoretical literature and the most recent empirical contributions on knowledge network structures and dynamics within local systems. After the introduction, in Section 2 we review definitions and building blocks of knowledge and knowledge networks to understand roles they play in local systems. In Section 3 we surveyed contributions that pay attention to roles played by actors' characteristics and perceptions for the exchange of knowledge, homogeneity/heterogeneity of their features, and we explore the most common network mechanisms for the exchange

of knowledge working within local systems. In Section 4 we exploit these concepts to suggest a novel interpretation of local systems' evolution from a knowledge network perspective. Finally, Section 5 concludes with a critical assessment of the existing literature on the topic, offering some ideas for a new research agenda.

2 Definitions and building blocks of knowledge categories within local systems

Inter-firm relationships are often studied as one of the critical channels of knowledge sharing (Karlsson and Stough, 2005). For example, a few scholars explored relationships among firms within the same industry where also entities that operate outside the local system's boundary play a critical role (Asheim and Isaksen, 2002), others investigated interconnections across firms belonging to different (and often related) sectors (among others, Schilling and Phelps, 2007).

Moreover, also inter-organizational studies, where firms are only a part of the story, attracted the attention of several scholars. In fact, not exclusively economic actors, like institutions, research centres, universities, consulting companies, etc., are most of the time considered to highly affect local systems' performance and their dynamics since they rule (or may be the source of) innovation or problem-solving related issues (Menzel and Fornahl, 2009).

Knowledge networks are sets of nodes interconnected by relationships that facilitate or limit acquisition, transfer, and creation of knowledge (Yayavaram and Ahujam 2008; Phelps et al., 2012). Even if definitions of different knowledge-related forms are often overlapping since they are intrinsically interrelated and boundaries among them are not so easily identifiable, to have a wide picture of different roles played by knowledge within local systems we may categorize it from several perspectives.

First, following Phelps et al. (2012) knowledge needs to be created, transferred, and adopted. Knowledge creation is the emergence of new ideas, practices, inventions, or products; knowledge transfer is the sharing process across sources and receivers, and it requires a process made with acquisition and absorption; knowledge adoption is the capacity of use and implementation in real processes, practices, or products.

Second, the literature identified at least three main different knowledge bases (Asheim and Coenen, 2005). Analytical knowledge refers to economic activities based on formal models and high levels of codification (for example, science-based knowledge in biotechnological industry), synthetic knowledge refers to economic activities where

combination of existing knowledge leads to innovation (for example, engineering-based knowledge in industrial machinery sector), symbolic knowledge refers to cultural artefacts characterized by aesthetic attributes, design, and images (for example, arts-based knowledge in film or music industry).

Third, basing on codification and codifiability, knowledge may be located across different degrees between tacitness and explicitness (Polanyi, 1966; Breschi and Lissoni, 2001), where the former is less easily codifiable and is more dependent on face-to-face contacts, and the latter is relatively more easily codifiable and more dependent on formal settings. This is a critical categorization for local systems because the more knowledge is tacit the more it is difficult to be imitated by others and it may be an efficient conduit of details and highly specific knowledge, but for the same reasons the more knowledge is codifiable, the easier it spreads since it is less difficult to understand (Bell and Zaheer, 2007). Related to this and regarding settings where knowledge is created and shared, it can be distinguished by formal and informal (Allen et al., 2007), where the former emerges within planned contexts and the latter into unplanned ones.

Fourth, four main knowledge contents are identifiable (Johnson et al., 2002). If it is about facts it is defined as know-what, if it is about principles and general laws it is defined as know-why, if it is about ability to do something (skill) it is defined know-how, and if it is about who knows what and who knows what to do is defined as know-who.

Fifth, two main knowledge-related structures may be identifiable (Tallman et al., 2004). On the one hand, component knowledge consists of specific resources, skills, and technologies belonging to identifiable parts rather than a system as a whole; on the other, architectural knowledge is a system of routines for coordination and integration of component knowledge.

Finally, past contributions proved that labour mobility, research collaborations, formal alliances, spin-off processes, informal advice sharing, friendship, trade associations, or client-supplier's relations – among others – may critically affect knowledge diffusion in local systems. This opened a rich debate where Malmberg et al. (1996) distinguish by knowledge embedded in physical capital (e.g. materials, machinery, etc.), knowledge embedded in human capital (e.g. management, experts, etc.), and knowledge embedded in social capital (e.g. rules, business practices, institutions, etc.), Uzzi (1997) distinguishes by market-based (arm's length ties) and close relationships (social and embedded ties), Balland et al. (2016) divide in technical know-how, market information, and business knowledge, and Konzelmann and Wilkinson (2016) argue that technical knowledge refers

to functional knowledge for the production process made by objective and impersonal interconnections; while, social knowledge refers to every kind of subjective and personal interconnections that, in turn, are fundamental to create a social structure also useful for the existence of formal knowledge channels and the reproduction of technical knowledge, and, on a wider perspective, it operates like an instrument of coordination and control.

3 Network determinants of exchange of knowledge within local systems

Several of the concepts presented above have been theoretically and empirically investigated over the last few years, especially in organizational settings where firms play a fundamental role. The starting point is that once two actors interact, they exchange a portion of their own knowledge leading to "localized learning" (Malmberg and Maskell, 2006). The latter plays a critical role in this debate; particularly, the literature stressed the importance of learning by doing and learning by using (Asheim and Coenen, 2005), and already Sabel (1993) introduced an often-forgotten concept of learning by monitoring, drawing a model that has rules and practices at the core of coordination of activities among co-localized actors that in turn leads to collective learning. Moreover, Lundvall (1992) added the concept of learning by interacting, as the one that connects actors by observing and imitating. At large, Menzel and Fornahl (2009) referred to a more general concept of localized learning as the critical mechanism to exploit differences of skills and knowledge bases among different actors.

We individuated three main categories of determinants of exchange of knowledge within local systems. First, a few scholars explored roles played by individual characteristics (node level). Second, others studied to what extent similarities and differences between local actors affect structures and dynamics of knowledge networks within local systems (dyadic level). Third, the most common relational mechanisms scholars investigated at both the dyadic and whole-network levels are also individuated.

3.1 Knowledge networks, individual attributes and perceptions

Glückler's (2007) idea that firm-level decisions (as the micro-foundations of tie creation) are one of the fundamental factors affecting knowledge network's structures and dynamics, opened the door to an intense stream of agency-based research, where actors-focused analysis is seen as a useful research stream to understand relational mechanisms within local system-like areas (Hassink et al., 2018). In fact, over the last few years, roles of firm-level attributes have been empirically investigated, often proving that they

significantly impact on the exchange of knowledge (among others, Giuliani and Bell, 2005; Samarra and Biggiero, 2008; Broekel and Boschma, 2011). However, having an objective judgment of potential benefits of interacting with other actors may be difficult, thus they usually operate in an environment of uncertainty (Ibarra and Andrews, 1993) and they tend to interact with others that are perceived as actors capable to create new knowledge and improvements; while, attractive firms are less likely to interact with others having a lower level of perceived capabilities in terms of knowledge to offer (Crespo et al., 2013).

For example, actors with higher levels of status, which refers to the perceived relative qualities of a firm in a given market or organizational field and that may be related to an established level of individual reputation, may be more likely to receive advice requests than actors with lower levels (for an exception, see Giuliani, 2013). Others found out that also the number of ties can inherently affect the probability of other interactions (Giuliani and Matta, 2013) and, firms with a high level of reputation (e.g. prestigious actors) tend to centrally locate within a knowledge network (Stuart, 1998). In this way, knowledge networks are often based on hierarchical structures that show a tendency to reinforce or increment over time (Gould, 2002). In fact, Giuliani and Bell (2005) prove that knowledge diffusion mainly happens within core actors with high levels of absorptive capacity, rather than within peripheral (or isolated) agents with low levels of absorptive capacity. Moreover, firms with higher capabilities are more likely to be at the core of a knowledge network and firms at the core of a knowledge network tend to be more attractive over time, leading to a process where firms' capabilities and network positions reinforce each other's over time (Ter Wal and Boschma, 2011).

Generally speaking, this confirms the presence of hierarchy in network structures. In fact, on the one hand, this is related to in-degree popularity as the tendency of actors with an high number of (outgoing) knowledge ties to attract many incoming ties (for example, as empirically proved by Giuliani and Matta, 2013; Castro et al., 2014; Nicotra et al., 2014); on the other hand, to out-degree activity, as the tendency of actors with an high number of (outgoing) ties to transfer knowledge to many different others (for example, as empirically proved by Balland et al., 2015). Those two networking behaviuors critically affect knowledge diffusion to the extent that the former can be interpreted as the tendency to be sought by many other actors as knowledge sources, the latter can be interpreted as the tendency to seek many others as knowledge sources (Zappa and Robins, 2016).

However, central positions sometimes can be also dangerous since they can lead central actors to be limited in the novelty of shared knowledge that is more likely to be

carried from distant actors. For this reason, a mix between close and distant linkages should be a favourable solution to reproduce a well-working knowledge network, since this may be a sustainable way to innovate and reproduce over time the system as a whole (Nooteboom et al., 2007; Ter Wal and Boschma, 2011).

Moreover, innovation capacity may be another critical driver of knowledge diffusion, since certain firms possess higher levels of novel knowledge than others and only those actors can decide to share this internal knowledge when they act in well-performing local systems (on clusters, see Giuliani et al., 2018).

Furthermore, firms that are more opened to knowledge external to a local system, are also more likely to transfer it internally since this knowledge is different from the one already known by other co-located actors (Morrison, 2008) and they expect to be reciprocated in the future (Giuliani and Bell, 2005; Giuliani, 2011, Graf, 2011; Giuliani et al., 2018). These categories of knowledge are usually critical drivers for the rejuvenation process and useful instruments against potential lock-ins (Crespo et al., 2013).

Among other several individual features, scholars usually control for characteristics as age and size. For example, Balland et al. (2013) show that size in terms of firms' employees affects exchange of knowledge in the video game industry. Molina-Morales et al. (2015) in a study of a foodstuffs cluster in Spain and Lazzeretti and Capone (2016) in a study of a cluster of cultural goods in Italy control for actors' experience and they find that it positively affects knowledge network dynamics. On the contrary, Ebbers and Wijnberg (2010) find a negative result of individual experience in a study of alliances in a film industry, leading them to argue that more experienced actors are less likely to interact and Juhasz and Lengyel (2017) find a negative parameter for firms' experience when controlling for the persistence of ties in a printing and paper product cluster in Hungary.

3.2 Knowledge networks, actors' homogeneity and heterogeneity

Several scholars frequently discovered a critical role played by similarities and differences across characteristics and attributes of economic actors (Crespo et al., 2013); especially, from a relational perspective since they may exploit compatibilities and synergies; or, they may be more attracted by different others to discover novelties and implement creative development (McPherson and Smith-Lovin, 1987). In this vein, McPherson et al. (2001) argue that homophily tends to persist over time more than heterophily and they add that rarity in actors' attributes can foster the creation of relationships and McPherson and Smith-Lovin (1987) claim that relationships among

actors with different attributes are more common between organizations rather than persons.

Crespo et al. (2013) investigate the impact of both assortativity and disassortativity in clusters from a wide perspective. They argue that a network is assortative once the most connected actors are mainly tied with other highly connected ones and it is disassortative once the most connected nodes are mainly tied with weakly connected nodes. In this way, the degree of assortativity may be interpreted as an explanation of knowledge flows in core-periphery structures (Borgatti and Everett, 2000), where highly connected actors are tied in the core, while poorly connected actors are in a relational system in the periphery. From another point of view, those authors argue that assortativity may be related to a lock-in effect since it reduces the possibility of acquisition of new ideas. The contrary might be said for disassortative networks since they show a higher amount and/or higher frequency of relationships among core and peripheral actors.

Several empirical contributions explore those aspects. For example, Cantner and Graf (2006) and Ebbers and Wijnberg (2010) find a positive effect of homophily on exchange of knowledge; while, Balland et al. (2013) discover a negative effect. Moreover, Castro et al. (2014) and Nicotra et al. (2014) prove a positive effect of heterophily; while, Molina-Morales et al. (2015) discover a negative impact.

Within this debate, the so-called "proximity" school emerges as one of the most promising streams of research (Boschma, 2005; Torre and Rallet, 2005).

A first stream of literature investigates the role played by spatial proximity among economic actors as firms, proving that it is strictly linked to the tacit component of knowledge (Malmberg and Maskell, 2002). Knowledge can spread tacitly among actors that are neighbours through channels embedded in social interactions (e.g. face-to-face encounters). For this reason, knowledge diffusion can be spatially bounded within the region where those economic actors are based (Anselin et al., 1997; Feldman and Audretsch, 1999). Consequently, the degree of geographical proximity characterizing a firms' agglomeration may be considered as a primary source for the local exchange of knowledge (Audretsch and Feldman, 1994; Bathelt et al., 2004).

However, starting from Rallet and Torre's (1999) decoupling between the geographical and not-geographical dimensions of proximity, other scholars argue that geographical proximity is neither a sufficient nor a necessary condition for learning and innovation (Boschma, 2005) and for the spread of knowledge among all the actors belonging to a region (Giuliani, 2007).

Over the last twenty years, different kinds of proximity have been identified other than the spatial interpretation of geographical proximity, but particularly four of them are still at the core of the debate (i.e. cognitive, social, institutional, and organizational) and several scholars investigate how they interact to overcome the problem of coordination, uncertainty, and to prevent negative outcomes (Boschma, 2005). The five proximity dimensions are interrelated and can act as a substitute for the other forms of proximity or they may reinforce them. This relational structure may lead to two main consequences. On the one hand, a certain degree of cognitive proximity and its related absorptive capacity are the tools for effective interacting learning and innovation and the other four dimensions of proximity may solve the problems of coordination and control since they facilitate knowledge transfer among actors (Boschma, 2005); on the other, too much proximity may have a negative impact on innovation in terms of low level of openness and flexibility (lock-in problem) and too little proximity may be dangerous for interactive learning and network creation; effects that will be called the "proximity paradox" by Broekel and Boschma (2011).

From the empirical point of view, only a few contributions found out a negative impact of one those categories of proximity; particularly, Molina-Morales et al. (2015) for cognitive and institutional proximities in a study of a foodstuffs cluster in Spain, Geldes et al. (2017) for social and institutional proximities in a research on an agribusiness cluster in Chile, Capone and Lazzeretti (2018) for institutional proximity in an analysis of a cluster of cultural goods in Italy, while Ter Wal (2013) found out that the direct impact of geographical distance on tie formation decreases over time in the study of an inventor network in German biotechnology, and Broekel and Hartog (2013) discovered that geographical distance hinders link creation in a chemical industry in Germany.

Other than the individuation of the five main kinds of proximity, a few authors introduced other categories. For example, Gill and Butler (2003) claimed that also similarities in terms of culture may play an important role in facilitating communication (cultural proximity), Greunz (2003) indicated a similar effect when different actors shared technological experiences and knowledge bases (technological proximity), Caniëls et al. (2014) identified a critical role played by similarities among individual characteristics (personal proximity), Boggs and Rantisi (2003) identified propinquities in terms of interpersonal interactions that are non-pecuniary, based on social capital and built on what Storper (1995) named "untraded interdependencies" (relational proximity), Morgan (2004) introduced that also virtual communications (in the cyberspace) and electronic connectivity

may open to new ways of interactions (virtual proximity), and Cooke (2019) recalled that also all the external and internal relationships of an economic actor that are finalised for the identification of useful knowledge may be considered as another category of propinquity (managerial proximity).

3.3 Knowledge networks and their structural mechanisms

Several scholars investigated the most recurrent structural mechanisms involved in the exchange of knowledge at network level identifying them as traditional outcomes of relational micro-foundations like agency, opportunity, inertia (and random factors) (Ahuja et al., 2012). Particularly, those aiming at analysing knowledge networks within local systems, often started from common relational architectures (for example, dyads and triads) to investigate frequent relational mechanisms of knowledge diffusion. Particularly, reciprocity, transitivity, cyclicity, and density, are often found of affecting knowledge diffusion within local systems.

Reciprocity means that actors receiving a knowledge transfer from others are likely to reciprocate the link and this mechanism may incentivize them to reiterate relationships over time. Thus, it indicates an exchange of knowledge of the type $i \rightarrow j$; then $j \rightarrow i$. In this vein, a few investigations empirically proved the role of reciprocity as a critical mechanism explaining knowledge network structures and dynamics within local systems (for example, Giuliani, 2013; Giuliani and Matta, 2013; Balland et al., 2016; Giuliani et al. 2018).

Transitivity, also known as clustering or cliqueness, illustrates that two actors are more likely to interconnect once they have a previous common actor than they do not. Thus, it indicates an exchange of knowledge of the type $i \rightarrow j$; $i \rightarrow h$; then $j \rightarrow h$. This mechanism is often related to trust, since the common actor may increase the confidence of the other two in creating and maintaining a relationship. Moreover, on the one hand, it is an efficient instrument to mutually monitor opportunism since information on deviant behaviours rapidly diffuses in network contexts (particularly within dense ones); on the other hand, it may prevent such an action increasing the expected cost of opportunistic behaviour (Walker et al., 2000). Concerning this - among others - Ebbers and Wijnberg (2010), Boschma et al. (2013), Broekel and Hartog (2013), Giuliani (2013), Ter Wal (2013), Castro et al. (2014), Nicotra et al. (2014), Balland et al. (2016), and Lazzeretti and Capone (2016) agree that it is a significant factor increasing inter-organizational exchange of knowledge.

Cyclicity is the tendency of exchange of knowledge in cycles and it is proved by several contribution that it is a critical endogenous network effect that help explaining knowledge diffusion structures within local systems. In other words, it indicates an exchange of knowledge of the type i → j; j → h; then h → i. Several empirical papers found a negative coefficient for cyclicity and they interpret this result as an indicator of a certain degree of hierarchy in knowledge sharing (for example, Balland et al., 2016; Juhasz and Lengyel, 2018).

Furthermore, a few scholars investigated the role played by density as the overall tendency of actors to form ties. It is computed as the degree of connection based on the ratio between the number of actual ties and all possible connections. A few contributions in local systems empirically investigated the influence of density on inter-organizational and knowledge network structures and dynamics (for example, Balland et al., 2013; Giuliani and Matta, 2013; Ter Wal, 2013; Castro et al., 2014; Giuliani et al. 2018), and this measure results negative in all specifications as it can be interpreted as the cost of forming relations (Snijders et al., 2010).

4 Dynamic knowledge networks within local systems evolution

Dynamic investigations about the evolution of economic factors have mainly focused on life cycles (Bergman, 2009; Menzel and Fornahl, 2009, for an alternative conceptualization based on multiple path dependency, see Belussi and Sedita, 2009) and adaptive cycles (Martin and Sunley, 2011) and this fundamental substratum opened the way for first efforts in evolutionary interpretation of different localized productive systems (Swann et al., 1998; Scott, 1999; Becattini, 2004). However, even if there is a diffuse scholars' effort in explaining local system dynamics using traditional models and a few scholars are broadening the view with new approaches on cyclical developments (Fornahl et al., 2015), knowledge network evolution in local systems is still an underdeveloped field of study (Boschma and Fornahl, 2011)[7].

At the best of our knowledge, Ter Wal & Boschma's (2011) contribution on cluster evolution is the first one that has offered an extensive picture of an ideal-typical evolution of local systems-like context basing on characteristics and dynamics of knowledge networks (in addition to features of firms at the micro-level and of industries at the macro-

[7] A first explicit recognition of the importance of an analysis of a local system (particularly a cluster-based) evolution can be found in *Clusters and the new economics of competition* (Porter, 1998), but an in-depth study was still not offered at that time (Martin and Sunley, 2011).

level). With this section we aim at expanding on the exploration of the knowledge network level focusing on network determinants of exchange of knowledge within local systems previously presented. Thus, a knowledge network-centred investigation of their structures and dynamics is proposed, highlighting stylized elements and features through the emergence (birth), the growth, the mature phase, the transformation (if any), and eventually the disappearance of such systems.

4.1 Emergence

Menzel and Fornahl (2009) argued that relations among companies play a critical role during the emerging phase. Particularly, this stage is characterized by uncertainty and a low awareness of other economic actors, thus networking is expected to be low in terms of number of interactions and amount of shared knowledge or its quality. These few interactions are mainly determined by the most apparent characteristics of other local actors even if they only partially represent the potential benefits given by an interaction (Bergman, 2009).

The emerging phase is difficult to be recognized and "remains largely obscure, in the sense that is almost impossible to determine ex ante" (Maskell and Malmberg, 2007, p. 611). Focusing on knowledge networks, actors rarely interact and can take advantage of synergies, but a few actors already presents potential characteristics of future development pattern and the institutional, social, and cultural context that may foster knowledge sharing can be already present (Menzel and Fornahl, 2009). In fact, in this phase, the place where the local system is emerging can already "host a kind of historical 'sediment' of knowledge and competencies, as well as local culture" (Belussi, 2018, p. 1803). Moreover, at the beginning of their existence knowledge networks' structures are more likely to be unstable due to lack of knowledge (Suire and Vicente, 2009).

Consequently, in this phase, knowledge networks are generally highly fragmented, composed by a limited number of actors, and characterized by a significant number of isolates and low network density. In this phase, knowledge is often exchanged without a clear idea of long-term development possibilities, it is sometimes transferred by chance, and it is likely to have general contents. Particularly, in most of the cases it is shared within informal settings, and in formal ones when local systems are mainly the result of a top-down project or of a policy-related initiative.

4.2 Growth

If a local system does not fail during its emergence, a growing phase later or sooner starts. Local systems may attract new entrants that bring with them novel knowledge and, once interacting with incumbents, create new combinations of knowledge and new learning processes. Moreover, attracted by gain opportunities, former employees of a local firm can start their own companies, thus participating at the process of the spread of knowledge (Klepper, 2001). Furthermore, external knowledge plays a critical role as well (Bathelt et al., 2004). In fact, during this phase a few firms can act as gatekeepers because they transfer knowledge originated elsewhere within the local system and they contribute to its circulation among local actors, as empirically proved by Giuliani, 2011 with a study of a wine cluster in Chile, or theoretically reviewed by Belussi (2018). In this way, a significant number of new interacting partners and new potential relations emerge, creating several possibilities for innovation networks as well (Menzel and Fornahl, 2009).

Consequently, in this phase, knowledge networks generally decrease their degree of fragmentation and the number of isolates, while they increase the degree of density and the number of members belonging to them. In this phase, exchanged knowledge is more specific, several different knowledge networks may simultaneously operate, and local actors interact with other relevant sources of knowledge outside the local system. Also, knowledge is exchanged in formal settings where a lower level of knowledge absorptive capacity is required, even if informal ones continue to be a critical locus for its diffusion.

4.3 Maturity

A mature stage can be characterized by increasing similarities (decreasing heterogeneity) among economic actors and by the presence of more codifiable knowledge (Menzel and Fornahl, 2009). In this way, exchanges of knowledge are influenced by expected benefits of the exploitation of synergies among relatively similar actors (Tichy, 1998) in systems with both higher or lower levels of diversity (Menzel and Fornahl, 2009). After the initial unstable structure, knowledge networks become more stable (Suire and Vicente, 2009).

Consequently, in this phase, knowledge networks generally present a relatively stable degree of density, degree of fragmentation, and number of members and of isolates. In this phase, knowledge that is perceived to be useful and in line with the local system dominant development trajectory is shared, bringing to a selection of knowledge networks as well.

The latter are frequently embedded in formal environments and novel knowledge is less likely to be transferred.

4.4 Decline

One of the reasons for a decline can be due to local actors that, leaving a local system, can decrease the amount of knowledge and all the related combinatorial possibilities (Van Klink and De Langen, 2001). In this way, the amount and quality of knowledge may be fixed, heterogeneity is no more sustained (Menzel and Fornahl, 2009) and the related learning possibilities may decrease (Pouder and St. John, 2003). In fact, "as the number of firms is reduced, sophisticated networks are no longer necessary, as no new information has to be transferred; nor clusters are any longer competitive, compared with vertically integrated firms, as the number of nodes has been drastically reduced. The smaller the networks, however, the less—and the less new and stimulating—information they can provide, the lower therefore the chance of the cluster inventing new products, new processes, or a new organization" (Tichy, 1998, p. 230).

If a declining phase persists, a local system may be characterized by knowledge networks with low levels of flexibility, where actors belonging to them are not ready to adapt in front of both internal or external changes and to renew themselves (Grabher, 1993), where they are not able to unlearn procedures and routines that were successful in the past since they are more likely to "look for solutions close to already existing routines" (Maskell and Malmberg, 2007, p. 614), and to be more closed and with a decreasing absorptive capacity (Ter Wal and Boschma, 2009). If knowledge (and knowledge sharing) is not renewed or no new applications of previous knowledge is detected, an increasing level of homogenization among individual and relational characteristics play a critical role and myopic behaviours of local actors can lead to immobilize the entire system, thus hiding different development trajectories and eventually leading the entire systems towards negative lock-in processes (Maskell and Malmberg, 2007).

Consequently, in this phase, knowledge networks are expected to present a relatively stable or decreasing degree of density, a relatively stable or increasing degree of fragmentation, the number of members is likely to be stable or to decrease, while isolates are fixed or potentially increasing. In this phase, knowledge is in line with the local system typical development trajectory and only a very few interactions with new sources of knowledge outside the local system emerge. Thus, knowledge is now characterized by a very low level of novelty, mainly leading knowledge networks considered at the core of

the previous stage to persist over time with fixed or decreasing interactions and composed by mainly homogeneous actors.

4.5 (Possible) rejuvenation

Before the disappearance of a local system, a transformation towards another form of a local system is possible. Knowledge networks play a critical role in this shift, because they may "allow technological 'pre-adaptation' in which firms accumulate a diversity of technological knowledge" (Martin and Sunley, 2011, p. 1313). This implies a novel increase of the level of heterogeneity among individual (in terms of involved actors) and relational (in terms of interacting actors or knowledge content of their interactions) characteristics of local actors in order to open the door to new knowledge and/or new combinatorial knowledge sets that can lead to a different local systems' development.

In this way, if the local system does not disappear, it can renew with related or with completely new development paths (Menzel and Fornahl, 2009). Particularly, it can happen if a certain degree of local heterogeneity is maintained over time (Rigby and Essletzbichler, 2006), "extrovert" actors that are members of non-local networks transfer parts of knowledge generated elsewhere (Tappi, 2005), or serendipitous or casual factors (as unintentional mistakes, accidental elements or side effects) take action (Staber, 2007). In this way, new interacting sets can be generated among different actors, leading to original learning processes, novel knowledge, and potentially rejuvenation at the systemic level.

On the one hand, a series of periodical adjustments and gradual innovation processes may lead to a rejuvenated local system that is likely to operate in line with previous technological domain (Tappi, 2005). In this case, gradual knowledge network dynamics are expected as well, with economic actors rarely changing interacting partners and relatively focused on knowledge in line with the previous one. On the other hand, more radical innovation through unrelated diversification (Boschma, 2017) can impact on a local system, leading to new sectors or original business models (Tödtling and Trippl, 2018) and, generally speaking, to new development opportunities (Dalum et al., 2005). In this case, new knowledge networks in terms of knowledge content and component actors may emerge, new categories of knowledge may substitute the ones originally shared between pairs of networked actors, while, some knowledge networks may disappear if they result obsolete.

5 Conclusions

Actors embedded within local systems often exchange portions of their knowledge even if they are rivals and they operate into uncertain environments. Particularly, they do not have a whole picture of potential effects of knowledge sharing with others, they cannot perfectly understand what kind of knowledge they need, and where it is available; thus, they frequently base networking decisions on others' reputation and on their apparent characteristics (Nooteboom, 2003). However, some of them are more likely to exchange knowledge via interactions because of mutual interest, reciprocity, and because they are more likely to share a common history, values, culture, norms, and a communication system (Rutten and Boekema, 2007). All those features lead actors to interact in an environment where trust play a fundamental role (Lorenzen, 2001).

With an extensive survey of the literature, we distinguished determinants of knowledge networks by node-level characteristics (i.e. features of an actor) and dyadic level ones (i.e. similarities or differences of the same characteristics between two actors). Moreover, we explored the most common relational mechanisms affecting knowledge networks structures.

Particularly, we found that different contributions proved that actors' characteristics (i.e. firm-level) play different roles for the explanation of knowledge networks' structures in local systems and they may have both positive or negative influence (or no influence) on their dynamics (Ahuja et al., 2012). They analysed knowledge networks controlling for features like actors' status, reputation, experience, size, openness to non-local knowledge, innovation capacity, proving that they may affect knowledge networks in the same direction or in the opposite one. In this way, if a characteristic may be more attractive for other actors' purposes of relations, other actors' features may be simultaneously less attractive (Rivera et al., 2010). However, the extent to which different aspects may substitute each other is still to be explored; for example, one actor may interact with another one since it is attracted by one kind of features, while the latter may reciprocate the tie since it is attracted by another kind of characteristics. Moreover, traits that are more likely to avoid or interrupt an interaction are not enough explored.

At the dyadic level, we surveyed several contributions that study to what extent homophily or heterophily are more likely to induce an interaction between two independent actors within a local system. In other terms, we studied whether previous contributions found that local actors prefer linking with similar or different others (assortativity and

disassortativity, respectively). Contrasting results emerged in favour of both relational determinants of exchange of knowledge. Anyway, the related-literature stressed that even if economic actors are likely to interact with similar others by their very nature (leading local systems to be more hierarchically structured over time), disassortativity can be a relevant mechanism in order to have different and novel knowledge and, in this way, to decrease the likelihood of different kinds of negative lock-ins (Crespo et al., 2013). Furthermore, proximity and knowledge networks are strictly interrelated, since the former affects knowledge ties that are the structure of the latter. Powell et al. (2005) made a step forward including the role of time and Balland et al. (2015) argued that "in the short run, proximity creates knowledge networks, in the long run, knowledge networks create proximity" (9). From another point of view, it means that actors related with knowledge ties, tend to affect their individual attributes over time, and this process may lead those actors to become more proximate. However, relations, proximities, and actors have a different rate of change, since proximities and relations may change faster than actors' attributes (Gay and Dousset, 2005). Moreover, the latter may be considered as one of the most relevant relational tendency to build flexible network structures that are readier in front of unexpected (also external) shocks (Crespo et al., 2015). However, as critically underlined by Cooke (2019), the similarity paradigm is still dominant, while less effort has been made by scholars in understanding differences. In fact, "this is consistent with a 'specialisationist' thesis in relation to cluster-formation rather than a 'diversificationist' one that celebrates difference rather than uniformity…" (Cooke, 2019, p. 13).

Within this category, several studies focused on the role played by proximities. This study explores three main passages from the original division between geographical and not-geographical proximity (Torre and Wallet, 2005), to the introduction of the five pillars of proximity (namely, geographical, cognitive, institutional, social, and organizational), to the enlargement of the concepts to – among others - personal (Caniëls et al., 2014), cultural (Gill and Butler, 2003), technological (Greunz, 2003), or virtual (Morgan, 2004) proximities. We found that several contributions empirically proved that proximities not only favour exchange of knowledge, but they can also hinder its diffusion into specific situations (i.e. cognitive and institutional proximities). However, even if scholars conceptually call for the relevance of more analysis of interconnections among different proximities and their evolution over time, at the best of our knowledge, empirical studies are still more likely to be focused on static and linear representations. In this way, as

introduced by Cooke (2019) still more effort is needed to delineate proximities as "fluctuating presences and absences over historic space and time" (Cooke, 2019, p. 1).

Furthermore, we stressed that also network-related features and mechanisms (i.e. transitivity, reciprocity, cyclicity, density), other than interconnections mainly influenced by node and/or dyadic level determinants, play a critical role in explaining relational structures and dynamics (Ahuja et al., 2012).

We propose to interpret those different levels of heterogeneity in terms of multiform heterogeneity (originally introduced by Blau, 1974), where "multiform heterogeneity means that network ties may be between individuals who are simultaneously similar and different, sharing similarities on some dimensions and differences on others" (Rivera et al., 2010, p. 97). In this vein, local systems can be represented by complex architectures where different determinants can affect each other's, and they can play different roles if they are investigated in different time and places. Moreover, different typologies of learning processes that mainly emerge from node and dyadic level heterogeneities, once are investigated with a dynamic perspective, can transform actors' characteristics and their relations as well, since they transform knowledge bases over time. In other words, heterogeneities lead to learning and in turn learning increases heterogeneity.

In addition, it emerged that several contributions proved that knowledge is likely to be embedded in places, as well as the spread of portion of knowledge among localized actors, but – the other way around - less effort has been made in understanding to what extent different places may erode or hinder knowledge diffusion, for reasons other than institutional (e.g. cultural, social, etc.). Moreover, from this review, it also emerged that from the contextual point of view, scholars are still inclined to investigate successful local systems rather than decreasing ones (for exceptions, see Hassink, 2010; Giuliani et al., 2018), and from the relational point of view, empirical contributions are still more inclined to study creation of new links, rather than their maintenance over time or their disappearing (Juhasz and Lengyel, 2018, empirically tried to move forward this research gap). Those gaps may be a focal point for further research.

Furthermore, scholars found out that critical determinants of knowledge network dynamics can be found in event happened in the past. However, actors belonging to local systems should also picture the future in order to create the conditions to innovate and for being competitive, sustainable and performative, or in other terms, they need to learn "from the future […] giving serious attention to collective reflections, observing to check them,

opening the mind for sensing and "presencing" an emergent future, crystallising the new idea, prototyping it and finally, performing or implementing it." (Cooke, 2012, p. 158).

To conclude, individual agency, degree of heterogeneity/homogeneity, place specificities, and eventualities matter for knowledge network structures and evolution, but all those aspects, their intensity and all their facets are context dependent. In this way, knowledge networks, their determinants, their structures, and their evolution, are core factors in investigating both benefits and costs, as well as strengths and weaknesses, of certain local systems.

However, this work presents a few limitations. First, we need to underline that the review mainly considered quantitative empirical studies, particularly when surveying contributions on knowledge network evolution. Second, in this review, actors' positions and their related network configurations like – among others – structural holes or brokerage roles, are only partially investigated. Third, the above presented knowledge network evolution within local systems is an ideal typical construction based on stylized facts that cannot fix every real situation.

To go beyond those issues, also qualitative empirical research (i.e. qualitative case-studies) should be taken into consideration. Furthermore, several other network configurations investigated by network scholars may clarify also critical aspects of knowledge networks within local systems. Moreover, how long a certain local system operates within a phase, whether a stage exactly follow the previous one in the order previously presented, and when a local system possibly shifts to another one is something that also opens the door for future research. On that route, more place and context-dependent investigations as well as interpretations, should be addressed in future.

Chapter II

Complementary Inter-firm Relations of Multiple Knowledge Networks. Evidence from a Growing Wine Cluster in Italy.[8]

Abstract

Studies on economic actors' relationships and network structures have attracted more and more attention from several scholars, but surprisingly little is known about the role played by heterogeneous knowledge ties among the same set of actors and to what extent they follow overlapping or different routes of exchanging knowledge. In this vein, an investigation of multiple knowledge networks in clusters is a fundamental approach to interpret the reasons for regional innovation and economic performance. With an original dataset comprised of data collected by surveys directly administered in local wineries in the Montefalco wine region of Italy, we aim to analyse the roles played by different local knowledge ties within a sector that is critically driven by the exchange of knowledge among economic actors. Social Network Analysis and Exponential Random Graph Modelling were applied in order to investigate the driving forces of the knowledge flows. The empirical results show that different kinds of relationships positively impact the spread of knowledge, but they are different in magnitude, and they follow complementary routes of exchange rather than overlapping ones.

Keywords: multiple networks; knowledge diffusion; Exponential Random Graph Model; industrial cluster; wine industry

[8] A previous version of this work has been presented in the first International Workshop on Rethinking Clusters in Florence, 3-4 May 2018. Many thanks to participants for their comments.

1. Introduction

After decades of studies about pervasive, wide, and inclusive knowledge externalities (Marshall, 1920; Pyke et al., 1990; Rosenthal and Strange, 2004) and the advantages of *being there* (Gertler, 2003), recent literature on management, economic geography, regional studies, and local development (among other related fields) has stressed that knowledge spreads imperfectly, unevenly, and selectively within regional and cluster contexts (Markusen, 1996; Giuliani, 2006; Törnroos et al., 2017) because of the presence of different kinds of heterogeneities. Concerning this matter, Social Network Analysis (SNA) and its recent developments offer both theoretical and methodological instruments to unravel the relational structures at the root of this phenomenon.

In order to understand the roles played by relational architectures, both theoretical and empirical contributions have often investigated nodal, dyadic, and structural characteristics (Ahuja et al., 2012); however the literature has paid less attention to heterogeneity of ties (Ahuja et al., 2012; Lorenzen and Andersen, 2012) even if it is a fundamental property of a relational set that involves different typologies of connections among two actors (Wasserman and Faust, 1994).

Among the few exceptions to the multiple ties approach to network analysis, Ferriani et al. (2012), in a study of a cluster of multimedia firms located in northern Italy, found out that both social interactions and economic exchanges are critical factors for the emergence of multiple ties within inter-organizational networks, with a primacy of the former on the latter. Lorenzen and Andersen (2012) conducted an investigation within the Bollywood filmmaker industry, which is distinguished by uniplex, multiplex, and diverse social ties, and they demonstrated that diverse ties strengthen the positive performance related to uniplex (e.g., resource priority) ties and that they counteract negative effects related to the same multiple ties (as resource iteration and the lock-in effect) because they facilitate the search for knowledge. Capone and Lazzeretti (2018) detected that in the cluster of high technology applied to cultural goods in Tuscany, friendship and the network of technical advice positively impacted the likelihood of having a relationship for innovation. Contreras Romero (2018), studying a high-tech cluster in Chile, found a positive and statistically significant relationship between personal and business ties. Consequently, we focus on an inter-firm network approach because the relational setting is a critical instrument of coordination. In fact, on the one hand, relationships impact the diffusion of specific knowledge; on the other hand, they rule the variability of access to knowledge across

heterogeneous, cooperative, and competitive actors (Gnyawali et al., 2016). Thus, an economic actor in a multiple network environment operates between relational heterogeneity and interdependences.

In this work, we focus on this unexplored side, aiming to understand to what extent different kinds of ties can influence local knowledge diffusion and exchange. In particular, we distinguish between the relational content, as the substance of specific knowledge (i.e., technical), and several knowledge ties, as the drivers of multiple specific exchanges of knowledge (i.e., social and economic). This study contributes to the debate on inter-firm knowledge networks, innovation, and the competitiveness of firms proximate in space, and it provides more in-depth information of knowledge networks through relational multiplicity (Snijders et al., 2013). This work focuses on the following research questions. What kind of ties promote the exchange of knowledge within knowledge networks? To what extent do they impact the exchange of knowledge? Do they follow different or overlapping routes of knowledge diffusion?

We empirically explore these topics with an original dataset comprised of data collected by surveys directly administered in local wineries in the Montefalco wine region of central Italy. Specifically, we investigated this cluster because knowledge diffusion among co-localised economic actors critically affects the spread of contextualised and specific knowledge, the learning and innovation processes, and, in turn, the competitive advantage of a place hosting those actors (Bathelt, et al., 2004; Nicholson et al., 2013; Brink, 2018).

An Exponential Random Graph Model (ERGM) was applied to measure the impact of diverse knowledge ties on the technical knowledge network and to what extent they involve different or the same set of actors.

We organise our argument as follows: the next section presents the theoretical background and research hypothesis; Section 3 describes the data collection, methodology, and construction of the models' variables; continuing, Section 4 illustrates the empirical context; Section 5 shows the descriptive statistics and empirical evidence; and, finally, the discussion, main conclusions, and a few limitations are specified in Section 6.

2. Multiple knowledge ties and knowledge networks

2.1 Multiple knowledge ties

Over the last few decades, a portion of economic contributions have distinguished between formal/economic and informal/social ties (Owen Smith and Powell, 2004; McEvily et al., 2014), but a multiple ties approach to network analysis is still in its infancy, particularly from an empirical perspective. However, there are a few examples of well-known network-related contributions that have addressed this topic, at least indirectly. For example, Granovetter (1973) explored the roles played by two different kinds of dyadic interactions as weak ties (casual acquaintances) and strong ties (close personal friendship) to understand to what extent they are related and how they influence information diffusion, mobility, and community organization. Padgett and Ansell's (1993) contribution on the Florentine families in the Renaissance analysed two different categories of connections (marriage and economic ties), arguing that a large number of oligarch families (except the Medici) were linked with the others through both kinds of connections, and, when they were overlapping, they were more likely to possess close and holistic obligations. In the present work, we explain network structures considering three fundamental typologies of ties by means of which they promote the exchange of knowledge: social ties (friendship), labour mobility (previous employment in another local firm in the same industry), and material exchange (sales or rental of machinery, raw materials, or semi-finished products).

2.2 Social ties and knowledge networks

Social ties are based on social and interpersonal relations, which several contributions have referred to as friendship and family relations among actors (Boschma, 2005). Also, several cluster-related scholars have studied the role played by social ties in networks. In fact, a critical mechanism of knowledge diffusion among rival co-located firms is learning from the experience of the others (McEvily and Zaheer, 1999), particularly through interpersonal interactions among individuals.

However, spatial proximity does not automatically imply knowledge spillover among firms, but social connectedness in networks does (Breschi and Lissoni, 2001). Specifically, unplanned meetings within informal contexts – sometimes known as the "cafeteria effect" – are fundamental instruments for the spread of tacit and scarcely codifiable knowledge (Asheim, 1996; Cooke, 2001). This is even more significant within clusters where learning

is a social process involving economic actors operating with similar cultural values (Audretsch and Feldman, 1996; Bathelt et al., 2004). In fact, typically, clusters host a high degree of connectedness among economic actors that are thereby embedded in specific places where relevant knowledge is highly tacit (Ter Wal and Boschma, 2011; Broekel and Boschma, 2011).

Furthermore, other contributions have underlined that social ties are a good instrument to ease the exchange of knowledge among different actors who need a certain level of effort to understand knowledge of others (Srećković and Windsperger, 2011), especially if the other side of a relationship uses subtle or difficult phrases and concepts (Uzzi, 1997). Moreover, social ties are critical instruments for reducing risks once an actor aims to receive knowledge or transfer it to others (Larson, 1992), particularly those related to opportunistic behaviours (Uzzi, 1996). In this vein, Nooteboom (1996) argued that social ties are related to "goodwill trust", as the intention of related actors to perform according to a deal.

Several empirical contributions have identified the positive effect of social ties on different typologies of knowledge networks. For example, Dahl and Pedersen (2004) showed that social ties represent an important manner of knowledge diffusion in a cluster of wireless communication firms in Northern Denmark. Further, Bell (2005) demonstrated that informal friendship is a fundamental driver for innovation among mutual fund companies in the industry cluster of Toronto. Ter Wal (2013) showed the relevance of the exploration of knowledge (when knowledge is predominantly tacit) of the inventor network in the German biotech industry. More recently, Capone and Lazzeretti (2018) revealed that friendship and technical advice relationships impact the formation of innovation relationships in the cluster of high technology applied to cultural goods in Tuscany.

Thus, we propose the following hypothesis. HP1: Social ties between two firms have a positive impact on the likelihood that they exchange technical knowledge.

2.3 Economic ties and knowledge networks

The exchange of knowledge is also highly affected by formal ties based on different kinds of economic transactions (Uzzi, 1996). In this case, they are characterised by official administrative rules, explicit systems of incentives, and formal resource allocation (Lomi et al., 2013); however, they are fundamental instruments for potential future reciprocation of economic exchange because they take with them a guarantee of others' competence, credibility, and reliance (Chua et al., 2008).

Moreover, established formal economic relations may increase individual awareness of others' knowledge, particularly the one that is relevant for specific economic tasks (Austin, 2003). Economic ties are more likely to be suspended than social ties related to affective mechanisms if the relationship is not more beneficial or if it becomes problematic (Ahuja et al., 2012). Finally, Nooteboom (1996) claimed that economic ties are related to "competence trust", as the ability of related actors to perform according to an agreement; thus, this category of trust is critical for successful economic exchange.

Past contributions have focused on several economic-related ties of the spread of knowledge among co-localised firms. Breschi and Malerba (2001) identified the inter-firm labour mobility of workers as a critical economic factor for understanding the exchange of knowledge. Cantner and Graf (2006) argued (and empirically proved) that the labour mobility of scientists can predict the structure of a cooperation network of innovators in Jena. Also, Ter Wal and Boschma (2011) claimed that knowledge critically spreads among firms through labour mobility because recruiting employees who previously worked in other firms is an important way to access different knowledge. Almeida and Kogut (1999) further showed that workers often move within regions, leading to the result that local labour mobility is a fundamental way of regional and local knowledge flow. Moreover, Giuliani et al. (2005) added material and machinery exchanges as additional fundamental vehicles of knowledge diffusion within formal and planned environments. Nevertheless, to the best of our knowledge, the empirical efforts concerning this way of knowledge diffusion are much more limited.

Thus, we propose the following hypothesis. HP2: Economic ties between two firms have a positive impact on the likelihood that they exchange technical knowledge

2.4 Network multiplicity and exchange of knowledge

Focusing on an organizational setting, several contributions have stressed that knowledge is often difficult and costly to be exchanged because it needs a common communication base and a certain level of absorptive capacity (Cohen and Levinthal, 1990), and the cost of the multiple maintenance of different typologies of relationships can be even higher (Rothaermel and Alexandre, 2009). However, others have underlined that personally knowing the other part of the interaction through social ties and having learned how to work together through economic ties may mitigate these constraints (Hansen, 1999) because, in this way, they build a shared communication frame (Uzzi, 1997).

Moreover, knowledge shared through different knowledge ties, rather than only through one of them, may be more trusted (Granovetter, 1985); this is strictly related to knowledge extension because different networks are also representations of different role structures (Padgett and Powell, 2012), or multiplicity allows an actor to see actions by other actors playing multiple roles. Thus, it reduces uncertainty (Heaney, 2014). Consequently, in an environment characterised by multiple knowledge ties, social and economic ties can alternate their roles and their intensity over time. They can substitute each other's roles because they are intricately intertwined, and they may jointly affect the diffusion of knowledge (McEvily et al., 2014).

Ghosal and Nohria (1989) suggested that in relational organizational settings, social ties may provide integration across competing actors while economic ties are more likely to enhance differentiation. Hansen et al. (2005) widely explored the distinctions and similarities between social and economic ties, and they argued that social ties are affect-based and economic ties are cognition-based; thus, they are expressive and instrumental ties, respectively. In this vein, even if they assumed that both ties are critical factors for knowledge exchange, they also suggested that social ties have a higher level of intimacy, are more likely to create a sense of identity and social belonging, and have a stronger tendency towards mutuality. More recently, Ferriani et al. (2012) also discovered that both social and economic ties are drivers of multiplexity, but the former has a higher impact than the latter.

Thus, we propose the following hypothesis. HP3: Social ties have a higher impact on the exchange of technical knowledge than economic ties.

Finally, social and economic ties can simultaneously affect the exchange of knowledge because their routes of diffusion are critical aspects for understanding whether relational co-existence influences network structures. Uzzi (1996) suggested that different kinds of relationships among the same set of actors may be maintained over time because the presence of one typology of ties may foster and increase the stability of another typology of ties. He found that social ties promote the emergence of economic ties because they encourage an environment of trust and a common language.

Their co-existence may be guided by overlapping or differing routes of knowledge diffusion. On the one hand, overlapping structures may be costly and redundant because they lead to a waste of relational effort in creating a new link with a partner who is already tied through a different tie, and they may be risky because they involve the same set of actors (Laumann and Marsden, 1982). On the other hand, they may be an efficient

instrument to decrease uncertainty towards other actors because they are likely to increase their reliability and their trustworthiness; furthermore, actors interacting with more than one kind of relationship may build an intense manner of exchanging knowledge based on a strong common knowledge base and language that leads to easier ways of absorbing other's knowledge and to an improvement in their stability (Lorenzen and Andersen, 2012). In this way, increasing returns can be present in the form of overlapping sets of relationships (Powell et al., 1996) because different actors secure important connections and critical flows of resources (Lomi and Pattinson, 2006). Complementary diffusion routes may also result in a reduction of dependency on a single typology of ties or a limited set of actors, thus, decreasing the risk of potential inward-looking mechanisms and negative lock-ins (Ferriani et al., 2012).

Thus, we propose the following final hypothesis. HP4: Social and economic ties are more likely to exist if they are overlapping. Table 1 presents the four research hypotheses.

Table 1: Research hypotheses

HP	Expected results
HP1	Social ties between two firms have a positive impact on the likelihood that they exchange knowledge
HP2	Economic ties between two firms have a positive impact on the likelihood that they exchange knowledge
HP3	Social ties have a higher impact on the exchange of knowledge than economic ties
HP4	Social and economic ties are more likely to exist if they are overlapping

Source: our elaboration.

3. Research design

3.1 Data collection

Even if different knowledge ties are not always easy to distinguish in practice (Podolny and Page, 1998), we attempted to overcome this problem by collecting primary data with an explicit distinction between different forms of relationships. A survey was administered in December 2017 and January 2018 within local wineries in an Italian wine cluster in central Italy (Montefalco region, Umbria). Telephone calls were made to increase the response rate and to schedule meetings directly in the wineries with the firm owners, technical professionals, or the agronomists (thirty cases). If that was not possible, an online questionnaire was delivered (eleven cases). Directly administered questionnaires had an

average completion time of 40 minutes. An original list of 58 wineries was provided by the Consorzio Tutela Vini Montefalco, the local consortium responsible for coordinating more than 80% of local certified wine production in terms of hectolitres and all of the most important wine firms (Consorzio Montefalco Sagrantino, 2017). At the time of the data collection, seven of these wineries were definitively closed, or they were no longer producing wine; thus, the final database was comprised of 51 actors. In this case, 41 questionnaires were fully completed, reaching 80% of the total population.[9] Moreover, a semi-structured interview with the head of the local wine consortium ensured that we covered all of the most important wineries of the region. The very few wineries that did not agree to participate in the survey can be considered marginal in terms of their importance (for example, measured with size and reputation).

As in previous contributions (Giuliani and Bell, 2005; Morrison and Rabellotti, 2009; Hira and Aylward, 2013; Balland et al., 2016; Capone and Lazzeretti, 2018), different typologies of data were collected, including basic firm- and industry-level information, network data, and strategy-related information. Network data are usually collected with three main alternative methods (Wasserman and Faust, 1994). First, a roster-recall method where questionnaires are presented with a complete list of possible reachable others (for example, actors are asked to name all the actors they are linked with choosing from a roaster); second, a free-recall method where respondents are allowed to generate lists of names (for example, actors are asked to name all the actors they are linked with without choosing from a roaster); third, a fixed-choice method where respondents can generate lists of names but with constraints (for example, actors are asked to name the first five other actors they are linked with). In our case, network data were collected with a combination of the free-recall and fixed-choice method; thus, the interviewer showed the complete list of other local wineries and then he asked for a maximum of five ties. In this way, the respondent had a complete picture of all the possible linkages, and she/he was encouraged to nominate the main important relationships.

3.2 Methodology

Since theoretical and empirical efforts have prompted developments to model multiple relationships, especially in social networks, multiple network analysis has recently emerged as an auspicious research stream from the statistical perspective as well (Snijders

[9] SNA methodologies are designed for complete networks, however, Kossinets (2006) proved that network properties are preserved with a response rate higher than 70%.

et al., 2013). Particularly, misquoting Lazega and Snijders (2015), we could find three main categories of statistical analysis of multiplicity; first, a multiple analysis of networks, when a system is composed of parallel networks according to a common model; second, an analysis of multiple networks, when a system is composed of nodes of several typologies; third, an analysis of networks with a multiple node set, when networks are composed of hierarchically structured node set. From a methodological point of view, gravity models, quadratic assignment procedure, Exponential Random Graph Models (ERGMs), and Stochastic Actor-Oriented Models (SAOMs) have been proposed to investigate structures and dynamics of networks (Broekel et al., 2014) and they recently attracted attention of several scholars in empirical contributions studying regional and local systems (for example, Cantner and Graf, 2006; Breschi and Lissoni, 2009; Broekel and Hartog 2013; Lazzeretti and Capone, 2016; Juhasz and Lengyel, 2017). We implemented ERGM because of its greater applicability and power than other models (this argument also applies to SAOM); in particular, it is one of the preferable models in the case of small networks or a lack of longitudinal network data. Specifically, it is a stochastic model that allowed us to investigate the propensity for link formation as a continuous process over time, where the observed network is perceived as one realization from different potential networks built on similar characteristics (Robins et al., 2007). We executed ERGM using R-software with the STATNET-ERGM package (Handcock, et al. 2008) in order to analyse the role played by knowledge ties in technical knowledge transfer, considering node-, dyadic-, and structural-level factors. Moreover, it provided several different assessments on the quality of the model, such as goodness of fit (GOF) statistics, the Akaike Information Criterion (AIC), and the Bayesian Information Criterion (BIC).

We followed Broekel and Hartog (2013) to estimate the models, relying on trial and error processes across different model specifications. The best model is a model that is stable, converges, and provides satisfactory GOF diagnostics concerning the observed network. We present the GOF diagnostics of the full model in Table 3, Appendix.

3.3 Variables construction

The response variable was the technical knowledge network. It was based on the technical knowledge exchange regarding the production process and was determined by the answer to the question “what are the first five other local wineries among those listed to which you transfer technical knowledge to solve a problem in the production process?”. We focused on technical knowledge transfer because its relevance has been proven in

understanding the exchange of knowledge and the learning processes within clusters (Giuliani and Bell, 2005; Giuliani, 2010; Morrison and Rabellotti, 2009; Juhász and Lengyel, 2017). We focused on the spread of technical knowledge as one of the most critical contents of inter-firm exchanges. In particular, we studied the exchange of knowledge to solve specific problems because, in this way, firms develop capacities for mutual problem solving (Uzzi, 1997). In other words, we investigated firms in knowledge networks where they diffuse "[…] innovation-related knowledge, aimed at the solution of complex technical problems" (Giuliani, 2010, 265).

The explanatory variables included the other three networks. First, the "social (friendship)" variable was based on friendship and was determined by the answer to the question "what are the first five other local wineries among those listed where you have friends regardless of professional relations?". Second, "labour mobility" was based on previous employment in another local firm in the same industry. Third, "material exchange" was based on sales or the rental of machinery, raw materials, or semi-finished products[10].

We also controlled for three main structural variables that are often included in ERGMs (Snijders et al., 2006). First, "edges" are the number of links at the network level, and they may be interpreted as the intercept parameter of the model. Second, "mutual" is the tendency of ties to be reciprocated; consequently, the variable needs directed ties to be estimated. Third, "triads" are captured by Geometrically Weighted Edgewise-Shared Partner (GWESP) statistics, and they are the number of triangles in the whole network, exploring how frequently two nodes are linked through another node (a two-path length connection).

Finally, some node-level variables and geographical proximity were modelled in the full model because several contributions have discovered that they play a critical role in knowledge transfer (Giuliani, 2010; Balland, et al. 2012; Hansen, 2015). In particular, we controlled for "firm size" and "firm experience" as categorical variables for the number of employees and the years worked in the wine industry within the region, as indicated by the survey respondents, respectively. "Firm local reputation" was a categorical variable for the

[10] Investigated networks are directed. This means that if an actor A argues of having a tie with an actor B, this not directly implies that B argues of being directly linked to A. However, some authors assume that "knowledge exchanges are always reciprocal in nature" (Broekel and Boschma, 2011, p. 417) since if an actor A argues that an actor B is a relevant contact, also A should be a relevant contact for B.

sum of times a local winery was indicated by other wineries as having a high-level local reputation.

"Local R&D" and "external R&D" were binary variables for R&D developed in a research centre or university within or outside the region, respectively. "External consultant" was a categorical variable added when the interviewees answered as having sought advice from an external wine consultant. "Local wine institutions" and "external wine institutions" were binary variables that referred to wineries related to the local wine organizations and local wine routes (the local ones) or to the national wine tourist welcoming movement, the national sommelier association, and the national agricultural enterprises association, respectively. "Other local institutions" and "other external institutions" were binary variables referring to interviewees answers that local municipality, province, region (the local ones), national, or European institutions could be important actors to gain knowledge from, respectively. Finally, "geographical proximity" was the traditional categorical variable at the dyadic level for the physical propinquity between wineries based on the longitude and latitude of their locations.

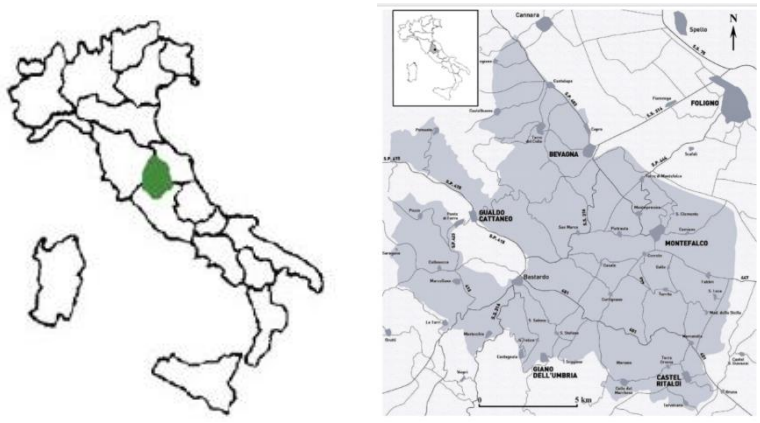
4. The context

Several contributions investigated different quality wine production places within Italian regions. For example, Brunello di Montalcino (Mattiacci and Zampi, 2004; Alampi Sottini et al., 2013), Chianti Classico (Doria et al., 2004), Bolgheri and Val di Cornia (Giuliani, 2008), Colline Pisane (Giuliani, 2008) in Tuscany, Colline Novaresi (Morrison and Rabellotti, 2009), Barolo and Barbaresco (Hannan et al., 2007) in Piedmont; Conegliano Valdobbiadene (Rossetto et al., 2011; Boatto et al., 2013) in Veneto; Franciacorta (Zamparini and Lurati, 2012) in Lombardy, but, no one investigated the Montefalco area even if it is one of the Italian wine regions that is more attracting the interest of both international consumers and investors and it is emerging as one of the most promising areas for potential economic performance (WineSpectator, 2017). Montefalco is a village in the province of Perugia (Umbria region, Italy) surrounded by hills covered with a few grape varieties, particularly the *Sagrantino* variety, because the natural conditions (like soil conformation and a climate with hot, dry summers, fairly cold winters, and moderately rainy seasons) are very favourable for wine production. The local wine tradition has its roots in the 11th century, when the monks cultivated a wine grape imported from Turkey in their churchyard (in Italian, *sagrato*, from which the name *Sagrantino* comes).

The “modern” wine history had its fundamental beginning around the 1980s, when the Montefalco area started being identified as a wine region due to the initiatives of two entrepreneurs (one was a furniture dealer, and the other was a textile trader before entering the wine industry) who, at the beginning of the 1970s, shifted wine production from sweet wines to dry ones. This process led to a denomination of origin (DOCG Montefalco, received in October 1979) and the establishment of a local consortium (Consorzio Tutela Vini Montefalco, founded in 1981). In this way, the Montefalco region began to be nationally and internationally recognised as a unique *terroir*, and a local identity began forming in that area where the residents started feeling embedded.

Nevertheless, the shift from quantitative to qualitative productions happened with the turn of the new millennium, and, over the last two decades, this wine region has entered the market of medium-high quality wines thanks to the production of the majority of local wineries (Consorzio Montefalco Sagrantino, 2017). Wine firms clustered in the Montefalco region operate in niche markets, and only a few bottles of *Sagrantino* are sold through large retailers in mass distribution while most of them have boutique stores, typical- and high-quality restaurants, and specialised wine stores as their main distribution channels. This system exploits product uniqueness and high-quality levels, which are reinforced by stories of tradition and authenticity as the main marketing message. In fact, after a survey, a wine producer claimed, “I more than doubled profits with a twenty percent increase in prices of high-quality bottles”. In this vein, the wine tradition is the main cultural source of the region, and the wine industry (as well as the related sectors) is the most important local source of employment.

Figure 1: Montefalco wine region



Source: Consorzio Tutela Vini Montefalco website.

5. Empirical analysis

Table 2 presents descriptive statistics at the firm-level. It shows that the vast majority of the analysed sample was comprised of small firms in terms of employees that started operating within the region during the last five decades and particularly within the new millennium. Almost the totality of the firms were not part of a group and were typically family-run. Detailed firm-level descriptive statistics are presented below.

Table 2: Firm-level descriptive statistics of the analysed sample

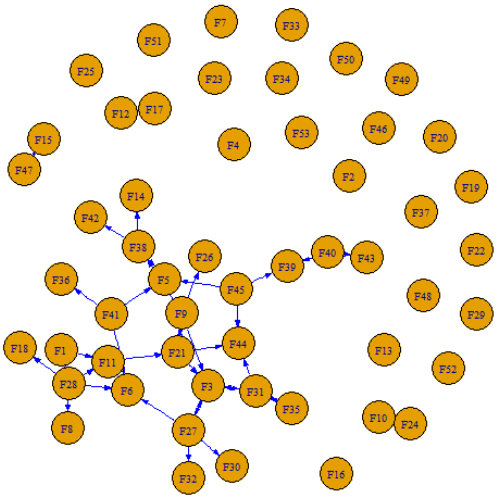
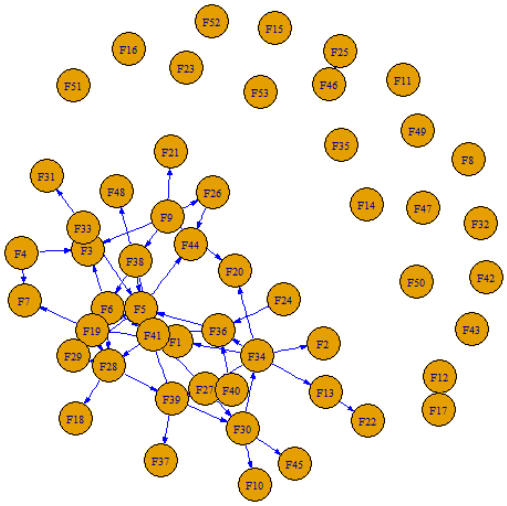
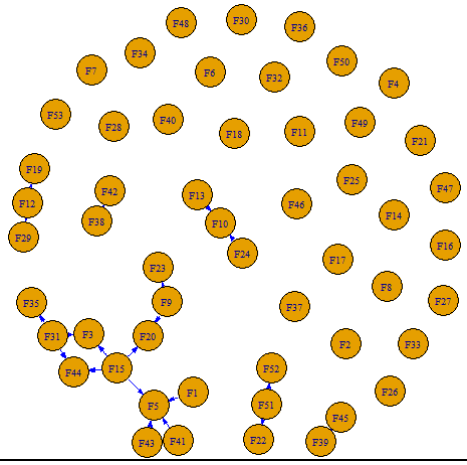
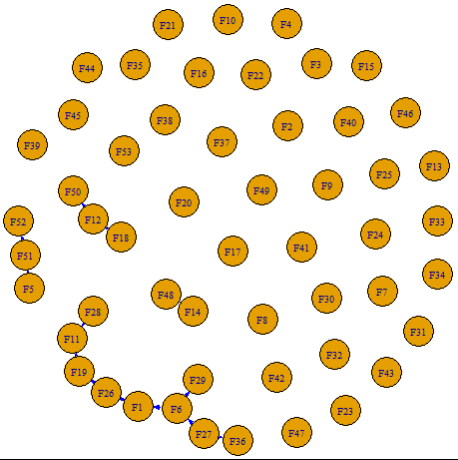
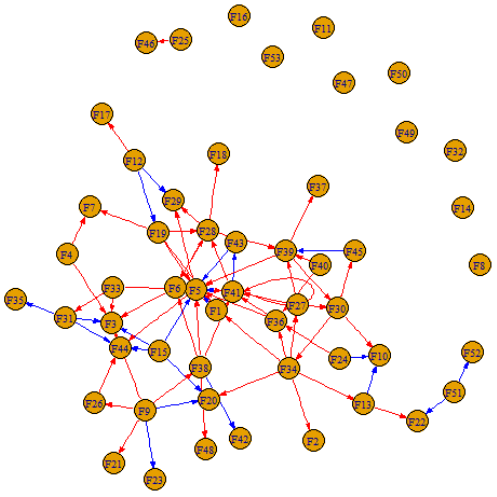
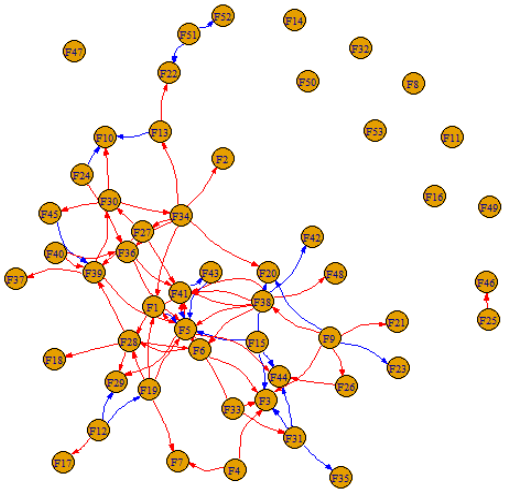
Size (number of employees)	Small (1-19)	87%
	Medium (20-99)	10%
	Large (≥100)	3%
Decade of localization/birth	Up to 1969	15%
	1970s	21%
	1980s	0%
	1990s	15%
	2000s	36%
	2010s	13%
Organisational structure	Independent	90%
	Part of a group	10%

Source: our elaboration.

Graphs in Figure 2 present the technical knowledge network (2.1), social ties based on friendship (2.2), material exchange (2.3), and labour mobility (2.4). Every circle (node) represents a wine firm. Arrows between two nodes represent interactions and their directions. If no arrows are present, it means that no interviewee mentioned the isolated firm/node as the recipient of the interaction. Graphs 2.5 and 2.6 present the union of the social ties network with the labour mobility and material exchange networks, respectively.

As we can see from the graphs, different sets of relationships present different network structures. Particularly, networks based on technical knowledge exchange and on social ties seemed to be denser than those based on labour mobility and on material exchange. In fact, the first two networks had a higher number of nodes linked by a relationship and a lower number of isolates than those based on labour mobility and material exchange. However, only networks built on technical knowledge exchange and social ties presented mutual ties (four ties and one tie, respectively) while the other two had no mutual ties.

Figure 2: Network graphs

2.1 Technical knowledge network	2.2 Social ties (friendship)
	
2.3 Material exchange	**2.4 Labour mobility**
	
2.5 Social ties (red) and Labour mobility (blue)	**2.6 Social ties (red) and Material exchange (blue)**
	

Source: our elaboration.

These aspects are also confirmed by network-level descriptive statistics provided in Table 1, Appendix. Table 2, Appendix shows the correlation matrix between social and economic ties and the technical knowledge network and they present low correlation values in every case.

Estimations are presented in Table 3.

Table 3: Summary of ERGM fit for technical knowledge network

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Edges	-4.829*** (0.203)	-4.755*** (0.193)	-4.604*** (0.186)	-5.086*** (0.232)	-5.025*** (0.226)	-4.893*** (0.212)	-5.992*** (0.018)
Mutual	2.933*** (0.639)	2.997*** (0.658)	2.939*** (0.657)	2.881*** (0.651)	2.836*** (0.661)	2.971*** (0.649)	2.698*** (0.015)
Triads	0.909** (0.319)	0.981** (0.372)	1.019** (0.377)	0.801* (0.361)	0.755* (0.348)	0.852* (0.365)	0.661*** (0.011)
Social (Friendship)	2.966*** (0.382)			3.102*** (0.416)			3.134*** (0.011)
Material exchange		3.751*** (0.486)		3.776*** (0.561)			3.871*** (0.017)
Labour mobility			2.601*** (0.790)	2.624** (0.932)			2.644*** (0.024)
Firm size							-0.017 (0.012)
Firm experience							0.009* (0.001)
Firm local reputation							0.015 (0.029)
Geograph. proximity							-0.001 (0.001)
Local R&D							0.755*** (0.028)
External R&D							-0.094*** (0.019)
Local wine institutions							-0.076 (0.039)
External wine institutions							-1.211*** (0.039)
Other local institutions							0.222*** (0.026)
Other external institutions							0.722*** (0.043)
Wine consultants							0.451*** (0.030)
Social& Material exchange					3.304*** (0.351)		
Social& Labour mobility						2.998*** (0.368)	
AIC	352.8	355	383.2	317.8	320.9	435.6	329.4
BIC	376.5	378.7	406.9	353.4	344.6	369.3	430.1

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05. Source: our elaboration.

Model 1 includes the three main structural variables of the ERGMs and social ties. Models 2 and 3 substitute social ties with material exchange and labour mobility, respectively. Model 4 includes all of the three previous relations altogether. Models 5 and

6 include the three main structural variables and the union of social ties with material exchange and the union of social ties with labour mobility, respectively. Finally, Model 7 includes the three main structural variables, the three typologies of ties, and the control variables.

The full model is stable and converges. Following Hunter et al. (2008), we implemented GOF diagnostics to assess to what extent the parameters of the ERGM accurately predicted the observed network (the one based on empirical data). This was made by a comparison between the structure of the simulated network and that of the observed network. This model appears to be characterised by satisfactory GOF statistics for the distributions of the geodesic distance (the number of pairs for which the shortest path between them is of length k for each value of k), the edge-wise shared partners (the number of links in which two firms have exactly k partners in common for each value of k), and the in-degree (the in-degree distribution is due to the direct graph). In fact, data for the observed network overlapped the boxplots representing the distribution of the corresponding degrees across the simulated networks, and they were within lines corresponding to the 95% confidence interval. They are shown in Table 3, Appendix.

Structural network variables demonstrated results in line with other empirical studies. All of the models presented negative and statistically significant coefficients for “edges” because they represent the density of the network in log-odds if other effects are excluded; in other words, the negative value is due to the fact that the actors were less prone to interact with each other in comparison to what is observed in random networks. Statistically significant and positive values for both the “mutual” and “triads” coefficients show that there is a tendency towards mutuality (as the tendency for ties to be reciprocated) and triadic closure (as the tendency for two nodes to be linked through another node) in the network.

The results presented in columns (1), (2), and (3) of Table 3 confirmed the first two hypotheses. Both the social ties and economic ties between two actors had a statistically significant and positive impact on the likelihood that they transferred technical knowledge; thus, they are critical knowledge ties. The results in column (4) refute the third hypothesis since material exchange ties were more likely to positively affect the technical knowledge network than social ties (even if social ties presented a stronger value than labour mobility).

Regarding the last hypothesis, no overlapping ties existed between the network built on social ties and the one on labour mobility and only two wineries (F20 and F9) had simultaneously social and material exchange ties. This is enough to refute the fourth

hypothesis and prevents empirically testing this aspect[11]; consequently, it leads us to move towards the complementarity interpretation. Columns (5) and (6) of table 3 present the results concerning joint networks, and they both had positive and statistically significant impact.

In column (7), we also controlled for several control variables, like size, experience, and local reputation at the firm level. Only the firm experience results were positive and statistically significant while it is not possible to confidently determine either the direction of the effects of the others or of the geographical proximity. Moreover, we controlled for the potential roles played by research centres and universities, consultants (because they usually play a critical role as sources of knowledge within wine industries), wine-related institutions, and other institutions, distinguishing between local and external ones. First, the results showed that actors were more likely to form knowledge ties if they were linked to local R&D sources (the corresponding probability was $p = 0.68$) than to external ones (the corresponding probability was $p = 0.47$). Second, it seems that wine-related institutions outside the wine industry were another driver of exchanging knowledge (but a statistically significant result was not detected for local wine-related institutions). Third, the results showed that the actors were more likely to form knowledge ties if they were linked to other external institutions (the corresponding probability was $p = 0.67$) than linked to local ones (the corresponding probability was $p = 0.56$). Finally, a critical role played by consultants was also detected.[12]

6. Discussion and conclusions

The aim of this work was to contribute to a better understanding of the mechanisms of the exchange of knowledge in geographical concentrations, such as clusters and industrial districts. Adopting a network perspective, we explored this critical issue from an innovative multiple ties approach involving different sets of relations comprised of social and economic ties. The empirical results showed that social ties based on friendship, economic ties based on labour mobility, and material exchange play fundamental roles in the local spread of knowledge but at different levels. In fact, once they were simultaneously investigated, it appeared that the local actors were more likely to provide knowledge to others if they met to sell or rent machinery, semi-finished products, and raw materials than

[11] We also tested this aspect with a specific model, but the algorithm did not converge.

[12] The log-odds of any tie occurring are a coefficient of the model multiplied by the changes in the number of ties. The probability corresponding to coefficients of the model is computable as exp(coeff.)/(1+exp(coeff.)).

if they knew each other on a friendship basis. In this case, labour mobility was the less critical knowledge tie. Moreover, social and economic ties did not overlap. This leads us to recall that different knowledge ties may contribute to the spread of knowledge by extending its diffusion throughout complementary routes.

We suggest that this study contributes to several related debates. First, we went one step further within organizational studies towards contributing to a better understanding of to what extent a combination of social structures guided by informality and formality affects the sharing of knowledge (Inkpen and Tsang, 2005). The empirical results showed that knowledge exchange is not only involuntary but is also well-regulated by more formal exchanges within certain contexts. Moreover, the higher impact of the typologies of ties based on formal/economic exchange than the others based on informal/social connections may have different effects. First, there may be a positive impact in the case of a crisis because social ties are more comprised of a sense of obligations, such as emotional needs, than economic ties. Moreover, they are more embedded in a social system where the local reputation plays a critical role, and every economic actor is likely to know every other economic actor; thus, they are less likely to lead the entire system to negative lock-in processes based on over-iterations and a scarcity of novel knowledge. This is even truer if we implement a multiple network analysis of the interconnections of different knowledge ties (substitutive vs. complementary relational structures); in fact, we suggest that our results in favour of complementary networks may be interpreted as a source of differentiation. Considering their heterogeneity, we also demonstrated that other different actors with potential novel knowledge are reachable through different relational patterns. Moreover, from an individual point of view, an alternative explanation for non-overlapping ties emerges. Since social and economic ties are particularly intertwined and sometimes difficult to be separately identified, an actor who does not belong to a network made of a kind of relationship or who has a peripheral position may be incentivised to form other typologies of connections as substitutes for the others. This may be an important alternative way to bridge the structural holes of a single knowledge network.

Second, within network studies, we theoretically and methodologically contributed to a shift from the observation of singular relations to inference on which kinds of connections influence given networks and to what extent they follow common or divergent relational structures (Lazega and Snijders, 2005). To the best of our knowledge, multiple networks have been attracting a low amount of attention in research (Hansen et al., 2005; Ferriani et al., 2013) even though an investigation of network multiplicity allows us to more

deeply explore network structures (for a theoretical argumentation, see Ahuja, et al. [2012] and Lorenzen and Andersen [2012]). In fact, from a whole network perspective, a set of relations may seem to be structurally stable over time (for example, its descriptive network statistics may be relatively unchanged); meanwhile, it is possible that different sub-sets are co-changing in such a way that an effect in one set of relations is compensated by another phenomenon in the other. For example, an actor may delete a tie within a network and compensate for this with a new link within a different network, leading the entire system to appear structurally equivalent. In particular, we stressed the scientific relevance of a multiple relational perspective, and we suggested that ERGMs are useful methodological tools to study structures of networks comprised of different typologies of ties through which knowledge is transferred and that they allowed us to control for structural relational mechanisms other than node and dyadic features (Robins et al., 2007).

Third, within regional and local development studies, we suggest that different kinds of knowledge ties may stimulate the transfer of knowledge because they can benefit from proximity and advantages of repeated interactions (Boschma, 2012). This investigation tried to explore this issue, focusing on an industry where the knowledge-formation process is mainly incremental, and we found that different knowledge ties expose rival and cooperating economic actors to different knowledge with different degrees of novelty from other potentially remote and different actors. We proved that a multiple ties approach gave us the possibility to go deeper in understanding the collaboration-competition system typical of industrial districts and clusters (Becattini, 1990; Porter, 1998); in particular, we argued that multiple ties may be more conducive to transferring knowledge as a whole and to diffusing more specific knowledge for different strategical needs. Moreover, even if maintaining different sets of relationships is likely to have a high cost, different knowledge ties may be critical tools to face opportunism thanks to the trust present in both social and economic contexts while, at the same time, they are fundamental instruments to decrease dependency upon a single link.

Focusing on the wine industry, we can understand the reason why labour mobility fosters knowledge diffusion to a lesser extent than the other determinants. In fact, in this industry, workers sometimes move to other wineries because of tensions in the previous labour environment; thus, they are less likely to share fundamental information and specific knowledge. On the contrary, social ties and other categories of economic ties may have a stronger impact because they reduce transaction costs, they ease and increase efficacy of

knowledge transferring, and they enhance the efficiency of mutual learning. These effects can be even higher if embedded in different sets of ties that simultaneously evolve.

To conclude, we theoretically designed a new picture of network multiplicity, and we empirically proved that different typologies of ties may have different impacts on local knowledge diffusion. In this vein, having discovered that they follow complementary routes, we suggest that they co-exist in several economic systems in being sources of novelties and differentiation of knowledge.

This work has some limitations. We studied only one cluster within an industry characterised by specific conditions, so we are not necessarily able to claim that the same results may be replicable in other clusters and other industries. Moreover, this work did not analytically explore whether one kind of relationship may be a bridge for another. In other words, we did not study whether one knowledge tie (for example, social ties) is more likely to bridge structural holes of other networks (for example, of economic ties). This may be an important field of research in the future.

Finally, these results may be considered by managers and local institutions that operate at the regional- or industry-level, since they suggest the possibility of implementing firms' strategic planning and political instruments in favour of different forms of collaborations among firms and in favour of more inclusive knowledge-sharing within networks with high levels of isolated firms. This is especially important for a sector like the wine industry in Italy, where consortiums of wine producers play a fundamental role in implementing formal relationships, inter-firm marketing cooperation, and trust among competitors.

Appendix

Table 1: Network-level descriptive statistics

Network/Measures	Technical knowledge network	Social ties (friendship)	Labour mobility	Material exchange
Nodes	53	53	53	53
Edges	38	56	21	30
Triangles	3	10	1	10
Isolates	21	16	36	28
Density	0,0138	0,0203	0,0047	0,0076
Cluster Coeff	0,0938	0,1399	0	0,1250
Diameter	5	8	1	4
Avg Path Length	2,5333	3,2884	1,1875	1
Avg Degree	1,4340	2,1132	0,4906	0,7925
Degree centralization	0,0447	0,0773	0,0246	0,0314
Betweenness centralization	0,0148	0,0470	0,0007	0
Closeness centralization	0,0092	0,0124	0,0015	0,0014
Components	25	19	40	34
Mutuals	4	1	0	0
Asymmetrics	30	53	13	21
Nulls	1344	1324	1365	1357
Reciprocity	0,2105	0,0364	0	0
Assort Degree	0,1032	-0,1387	-0,4260	0,0508

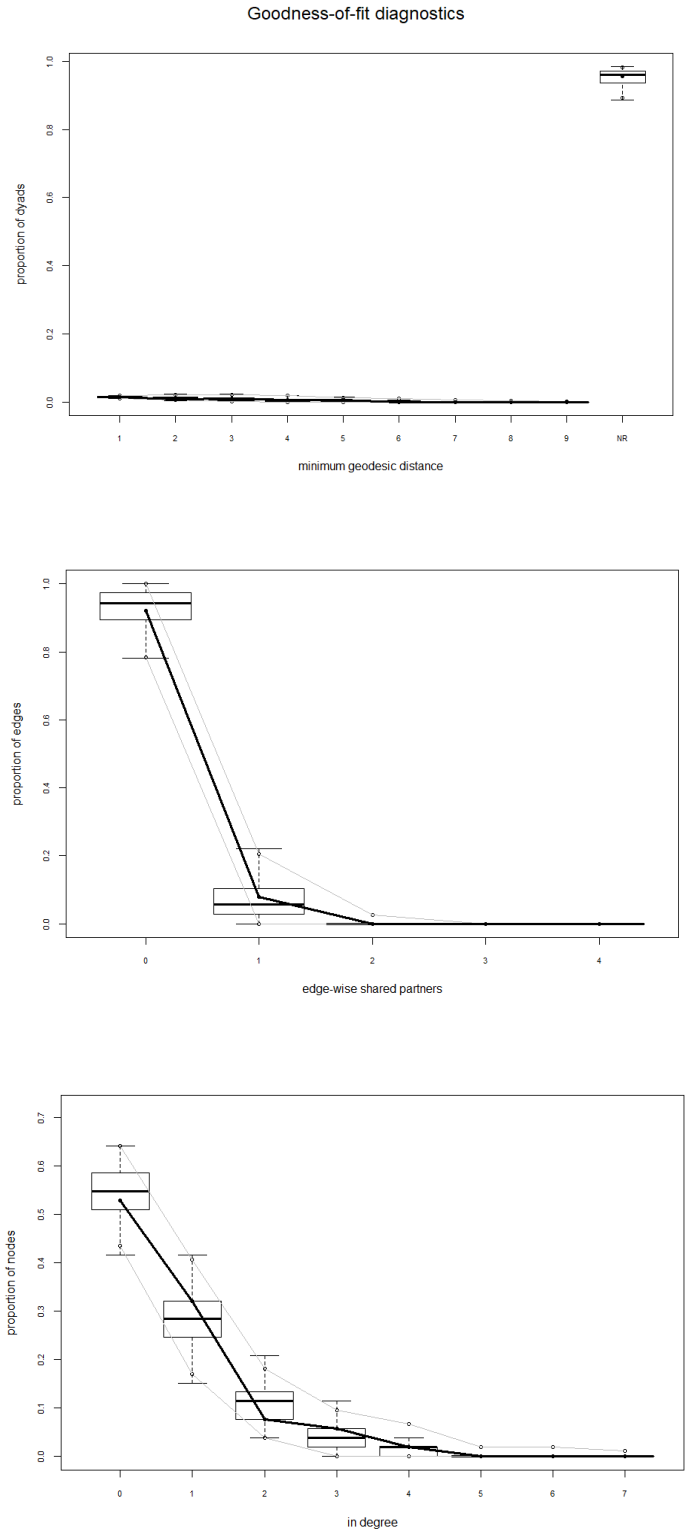
Source: our elaboration.

Table 2: Correlations between knowledge channels and technical knowledge network

	Technical knowledge network	Social ties	Material exchange	Labour mobility
Technical knowledge network exchange	1			
Social ties	0.204	1		
Material exchange	0.241	0.017	1	
Labour mobility	0.083	-0.009	0.055	1

Source: our elaboration.

Table 3: Goodness of fit diagnostics for the full model



Source: our elaboration.

Chapter III

Status and the Assortative Dynamics of Knowledge Networks. Evidence from a Successful Wine Cluster in Italy[13]

Abstract

Among advantages of belonging to a successful cluster, the regional economic literature has stressed the critical role played by localized knowledge. For some time, scholars have been arguing that knowledge spreads unevenly among local actors, rather than pervasively and widely, but, its drivers, underlying social structure, and evolution over time remain poorly understood. Heterogeneity of firms and the way they are perceived are fundamental features to understand evolutionary patterns of clustered firms acting in a world of uncertainty and imperfect information. This work focuses on status, which refers to the perceived relative qualities of a firm in a given market or organizational field, and it aims to investigate to what extent it affects assortative dynamics of knowledge network evolution in clusters. Even if status is a critical carachteristic for firms' success and it is theoretically assumed that assortativity is a fundamental relational mechanism of network dynamics, it has not been empirically investigated to what extent the former drives the latter in the context of local clusters. Stochastic Actor-Oriented Modelling (SAOM) is used to model the evolution of the advice network of a successful Italian wine cluster. This contribution is the first one to empirically investigate status-driven assortative network dynamics in clusters and our results indicate the presence of an assortative network change, where high-status firms are more likely to interact with other high-status firms but not with low-status firms (and vice-versa). These findings have implications for theories on status and industrial clusters.

Keywords: status; knowledge network evolution; assortativity; SAOM; wine cluster.

[13] Many thanks to Elisa Giuliani for providing a large part of the dataset and for her support in the theoretical part of this chapter. Many thanks to Pierre Alexandre Balland for his support in the analysis. A previous version of this work has been presented at the 4th Geography of Innovation Conference, Barcelona, January 31st February 2nd, 2018.

1. Introduction

Over the last decades, several disciplines within social sciences like sociology (Uzzi and Spiro, 2005; Centola and Macy, 2007; Kossinets and Watts, 2009), innovation studies (Asheim and Coenen, 2005; Cantner and Graf, 2006), management (Capaldo, 2007; Rahmandad and Sterman, 2008) and; particularly, economic geography and regional studies (Glückler, 2007; Ter Wal and Boschma, 2011; Balland, 2012) became progressively more interested in understanding networks dynamics as processes of knowledge flows among related actors. Focusing on analysis of co-located actors within regions, for example, Porter (1998) claimed that "a cluster is a form of network" (p. 226) and Saxenian (1996) drew attention to "alternative network approach to analysing regional economies" (p. 41).

Although the traditional view based on the Marshallian "industrial atmosphere" concept (Marshall, 1920) has shown that knowledge spreads widely and pervasively among firms within clusters (Pyke et al., 1990), more recently scholars have questioned this perspective (Breschi and Lissoni, 2001) and have showed that knowledge flows through hierarchically structured networks of co-located actors (Markusen, 2002; Giuliani and Bell, 2005) and it is selectively diffused (Giuliani, 2007). More importantly, others have investigated the micro-level factors affecting the structure of local knowledge networks. Yet, while most of the earlier research has focused on endogenous drivers of network change, such as closure, centrality, or preferential attachment (Lechner and Leyronas, 2007, Giuliani, 2013, Ter Wal, 2013), less attention has been paid to understand how cluster firms' own characteristics affect network dynamics. Empirical research has looked at firm-knowledge bases (e.g. Giuliani and Bell, 2005), firm-size (e.g. Balland et al., 2013; Castro et al., 2014) or age (e.g. Molina-Morales et al., 2015), but, it has largely neglected the fact that knowledge transfer depends on entrepreneurs' and local professionals' perceptions about the qualities of actors involved. Because of imperfect information, these qualities are often hard to judge on an objective basis (Gould, 2002), and, therefore, they are perceived based on the signals offered by the potential knowledge givers to the seekers. In that context, we argue that firms' status (Podolny, 1993; Podolny and Phillips, 1996), defined as the perception of the relative qualities of a firm in a given market or organizational field, is likely to influence decisions about the spread of knowledge in clusters, and to influence the dynamics of local knowledge networks.

Status considerations have been generally neglected in accounts of regional knowledge networks (exceptions include Giuliani, 2013; Balland et. al., 2016), possibly because conventional wisdom suggests that information asymmetries are likely to be limited in spatially bounded areas such as industrial clusters. In contrast, we challenge this conventional view, and posit that even in the presence of spatial proximity, firms and their managers may be ill-informed about the real qualities of the other firms and, when they would need to gather technical advice, they would be guided by their perceptions about the rest of the firms, and therefore by status considerations.

Moreover, the literature investigating network assortativity mechanisms in this debate is very incipient. Crespo et al. (2013) contributed with a theoretical paper on degree-related assortativity (as structural homophily) and degree-related disassortativity (as structural heterophily), where they discussed features, statistical measures, and policy-oriented analysis of network structures where highly connected nodes are more likely to be connected with highly connected others (degree assortativity) or with poorly connected others (degree disassortativity). Even if Crespo et al. (2015) empirically tested these concepts in the European mobile phone industry, finding that degree-related disassortativity fosters innovation, none of the previous contributions aimed to study the relationship between status as an attribute-based variable and assortative or disassortative attitudes and none of them aimed to have such an investigation within local clusters.

More specifically, we want to investigate how status considerations influence the formation of assortative (i.e. high-status firms are more likely to interact with high-status firms and low-status firms are more likely to interact with low-status firms) or disassortative ties (i.e. high-status firms are more likely to interact with low-status firms and low-status firms are more likely to interact with high-status firms) and contribute to the dynamics of the local knowledge network. Investigating these processes is important because it can tell a lot about the way coalitions are formed within clusters and the extent to which low status firms are in or out the 'circles that count'.

To investigate these issues, we use an original dataset with longitudinal data collected in an Italian wine cluster in the wine region of Bolgheri and Val di Cornia (Tuscany, Italy), which is considered a superstar cluster for the high quality of its wines (sometimes known as 'Supertuscans') and for the exceptional premium prices attained by several cluster's firms. With surveys administered to wineries in two points in time (2003 and 2013), we empirically test the role of status in the evolution of relationships among wineries; particularly, focusing on transfer of technical advice. This wine cluster has been already

studied over the last years (for example, Giuliani, 2006), but in this work its status-related evolution over time is investigated for the first time.

Focusing on status in the wine industry is adequate because certain status indicators, such as wine ratings received by national and international field rankings, are often seen as a signal for quality (Benjamin and Podolny, 1999). Moreover, investigating this industry is salient since it is an excellent case of a globally competitive sector, as well as a regional development case of a natural resource-based industry where knowledge networks play a critical role in explaining its architecture and evolution over time (Benjamin and Podolny, 1999; Porter and Bond, 2004; Giuliani, 2006).

We implement a dynamic network analysis to investigate how status affects decisions to diffuse knowledge across other local firms, controlling for a set of relevant other factors influencing network change. We use Stochastic Actor-Oriented Modelling (SAOM) because it is a statistical model for the analysis of network dynamics that simultaneously allows us to model structural dependencies and assortative dimensions, while controlling for heterogeneity of the attributes of the actors. More precisely, we use SAOMs implemented in the RSiena statistical software.

This work is structured as follow. Section 2 introduces the theoretical framework, focusing on status and its related assortativity/disassortativity debate. Section 3 describes the empirical setting, data source and characteristics, and the methodological approach. Section 4 shows network-level statistics and results of the models. Section 5 concludes with a discussion of main results, finding implication for theories on status and industrial clusters.

2. Theory

2.1 Status

From Weber's (1922) definition of status as "an effective claim to social esteem in terms of negative or positive privileges" (p. 305), scholars from different disciplines focused their attention on how status considerations shape society, organizations, and their networks. Economists and management scholars have also been interested in understanding how status influences the economic performance of firms. With Podolny's (1993) definition of the producer's status as "the perceived quality of that producer's products in relation to the perceived quality of that producer's competitors' products" (p. 830), a stream of research has been opened about status, understood as a signal for some kind of quality

based on people's perceptions and opinions. In this vein, status is mainly an evaluated trait because it may be assessed once it is compared with everyone else's (leading an agent to have a "relative position"). Status considerations are also considered to influence relationships (Amendolagine et al., 2018), potentially shaping networks structures and their dynamics (Lazega et al., 2012).

Networking decisions are often taken under uncertainty and information asymmetries since firms do not know the real quality of other agents' features once they need to choose with whom to establish a relationship. Gould (2002) argues that there is not a system able to perfectly understand the values of singular qualities in order to give back rewards to every actor based on their differences. In this respect status may act as an indicator of quality (Baum and Oliver, 1992), it increases the visibility of a firm or product, and it may reduce the transaction costs with business partners (Podolny, 1993). Thus, firms have different status because they are different in individual attributes and status heterogeneity is influenced by the various individual social positions sometimes independent of real actors' qualities (Podolny, 1993). In fact, status relies on perceptions, since it is basically a judgment by others on the quality of one or more attributes, or a wide opinion on the quality of an actor, and in turn, it is an estimate of a social or economic position strictly related to authority, wealth, prestige, or political power (Gould, 2002). Consequently, status-related networks are made by different levels of actors' statuses that are structured as hierarchies since high-status agents have cumulative advantages in front of the disadvantages of low-status actors. Those hierarchical structures are likely to be stable and self-reinforcing over time (Lazega et al., 2012), given that both high and low-status agents recognize the paradigm within they are operating. Finally, status is also related to other two main effects; on the one hand, a high-status actor expects to get a preferential treatment and special privilege by the others; on the other hand, individuals strive for increase status through thoughtful affiliations (Weiss and Fershtman, 1998).

2.2 Status within clusters

Traditionally scholars of industrial clusters have considered the local firms' geographic and social proximities would keep information asymmetries to the minimum within such spatially bounded areas. The very Marshallian idea of "the mysteries of trade become no mysteries; but are as it were in the air" (Marshall, 1920, p. 271) has influenced a generation of studies where clusters and regional co-localized economies were seen as favouring knowledge sharing, on which basis firms, entrepreneurs, and managers (among

others) were assumed to rely on first-hand information about their partners or competitors. We question this assumption and suggest that status can be a fundamental attribute orienting networking decisions within clusters.

A very few studies have pointed at the importance of status or similar constructs in industrial clusters. For instance, Balland et al. (2016) investigated whether actors are more likely to establish ties with others with the highest number of connections (defined as "network status" and constructed as preferential attachment mechanism from the distribution of incoming ties) or with the strongest reputation (defined as "industrial status" and operationalized as the number of active years of a firm within the industry). They find a positive and statistically significant impact of both network and industrial status on the dynamics of a business knowledge network and not on the dynamics of a technical knowledge network.

With a micro-level approach within regional clusters, similar constructs measured with different actor-based features have been proposed. For example, a few contributions find that firm-size, number of goods produced, ages performing within an industry, actor's degree affect knowledge network dynamics (Balland et al., 2013; Castro et al., 2014; Giuliani, 2013).

2.3 Status-driven assortativity and disassortativity

Once we focus the attention on mechanisms driving status-related knowledge networks (and more in general networks where actors' attributes play a role), we need to understand to what extent actors are more likely to establish relations with similar others (assortativity) or if they tend to have links with different others (disassortativity). Being aware that status can be observed in several ways (for a review, see McPherson et al., 2001), past contributions seem to find support for both status-driven assortativity and disassortativity.

Regarding assortativity, Lazarsfeld and Merton (1954) define it as "a tendency for friendships to form between those who are alike in some designated respect" (p. 23) in a study about friendship among individuals. McPherson and Smith-Lovin (1987) find that it is common to have groups composed by homogenous (in terms of gender, age, nationality, etc.) components where there is an "induced" assortative behaviour; while, within heterogeneous groups there is propensity to link with similar others through a "choice" assortative attitude, and Ibarra (1995) finds that homophily is a critical driver for link formation because individuals expect to be accepted by self-similar others.

Focusing on the role of status as a driver for assortativity, Gould (2002) claims and provides a model explaining that actors' relational decisions are mainly driven by the homophily principle, according to which agents are more likely to interact if they are of similar status, and Centola, et. al. (2007) argue that status homophily is a critical example of the similar cultural background driving assortative attitude. Following this, we can suppose that high-status actors are likely to interact with other similar status actors in order to reproduce their position over time; while, low-status actors may establish relations with other low-status actors because they are more likely to return the interaction than high-status alters.

From a network perspective, if high-status actors are usually at the centre and low-status actors at the periphery, this leads to network structures where more central actors are likely to become more central over time (Barabasi and Albert, 1999; see also Nicotra et al., 2014 for evidence on industrial clusters); thus, confirming the idea that hierarchical networks tend to reproduce their architectures over time (a phenomenon also related to the "rich-club" effect where "rich-get-richer").

Regarding disassortativity, if we divide actors between those with high and those with low status, status-related disassortative mechanisms may be hypothetically driven by low-status actors that aim to establish relations with high-status actors, or by high-status actors that aim to be linked to low-status actors. Several contributions find that less prominent actors try to relate to more prominent others (Barabasi and Albert, 1999) and; conversely, more prominent actors are more likely to be attractive for less prominent others (Ahuja et al., 2012) once the latter aim to enhance their image based on quality and prestige, and in order to increase their status position (Kilduff and Krackhardt, 1994; Benjamin and Podolny, 1999). Furthermore, low-status actors are likely to forge links with high-status agents also in the cases where it is possible to assume that high-status actors are those that may have valuable information (Lazega et al., 2012). Those mechanisms have been also depicted in terms of a legitimisation process where linkages with high-status actors may lead to an external validation and a higher level of reliability for low-status agents (Wiewel and Hunter, 1985; Baum and Oliver, 1991).

Despite this remarkable number of contributions investigating different network mechanisms driven by status, only a few studies investigate reasons of relations from high-status actors towards low-status actors. For example, Powell (1998) calls for the possibility that high-status actors can create new relations with low-status actors when the former belong to an industry (in their case, the pharmaceutical sector) and the latter to another one

(in their case, the biotechnological one) because the former are able to provide a set of organizational capabilities; while, the latter are able to be on the frontier of the emerging science and discover novel methodologies. At the same time, a few contributions do not find support for disassortativity since low-status firms can find more difficult or costly to create relationships with high-status firms if the latter can explicitly avoid those linkages (Benjamin and Podolny, 1999). In fact, the perception related to a status level may be diminished once the agent decides to link with a low-status other; for example, high-status actors are more likely to avoid asking advice from lower-status others (Faulkner, 2003; Agneessens and Wittek, 2012).

3. Research design

3.1 The context

Italy is one of the most celebrated Countries of wine tradition. Italian wines range from low to top quality bottles and many of these are worldwide known for their variety and selections. The wine production in this Country dates back to the Etruscans, Greeks, and Romans, and nowadays, Italian wines are preserved by a tightened legislation consistent with the last EU wine regulation. The Italian wine system is characterized by a large number of small and medium firms, often members of local producers' associations. These organizations are *de facto* established as networks of wine producers and, in several cases, they have their own legislation that goes by the name of different guaranteed designations of origin. Nowadays Italy is the World's leading wine producer in terms of hectares with an average increasing trend over the last five years, it is ranked fourth in terms of acreage (following the general decreasing trend over time of the so-called "old World wine Countries"), number three in terms of millions of hectoliters of consumption with a general increasing pattern over the last five years, and number two in terms of thousands of exported hectoliters (OIV, 2017).

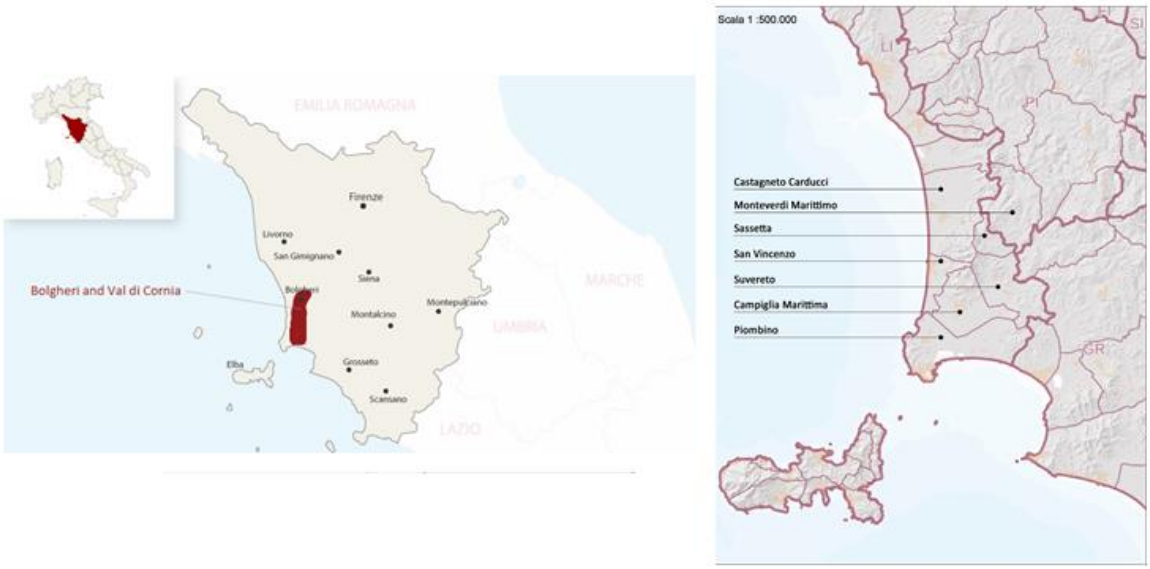
The *Bolgheri and Val di Cornia* region is located in the south-west part of Tuscany, Italy, directly overlooking the sea and it extends for less than 50 km north to south. Even if the wine production within this area dates back to the Etruscans, the "modern" wine history began in 1944, with the first French cabernet grapes planted in the area. Adopting French wine production systems, the first bottle of wine was sold on the market in 1968, and the region started attracting the attention of other wine producers, professionals, and consumers from all over the World. In a few years, several new wineries emerged, and old

local wine producers shifted their productions from autochthonous (particularly, Sangiovese, the most common wine grape variety within Tuscany) towards French grapes (particularly, cabernet, merlot, and petit verdot) and French production techniques, orienting the whole production system towards high-quality wines (Mansson, 1996).

In a very short time, several wines of the region were recognized to be among the best wines of the World by wine experts, with a peak in 2001 when four bottles of this region were ranked among the best 100 by a wine leading magazine and one wine was awarded to be the "wine of the year" (Wine Spectator, 2017). Therefore, this region is considered to be a superstar cluster for the high quality of wines and for the exceptional premium prices attained by several local wineries, to such an extent that sometimes they are recognized under the name of 'Supertuscans'.

A specific aspect of several wine regions and; particularly, a fundamental feature of Bolgheri and Val di Cornia area is the co-existence of a relational system among vertically integrated firms with a very competitive and cooperative environment. A large portion of the processes from the grape harvesting to the placing on the market of the final wine bottle is made within the singular firm; while, several forms of specific knowledge (e.g. technical and business ones) are shared among wineries via both formal and informal channels, since – among other reasons - they are very proximate in space.

Figure 1: Bolgheri and Val di Cornia cluster



Source: elaboration on Tuscany Region website.

3.2 Why status in this context

Firm's status is likely to influence decisions about knowledge diffusion in regional clusters; thus, it affects their network hierarchies and; especially, it influences the dynamics of local knowledge networks. This is particularly true in the wine industry (Morrison and Rabellotti, 2009; Giuliani, 2013). A few contributions investigated the role of status in this sector mostly taking wine guides as the main source of a status-related measure. For example, Benjamin and Podolny (1999) analyzed the impact of status ordering within the California wine industry and they found that; on the one hand, there is a link between status position and the quality at which firms decide to produce; on the other, hierarchies based on status are likely to be reproduced over time, since high-status wineries are more likely to look for high-status appellation affiliations. Malter (2014) investigated the role played by status on the price market within a high-quality French wine industry, showing that status is increasingly an attractor for conspicuous consumption, rather than a signal for quality as it was mainly in the past; while Zhao and Zhou (2011) showed the impact of consistency or inconsistency of several status indicators on product valuations and economic returns within the California premium wine market. Hay (2010) analyzed the role played by status in the globalization process through ratings by international wine critics in influencing wine prices in Bordeaux area and he found that they directly impact on status and they have a similar role to that of a credit-rating agency. Finally, testing preferential attachment as the fundamental status-related mechanism within a Chilean wine cluster, Giuliani (2013) showed that there is no support to argue that high-status wineries are more likely to create new relationships over time, but, that mechanism might be important once an actor needs to select with whom create a tie.

Furthermore, it is particularly important for a superstar cluster, like a successful wine cluster, where firms can be ranked referring to their perceptions in terms of high-quality (and luxury) productions. In those cases, status acts as a signaling feature. Following Veblen (1989), merely wealth or power is not sufficient to show a status position since it is not directly observable; thus, actors need to show status in order to be recognized and, thus, awarded (Weiss and Fershtman, 1998). In this vein, Humphreys and Carpenter (2018) argued that status is a critical driver for wineries' success distinguishing by high-status and low-status wine producers. Particularly, on the one hand, they claimed that high-status firms may drive markets, they influence retailers and distributors, they attract talents and resources, and they can also drive consumer preferences independently from quality; on the

other hand, they argued that related advantages can last for years at the expense of low-status wine producers.

Since status derived from past performance of actors involved in networks of alliances may be a predictor of future relationships (Ebbers and Winjnberg, 2010), we aim to analyze to what extent status perceptions affect network dynamics and; particularly, status hierarchies that are based on judgments of professionals. Specifically, we attempt to better understand the reasons for asymmetric network systems composed by low-status and high-status actors within an industry where individual and collective performances are critically driven by the reputational settings.

3.3 Data collection and data characteristics

We use an original database with longitudinal data collected within the Bolgheri and Val di Cornia wine cluster[14]. The survey was administered to collect different typologies of data, including basic firm and industry-level information, network data, and strategy-related information, both with quantitative and qualitative questions. Surveys were administered to local wineries at two points in time (2003 and 2013), with a structured questionnaire that had an average length of 40 minutes to be fulfilled. The survey was carried out to 41 local wine producers in 2003 and to 62 in 2013. Only in the second survey wave we do not reach the universe because a very few wineries did not accept to participate, but they can be considered as marginal ones in terms of their importance (measured with size and local reputation as they emerged from two firm-level questions of the questionnaire). Moreover, 5 wineries among those surveyed exited the cluster and 25 entered from 2003 to 2013. Interviews were usually carried out with technical professionals within wineries or, if they were not available, with those more directly involved in the production process. In a few cases, those roles were directly played by entrepreneurs themselves. Network-level data were collected with the roster recall method (Wasserman and Faust, 1994); namely, it was asked to every interviewee to answer to relational questions regarding knowledge transfer of technical advice referring to a roster composed by every other winery operating within the cluster. Particularly, it was asked "*what are the other local wineries among those listed to which you transfer a technical knowledge to solve a problem in the production process?*". We focused on technical knowledge transfer since its relevance in understanding learning process within clusters has been proved

[14] Amir Maghssudipour participated in the last phase of the survey administration in 2013. Other surveys of 2013 and 2003 waves were provided by Elisa Giuliani.

(Giuliani and Bell, 2005; Giuliani, 2007, 2010; Morrison and Rabellotti, 2009; Juhász and Lengyel, 2017). Answers were stored in asymmetrical square matrices where firms in rows transfer knowledge to firms in columns since knowledge transfer is reported as a directed tie from a source winery to a recipient other.

Table 1 shows firm-level descriptive statistics.

Table1: Firm-level descriptive statistics

Year of the survey		*2003 (n=41)*	*2013 (n=62)*
Size (number of employees)	Small (1-19)	90%	95%
	Medium (20-99)	4%	2%
	Large (≥100)	6%	3%
Ownership	Domestic	95%	82%
	Foreign	5%	18%
Decade of localization	Up to 1970s	24%	16%
	1980s	22%	14%
	1990s	23%	18%
	2000s	15%	52%
Organisational structure	Independent, vertically integrated	93%	95%
	Part of a group, vertically integrated	7%	5%

Source: Authors' own data.

This table shows an increasing trend in the number of vineries by about 50% over the two data collection waves. They are mainly small sized firms (less than 20 employees) and independent. Regarding ownership's forms, the vast majority is locally owned, even if it is possible to notice a slight decrease over time in favour of foreign ownership. As concerns the decade of localization, firms were almost equally distributed among four main periods (before 1970, between 1980-1990, between 1990-2000, after 2000) from the first survey wave; while, it appears that more than the half started operating within the region after 2000 from the second survey wave.

3.4 Method of analysis and construction of the models

Collected data were recorded in asymmetrical matrices indicating the presence (the interviewee declared to transfer technical advice to another winery) or the absence (the interviewee declared not to transfer technical advice to another winery) of a directed tie between two actors. Subsequently, we use a dynamic network analysis framework to investigate how status affects decisions to diffuse knowledge to other local wineries,

controlling for a set of relevant other factors influencing network change. Particularly, Stochastic Actor-Oriented Modelling (SAOM) is used because it is a statistical model for network dynamics that simultaneously allows us to model structural dependencies (like reciprocity) and proximity dimensions (like geographical proximity), while controlling for heterogeneity of the attributes of the actors. It has been recently acknowledged that SAOMs open new areas of inquiries to understand the spatial evolution of networks; so far, they have been applied to analyse the spatial dynamics of global and regional knowledge networks, for instance by Giuliani (2013) on a knowledge network of a wine cluster in Chile, by Balland (2012) on R&D collaboration networks in Europe, by Ter Wal (2013) on invention networks in Germany, by Balland et al. (2013) on the evolution of the global video games industry, by Lazzeretti and Capone (2016) on innovation networks in a cluster of high technology applied to cultural goods, and more recently by Juhasz and Lengyel (2017) on formation, persistence, and evolution of ties in a medium-tech industry.

This model elaborates critical measures for our case since the response variable is the creation of a relational tie between two agents. It is based on iterative Markov chain models that investigate the change probability from the current state of the network. Network dynamics result from decisions at the micro-level (i.e. an actor decides to establish a relationship with another firm, or to dissolve a past one, or to maintain it over time) and they are based on preferences of the individuals, as well as on constraints and opportunities they encounter. In turn, individual choices are dependent on ego characteristics (such as internal capabilities and individual attributes) and on systemic features (such as past networks and proximity structures) (Snijders et al., 2010).

Moreover, SAOMs allow us to implement three main covariate-related effects: 1) the covariate-similarity effect, where a positive parameter implies that actors prefer ties to others with similar values on this variable. 2) the covariate-ego effect, where a positive parameter will imply the tendency that actors with higher values on this covariate increase their outdegrees more rapidly. 3) the covariate-alter effect, where a positive parameter will imply the tendency that the in-degrees of actors with higher values on this covariate increase more rapidly (Ripley et al., 20011).

More precisely, we use SAOMs implemented in the RSiena statistical software (Ripley et al., 2011). We build five models based on several variables. Model 1 includes the three traditional variables for dynamic network analysis (“rate parameter”, “outdegree”, and “reciprocity”). Model 2 adds to Model 1 status-related variables since it models ego and alter effects (“status ego” and “status alter”). Model 3 adds the core status-related

variable investigated with the similarity effect ("status similarity") and it does not control anymore for variables previously resulted not statistically significant (following the parsimony rule of network dynamic modelling, Snijders et al., 2010). Model 4 also controls for geographical distance ("geo distance"); while, Model 5 also takes into consideration two more firm-level control variables, implementing ego and alter effects ("size ego", "size alter", "experience ego", and "experience alter").

Our critical variable is built on firms' status. Particularly, we implement the covariate-similarity effect to investigate the tendency of relating to similar others (assortativity) or different others (disassortativity) in terms of the selected variable. In other words, a negative result means that high-status actors are more likely to interact with low-status actors and low-status actors are more likely to interact with high-status actors; while, a positive result means that high-status actors are more likely to interact with high-status actors and low-status actors are more likely to interact with low-status actors.

One special characteristic of the wine industry is that it has many publicly available books and reports for the evaluations of products; in fact, to measure a firm's status we collect scores by Vini di Veronelli 2013 wine guide since it may be considered one of the leading magazines influencing the wine industry commercial trends and it is the one with the widest coverage in terms of rated wines for our case in comparison to other international sources such as Wine Spectator, Wine Enthusiast, Decanter, James Suckling, Wilfred Wong, Wine and Spirits, Robert Parker/Wine Advocate, Vinous, Jancis Robinson, and other national sources such as Gambero Rosso, L'Espresso guida vini, Vini d'Italia/Slow Food, Duemilavini/AIS. Scores are given by professionals to wine bottles based on the vintage within five categories from 50 to 100 points. The 2013 edition of the wine guide collects scores before 2013; thus, we calculate the average of all the scores for every winery since status is formed over time and we transform continuous rankings into meaningful categories as 1 = not scored; 2 = 50-59; 3 = 60-69; 4 = 70-79; 5 = 80-89; 6 = 90-100. The absence of a score means that wines are not evaluated in the wine guide and we may interpret this as the lowest indicator for status since wine producers, conscious of having produced low-grade wines, do not ask to be evaluated from experts of the wine guide. Status-related variables are based on these ratings; thus, they are individual attribute-based variables.

The rate parameter is always present in SAOMs and it indicates to what extent an actor is likely to consider exchanging its relation to alters. We also control for two structural path-dependent variables influencing network dynamics; on the one hand, outdegree

(density) is the general tendency of individuals to form ties; on the other, reciprocity is the general tendency of individuals that receive a relation, to reciprocate it.

We also test the role of geographical distance, to study to what extent the physical distance among wineries is likely to influence knowledge sharing since wine industries are usually aggregated in space, and this factor may favour casual and informal encounters among employees of different firms (so it is a critical information about basic contact opportunities). Specifically, it is the distance in kilometres between wineries based on Google Maps data. Finally, we control for two critical individual characteristics such as size and experience, since previous contributions indicate that they are likely to affect knowledge diffusion structures and dynamics within regional clusters. Size is an actor level variable that considers the number of employees; while, experience considers the number of years a firm operated within the industry. They are tested with a covariate-similarity effect.

Table 2 shows definitions of variables and (possibly) the question of the survey they are based on. Moreover, it presents the effect modelled on the variable (if any), the interpretation of potential results, and a brief description of variables' statistical categories. Finally, it is identified if primary or secondary data sources are used.

Table 2: Variables explanation

Knowledge transfer	Definition: If the interviewee of winery A claims to transfer a technical knowledge to winery B, then the edge from A to B takes the value 1, otherwise 0. Survey question: what are the other local wineries among those listed to which you transfer a technical knowledge to solve a problem in the production process? Category: response variable. Source: authors' interviews.
Status (ego/alter/ similarity)	Definition: If a winery has no ranked wines, it takes the value 1. If a winery has the ratings average of all rated years between 50 and 59, it takes the value 2. If it is between 60 and 69, it takes the value 3. If it is between 70 and 79, it takes the value 4. If it is between 80 and 89, it takes the value 5. If it is between 90 and 100, it takes the value 6. Note: ratings are per bottle. Effect: covariate-ego; covariate-alter; covariate-similarity. Ego-effect interpretation: a positive and significant value implies the tendency that wineries with higher status increase their outdegree more rapidly; a negative and significant value implies the tendency that wineries with higher status decrease their outdegree more rapidly. Alter-effect interpretation: a positive and significant value implies the tendency that wineries with higher status increase their indegree more rapidly; a negative and significant value implies the tendency that wineries with higher status decrease their indegree more rapidly. Similarity-effect interpretation: a positive and significant value implies that wineries prefer to exchange knowledge with others with similar status (assortativity); a negative value implies that wineries prefer to exchange knowledge with others with different status (disassortativity). Category: (node and dyadic level) explanatory variables. Source: Vini Veronelli wine guide.

Rate parameter	Definition: the estimated number of opportunities for change per winery. Interpretation: stability of the network over time. Category: (structural level) explanatory variable. Source: data-dependent elaboration.
Outdegree (density)	Definition: the proportion of all possible ties among wineries (the ratio of all the real ties to its theoretical maximum). Interpretation: a positive and significant value indicates an overall tendency of actors for exchange of knowledge. Category: (structural level) explanatory variable. Source: data-dependent elaboration.
Reciprocity	Definition: winery A exchanges knowledge to winery B and winery B exchanges knowledge to winery A. Interpretation: a positive and significant value implies a tendency of mutual exchange of knowledge. Category: (structural level) explanatory variable. Source: data-dependent elaboration.
Geo distance	Definition: distance in kilometres between two wineries. Interpretation: a positive and significant value implies that the more wineries are proximate, the less likely they will transfer knowledge; a negative and significant value implies that the more wineries are proximate, the more likely they will transfer knowledge. Category: (dyadic level) explanatory variable. Source: Google Maps elaboration.
Size (ego/alter)	Definition: number of employees of a winery. Effect: covariate-ego; covariate-alter. Ego-effect interpretation: a positive and significant value implies the tendency that larger wineries in terms of employees increase their outdegree more rapidly; a negative and significant value implies the tendency that larger wineries in terms of employees decrease their outdegree more rapidly. Alter-effect interpretation: a positive and significant value implies the tendency that larger wineries in terms of employees increase their indegree more rapidly; a negative and significant value implies the tendency that larger wineries in terms of employees decrease their indegree more rapidly. Category: (node level) explanatory variables. Source: authors' interviews.
Experience (ego/alter)	Definition: number of years a winery is working in the wine industry in Bolgheri - Val di Cornia region. Effect: covariate-ego; covariate-alter. Ego-effect interpretation: a positive and significant value implies the tendency that wineries operating for a higher number of years in the wine industry increase their outdegree more rapidly; a negative and significant value implies the tendency that wineries operating for a higher number of years in the wine industry decrease their outdegree more rapidly. Alter-effect interpretation: a positive and significant value implies the tendency that wineries operating for a higher number of years in the wine industry increase their indegree more rapidly; a negative and significant value implies the tendency that wineries operating for a higher number of years in the wine industry decrease their indegree more rapidly. Category: (node level) explanatory variables. Source: authors' interviews.

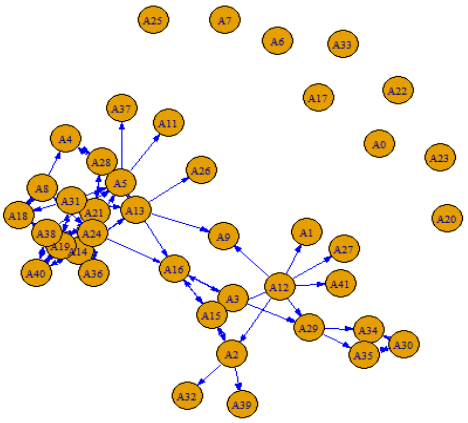
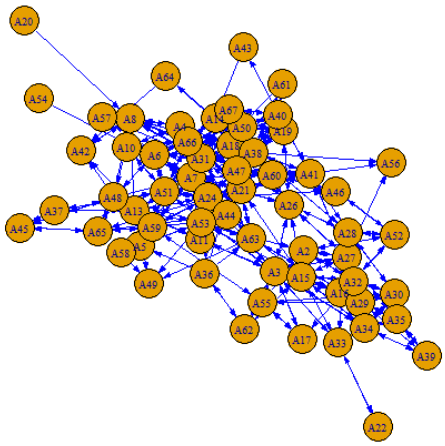
Source: authors' own elaboration.

4 Empirical analysis

4.1 Descriptive statistics

Several descriptive statistics on the change in networks are presented below in order to have a comparison among network structures. Table 3 shows graphs of the two networks.

Table 3: Network graphs

Net1, 2003	Net2, 2013
	

Authors' elaboration on R-software. Source: Authors' own data.

Controlling for entry and exit patterns, the final relational matrixes are composed of sixty-seven nodes (wineries). Table 4 presents several network-level static measures.

Table 4: Network-level descriptive statistics

Network/Measures	Net1	Net2
Observation Year	2003	2013
Nodes	41	62
Edges	84	381
Isolates	9	0
Components	10	1
Density	0.019	0.086
Cluster Coeff	0.291	0.284
Diameter	8	6
Avg Path Length	2.982	2.560
Avg Degree	4.098	12.290
Degree Centralization	0.127	0.264
Betweenness Centralization	0.074	0.205
Closeness Centralization	0.029	0.045
Mutuals	26	174
Asymmetrics	32	33
Nulls	762	1684
Reciprocity	0.620	0.913
Assort Degree	0.136	-0.067

Authors' elaboration on R-software. Source: Authors' own data.

Particularly, number of nodes (wineries in our case) increases from 41 to 62, number of ties increases around five times (from 84 to 381), and if nine nodes are not connected to the others in 2003, no isolates are present in the second network (it is also confirmed by the number of components). Density, that is the proportion of all possible ties that are actually present (namely, the sum of ties divided by the sum of possible ties) increases by more than

four times, moving from 1.9% of all possible ties to 8.6% of all possible ties; thus, we may suppose that there is an evident increase of the speed, even if modest, at which knowledge spreads among wineries over time. Cluster coefficient is a measure of the tendency towards dense local neighbourhoods and it is calculated as the average of the densities of the neighbourhoods of all actors (excluded the ego); in our case it is quite similar in the two networks. Diameter is a measure for size and is calculated as the largest geodesic distance in the connected network; in our case it decreases over time and it shows that no actor is more than 8 steps from any other in 2003 and 6 steps in 2013. Thus, the average path length is slightly lower in the second wave than in the first one, and also, average degree, as the average number of links per node (it may be calculated as density times the size of the network minus one), increases more than doubled over time, moving from the first period when a firm has little more than 4 relations on average to the second period when a firm has more than 12 relations on average. Three centralization measures are computed (degree, betweenness, and closeness) and they all show an increasing value over time. Mutual and asymmetric measures are straightforward statistics on a dyadic basis exploiting the fact that the network is directed. From the first survey wave to the second one there is a high increase in mutuality of relations since only 26 of them are mutual in 2003; while, 174 are mutual in 2013. Conversely, asymmetric ties are almost stable over time (but, the number of null ties increases by more than two times). The tendency to reciprocate a tie is increasing over time (from 0.620 to 0.913). Finally, assortativity degree, as the tendency of nodes with high values of degree to connect to others with similar values of degree is positive for the first wave (showing a degree-related assortative behaviour) and negative for the second one (showing a degree-related disassortative behaviour).

They show that the network composed by knowledge flows through advice within the wine cluster is – *inter alia* – denser and more cohesive over time, and no more isolates are present at the time of the second survey wave. On the one hand, this substantial change may be due to the effectiveness of the incentives to cooperate of the local wine-related consortium (the authority established for the protection, promotion, and coordination of the local wine production); on the other hand, several wineries at the beginning of the new millennium increased their popularity on the global level with the effect of being more likely to attract the interest of many other local wineries and new entrants.

4.2 Results

Results of SAOM for the five models are presented in Table 5. They are non-standardized coefficients obtained from logistic regression analysis and they are log-odds ratio (Steglich et al., 2010). Thus, the interpretation corresponds to how the log-odds of tie formation change with one unit change of the independent variable.

Table 5: Results of SAOMs

	(1)	(2)	(3)	(4)	(5)
	Coeff (SE)	Coeff (SE)	Coeff (SE)	Coeff (SE)	Coeff (SE)
Rate parameter	26.300*** (4.381)	28.683** (10.633)	26.480*** (3.326)	36.172*** (9.556)	38.798*** (4.879)
Outdegree (density)	-2.868*** (0.194)	-2.867*** (0.203)	-2.845*** (0.300)	-2.910*** (0.191)	-3.102*** (0.336)
Reciprocity	4.500*** (0.284)	4.392*** (0.379)	4.432*** (0.503)	4.286*** (0.281)	4.580*** (0.527)
Status ego		0.071 (0.060)			
Status alter		0.071 (0.037)			
Status similarity			0.291** (0.094)	0.224** (0.084)	0.217** (0.087)
Geo distance				-0.043*** (0.008)	-0.046*** (0.008)
Size Ego					0.030*** (0.007)
Size Alter					-0.012 (0.007)
Experience ego					-0.0113** (0.0038)
Experience alter					0.007 (0.004)

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05. Source: our elaboration.

The convergence of the approximation algorithm is good for all the variables of the different models since coefficients present *t*-ratios inferior to 0.1 in all models.

"Status ego" and "Status alter" are not statistically significant. Thus, they do not help in explaining the evolution of the network.

"Status similarity" is positive and statistically significant in every model where it is tested; thus, wineries with high status are more likely to interact with wineries with high status and wineries with low status are more likely to interact with others with low status. Exploring the impact of status on the assortative dynamics of a knowledge network, this result takes one step further in comparison to other studies that found out that firms with prominent status are likely to form more linkages over time (for example, Giuliani, 2013). We also implemented the same models with alternative wine guides as reported in the other three most important ones in terms of coverage for the Bolgheri and Val di Cornia case (respectively, Wine Spectator, Gambero Rosso, L'Espresso guida vini) and we obtained similar results in terms of statistically significance and magnitude.

"Rate parameter" indicates whether an actor is likely to take into account changing its relation to alters. It is positive and statistically significant in every model; thus, it shows a significant change in new tie formation between the two periods of time (Snijders et al., 2007). However, it presents a quite high value in comparison to other empirical studies where SAOMs are applied to investigate knowledge network dynamics (among others, Giuliani, 2013; Balland et al., 2016; Juhász and Lengyel, 2017; Giuliani et al., 2018); thus, the Bolgheri and Val di Cornia case does not seem to present a so stable structure of ties over time.

As expected, "Outdegree (density)" is negative and statistically significant in all models (Snijders et al., 2007). This means that wineries do not tend to form new ties with just any other winery in the cluster and this confirms findings of many other empirical contributions that studied the evolution of knowledge networks over time (among others, Balland et al., 2013; Giuliani and Matta, 2013; Giuliani et al., 2018).

"Reciprocity" is positive and statistically significant in every model and this means that an actor is more likely to reciprocate a tie, rather than to relate to others they have not received contacts (Snijders et al., 2007). This confirms findings of other similar studies (among others, Giuliani, 2013; Balland et al., 2016; Juhász, and Lengyel, 2017; Giuliani et al., 2018).

Once other variables are added, they do not have a remarkable impact on structural and core variables (in terms of both magnitude and direction of the impact).

"Geo distance" is negative and statistically significant and it shows that spatial proximity matters for knowledge diffusion. This is in line with several other contributions that analysed the role played by geographical proximity on knowledge network dynamics, like – among others - Broekel and Boschma, 2011; Balland, 2012; Castro et al., 2014; Molina-Morales et al., 2015; Capone and Lazzeretti, 2018). This is even more interesting for the cluster under examination because it shows that geographical distance matters for exchange of knowledge also in places with relatively restricted extension (this area extends for less than 50 km north to south).

Finally, ego and alter effects are modelled on two more control variables ("Size ego", "Size alter", "Experience ego", "Experience alter"). Other contributions studying knowledge network dynamics proved that the number of employees (for example, Giuliani et al., 2018) and the number of years operating in an industry (for example, Balland et al., 2013) impact on the dynamics of the exchange of knowledge. Once they are added, alter-effects for both control variables do not result statistically significant, thus they do not help in exploring knowledge network dynamics. However, ego-effects for both covariates show statistically significant results, but they are the opposite. On the one hand, contrary to several empirical contributions (for example, Balland et al., 2013, Castro et al., 2014; Molina-Morales et al., 2015; Lazzeretti and Capone, 2018) actors operating in this industry for a long time are less likely to interact with local others; on the other hand, in line with previous contributions (for example, Balland et al., 2013; Giuliani et al., 2018), those with more employees are more likely to establish outgoing local interactions.

5. Discussion and conclusions

In several organizational fields, and; particularly, in a system like a regional cluster, the socio-economic environment is characterized by uncertainty and imperfect information; thus, perceived relative qualities of other firms can influence decisions about knowledge diffusion. Unlike several other contributions that focused on the role played by indirect reputation-related features on knowledge network dynamics as firms' size or age (for example, Balland et al., 2013), we focus on perceptions about the qualities of the advice giver. At the same time, we take into consideration that they are difficult to be objectively judged by other actors and they are critically affected by signaling decisions offered by the source of knowledge diffusion (Benjamin and Podolny, 1999). Status is intrinsically relational and dynamic, because; on the one hand, it is made by others' opinion on individual features and it may be assessed once it is compared with everyone else's; on the

other, the more actors have contacts, the less they need status as a signal for quality (Podolny, 1993). Specifically, with respect to the existing literature on knowledge network assortativity (Crespo et al., 2013; 2015) we contributed focusing on status-driven assortativity within cluster contexts. Our analyses show that status is a fundamental driver of change over time of knowledge network structures in clusters; particularly, results support that high-status firms are more likely to transfer advice to other high-status firms, low-status firms are more likely to transfer advice to other low-status firms and not between themselves. We interpret our results in light of status theory as a driver of networking decision within uncertainty (Gould, 2002), as well as in light of the well-known debate about the cooperation-competition dynamics occurring in industrial clusters and in industrial districts (Dei Ottati, 1994; Newlands, 2003).

First, our result supporting assortativity may be interpreted as a relevant outcome of an individual (firm-level) choice since actors may decide to link with similar, as well as different others. This result is more consistent with a "choice" assortative behaviour than an "induced" one (McPherson and Smith-Lovin, 1987). In fact, the search for homophily critically leads firms towards assortative attitudes since they may expect to be more accepted by self-similar others (Ibarra, 1995). This finding also implies that hierarchical structures are likely to be stable and self-reinforcing over time, given that both high and low-status agents recognize the paradigm within they are operating (Lazega et al., 2012). In this vein, status is also potentially related to two main effects; on the one hand, a high-status actor expects to get a preferential treatment and special privilege by the others; on the other hand, individuals strive for increasing status through thoughtful affiliations (Weiss and Fershtman, 1998).

Second, we do not find support for disassortativity since low-status firms can find more difficult or costly to create relationships with high-status firms if the latter can explicitly avoid those linkages and high-status actors are more likely to avoid interacting with lower-status others (Benjamin and Podolny, 1999). If we take into consideration that high-status firms are often incumbents and/or big-sized and low-status firms are often new entrants and small-sized, an assortative knowledge diffusion may limit the spread of heterogeneous knowledge. In fact, if less recently established firms interact with other similar ones, they do not have access to novel and/or different knowledge and they risk being involved in (and being source of) a negative lock-in process; while, more recently established firms can only interact with similar others even if they would aim to relate with higher-status firms to improve their status level. Finding no support for disassortativity has

also implications related to the fact that actors with a certain level of status may have specific competencies that are not developed by actors with different levels of status or rare attributes that may be one another complementary specializations. With our result, it seems that potential specific competencies and rare attributes are less likely to be transferred across actors with different status.

Third, a few recent contributions exploring knowledge networks in clusters found out that status leads to increasing the concentration of knowledge in a few hands (for example, Giuliani, 2013; Giualiani and Matta, 2013). Our results are relatively different since they tell us that there are more levels of knowledge repositories where knowledge is exchanged within heterogenous groups of firms in terms of status. In other terms, those findings tell us that even if every actor may aim at interacting with others who have higher status (Lazega et al., 2012), not all of them can do that. Moreover, our results only partially confirm the literature arguing that actors may be encouraged to provide knowledge to others in order to further increase their status (Blau, 1964), since only those of them that have high (low) levels of status can interact with high (low)-status others.

Finally, this result has implication for the competition-cooperation debate within industrial clusters and industrial districts (Dei Ottati, 1994; Newlands, 2003). In fact, within this kind of territorial systems; on the one hand, co-located firms tend to be rival since they are independent and they compete on similar markets; on the other hand, they cooperate sharing different kinds of knowledge in formal settings and informal encounters. Results of this work highlights that high-status (low-status) firms are unexpectedly likely to exchange their knowledge towards other high-status (low-status) firms that may be perceived as direct competitors, but they are less likely to diffuse knowledge to others with a different level of status. In other words, those findings seem to show a structure where cooperation-competition dynamics among co-located firms is selective on the basis of status levels of firms.

Our contribution presents a few limitations and presented results should be interpreted with caution. Above all, it is affected by external validity problems for several reasons. Firstly, the study is based on a single wine cluster. This means that other wine regions in the same and in other countries can show different knowledge network-related structures and dynamics. Thus, further research may be implemented in other wine regions in order to compare their results. Second, this work refers to an industry with very specific characteristics. This implies that knowledge network structures and dynamics in other industries can be affected by different network-related aspects (for example, other kinds of

knowledge or other micro-level drivers may be more critical). Third, the investigated time period presents several factors traditionally characterizing a successful cluster. This aspect points out the need for more effort in investigating also underperforming clusters (as in Giuliani et al., 2018) or clusters in different evolutive phases. Fourth, this study does not accurately analysed non-local features that may affect the cluster under study. This is even more critical in the case of a wine cluster since the wine industry is dramatically and increasingly affected by international competitors and new consumers from all over the World.

Furthermore, regarding data used to represent firms' status, ratings on wine books are not so objective as assumed since they are based on critics' personal tastes and preferences. This means that other proxies for firms' status should be individuated in order to get different results (for example, a measure for within-cluster status may be analysed).

Finally, once assumed that regional clusters are composed by actors with different actor-based degrees of similarity/dissimilarity of individual features that operate within more or less related industries, we may expect the presence of similarities on some dimensions and simultaneously differences on others (a structure called "multiform heterogeneity" by Blau, 1974). Our results on control variables provide first insights to support this complex structure, but more effort on multilevel analysis of homogeneity/heterogeneity of individual characteristics and assortative/disassortative behaviours is needed.

Summary and conclusions

1 Main findings and contributions

The overall objective of this work was to investigate the role played by knowledge diffusion within local systems with a focus on relationships among co-located firms. For this reason, three main pillars are present over all the PhD thesis. First, theories of local development are the constant point of reference; second, a network approach mainly based on SNA and focused on knowledge diffusion is implemented both as theory and methodology; third, the wine industry is chosen as the empirical field. The introduction presented an overarching focus on the role played by different kinds of heterogeneity for knowledge diffusion within local systems. Two points needed to be highlighted before moving to more detailed conclusions. On the one hand, heterogeneity is meant at different levels such as individual characteristics (i.e. firm-level heterogeneity) or relational systems (i.e. network-level heterogeneity); on the other hand, heterogeneity may play its role within highly specialized sectors, as well as within diversified ones. After this general clarification, a discussion of the main results and findings of the three parts of this thesis is presented below.

The first chapter reviewed the state of the art of studies on knowledge diffusion in the form of knowledge networks within local systems. A few critical previous contributions are individuated in order to detect the main concepts of the literature on local development with a knowledge network perspective. Particularly, three main related categories of both theoretical and empirical investigations emerged. First, actors' individual characteristics (e.g. innovation capacity, openness to non-local knowledge, size, experience) and how they are perceived from others (e.g. status and reputation) impact on their decisions to ask for and diffuse knowledge. Second, similarity and differences among individual attributes, mainly highlighted at the previous point, impact on knowledge sharing following different patterns (usually recalled as assortativity and disassortativity) and producing different effects. Moreover, proximities emerge as a critical category within the boundary of studies on similarity and differences among individual attributes (Boschma, 2005). Different forms of proximity affect the spread of knowledge; particularly, if several empirical papers proved a positive impact of geographical, organizational, and social proximities (among others, Broekel and Boschma, 2011; Balland et al., 2013); opposite results are found for institutional, and cognitive proximities (for example, Molina-Morales et al., 2015). Third, also structural mechanisms may have a critical impact; particularly, several contributions proved a positive effect of reciprocity and triadic closure and a negative value is always

detected for density (for example, Giuliani, 2013; Balland et al., 2016). Moreover, after a detailed review of the main definitions and categories of knowledge and knowledge networks within local systems, a knowledge network-related explanation of their evolution is proposed. In this way, dynamics of the main determinants of the exchange of knowledge are investigated to explain an ideal-typical local system evolution through the emergence, the growth, the mature phase, the possible transformation, and eventually the disappearance.

The second chapter addressed some issues that are complementary to the critical assessment presented in the introduction, particularly focusing on network multiplicity. Different studies have recently pointed out that co-located actors can share knowledge through different channels, but only a few of them proposed a simultaneous investigation taking into account heterogeneity at network level (for example, Ferriani et al., 2013). This investigation implemented an Exponential Random Graph Model (ERGM) on an original database comprised of data collected in a wine region in Italy (Montefalco wine region). ERGMs are one of the most advanced methodologies for the study of networks and they are preferable in case of small networks and lack of longitudinal data; moreover, they allow us to simultaneously investigate different kinds of networks (Hunter et al., 2008). Since different kinds of relational systems – knowledge channels - exist among the same set of actors (i.e. a social network based on friendship and economic ties like material exchange and labour mobility), the aim of the work was to investigate what kind of knowledge channels explains the spread of technical knowledge, to what extent they impact on its diffusion, and whether they overlap. Empirical results showed that different kinds of relationships positively impact on the spread of technical knowledge, but they are different in terms of magnitude. Particularly, economic ties as material exchange (i.e. selling or renting machinery, semi-finished products, and raw materials) has the highest impact, followed by social ties based on friendship, and then by economic ties based on labour mobility. Moreover, this study found that social and economic ties do not overlap; thus, they follow complementary rather than substitutive network structures. The conclusions drawn from this part suggest that investigations of different kinds of knowledge channels may give a less partial picture of knowledge networks operating within local systems since if we simultaneously study multiple relational systems it is possible to include actors that would be isolated with an investigation of just one kind of them. At the same time, the result in favour of network complementarity may be interpreted as a critical source of heterogeneous forms of knowledge for local actors.

The third chapter addressed some other issues that are complementary to the critical assessment presented in the introduction, particularly focusing on the debate on assortative/disassortative relational mechanisms (Crespo et al., 2013). Several scholars have highlighted that economic actors need to decide with whom to interact in uncertain environments, thus they based their decisions also on judgments and perceptions of the others (Gould, 2002). This relational mechanism may be driven by assortativity meant as decisions to interact with similar others or disassortativity as decisions to interact with different others. Even if exchange of knowledge also depends on actors' perceptions about the qualities of the others, at the best of our knowledge, only a very few papers related to local development focused on status (Giuliani, 2013; Balland et al. 2016), as the perceived relative qualities of a firm in a given market or organizational field, since it is hardly measurable, but none of them empirically analysed to what extent status as an attribute-based variable affects assortative or disassortative network mechanisms. Compared to the second chapter, this study implemented another advanced network analysis (Stochastic Actor-Oriented Model – SAOM) (Snijders, 2017) on a longitudinal database in another Italian wine region (Bolgheri and Val di Cornia wine region). SAOMs are useful instruments since they allow to model structural dependencies, proximity dimensions, as well as to control for heterogeneity of characteristics and perceptions of actors. This analysis showed that actors perceived to have high levels of status are more likely to interact with other actors with high levels of status; while, actors with low levels of status are more likely to interact with other actors with low levels of status and not between themselves. This tendency towards network assortativity may be induced by the fact that individuals expect to be more accepted by self-similar others, implying that network structures and particularly hierarchical network structures are likely to self-reinforce over time. At the same time, finding no support for disassortativity may be explained referring to the social rule that high-status actors may deliberately avoid interactions with low-status actors in order to maintain their status level, but, in this way, they limit the diffusion of heterogeneous knowledge among actors with different levels of status. Moreover, this finding sheds some light on the cooperation-competition debate particularly discussed by scholars interested in industrial clusters and industrial districts, showing a new interpretation for the existence of selective and uneven knowledge diffusion.

To conclude, the thesis contributes to the literature in several ways. The theoretical framework is based on the literature focused on local systems and local development like studies on industrial districts and business clusters (Becattini, 1990; Porter, 1998), on the

proximity schools (Boschma, 2005; Torre and Rallet, 2005), on (dynamic) social network theories and their applications (Granovetter, 1973; Burt, 1992; Wasserman and Faust, 1994). In this way, it contributes to economic geography to the extent that it often settled its studies in similar or the same contexts, it often applies similar methodologies, and it sometimes took inspiration from the same schools of thought to frame itself.

More specifically, the literature review made in Chapter I shed new light on the state-of-the-art of contributions focused on local systems, their development, and on economic geography since it offers an original overview of (recent) empirical studies explicitly taking a network perspective. Moreover, it aims at stressing a few innovative interpretations of this literature such as multiform heterogeneity for exploration at the node-level and fluctuating proximities for studies at the dyadic level. Finally, it also puts attention on the role of relational structures and dynamics intrinsic to networks (e.g. reciprocity and triadic closure), rather than confining itself to micro-level determinants (e.g. organizations' status, experience, size, etc.).

Empirical studies are original works that shed light on aspects that have received little attention in the literature about local development and economic geography and empirical findings proved they play a fundamental role in explaining critical aspects of knowledge networks' structures and dynamics in local systems. Those contributions lie particularly in the theoretical discussion and empirical evaluation of network multiplicity and in the empirical evaluation of the role status plays for knowledge network evolution in local systems-like places.

Moreover, this work may be seen also as a first attempt to develop a coherent framework of (local) knowledge networks; namely, knowledge networks that frequently play a role for understanding structures and dynamics of local systems.

Finally, this work offers an in-depth insight into knowledge networks within the wine industry in Italy. This industry has been at the core of the literature, but Chapter II adds a study on the Montefalco region that has not been covered by any previous contribution, and Chapter III provides new insights on a well-known place of wine production.

2. Policy implications

Regional and regional innovation one-size-fits-all policies are more and more criticized by local development scholars since they are judged of being one of the most critical elements for the explanation of the failure of different local systems (Tödtling and Trippl, 2005; Barca et al., 2012; Fornahl and Hassink, 2017). Particularly, complaints

emerge about the applicability of successful initiatives in line with benchmarking and learning from best-practice actions across different local contexts (Visser and Atzema, 2008; Cooke, 2017).

In light of the investigations presented over the three chapters, the critical role of local specificities, as well as heterogeneity of local actors and relational settings are both emerged as fundamental factors to drive investigations on local systems and this approach may also stimulate a policy debate based on less-standardized interventions.

In this vein, Barca et al. (2012) individuated place-neutral and place-based approaches of local intervention distinguishing by those that are designed regardless of the local context from those that are context-specific. On the one hand, they underlined that place-neutral policies assume that people can move where they expect to be more productive and where they expect they can improve their individual lives (thus, leading to a supposed general economic growth). In this way, place-neutral policies risk to implement the same solution to similar problems that emerged from different local contexts with different and specific determinants (Chien, 2008), thus emphasising "top-down, supply-side, 'one-size-fits-all' quick-fixes eventually resulted in unbalanced policies, only relevant to the formal sector, and ultimately incapable of delivering sustainable development" (Barca et al, 2012, p. 137). On the other hand, place-based policies are designed to specifically address and build interventions on local knowledge, local values, and sense of community (Barca et al, 2012, p. 147). Following this perspective, we suggest that policies should be designed putting at the core of the intervention local contexts and their specificities in terms – among others - of historical, cultural, institutional, geographical aspects, but they should be also directed to individuals who live within such places[15].

A life cycle approach is considered relevant for local and regional economic policies (Hassink and Klaerding, 2011, Fornahl and Hassink, 2017). Chapter I offered an interpretation of the life cycle of a local system adopting a network perspective. Adding a network perspective, a few policy implications emerge following the general rule that

[15] In this vein, Iammarino et al., (2017) argued that both space-blind and place-based policy exclusively following efficiency, may lead to inequality. Thus, to go beyond the related place-people divide they introduce the idea of *place-sensitive* policies. With this idea they suggest "a different way of thinking based on maximising distributed development capabilities" (p. 27) across four *clubs* of regions, as groups of regions with similar development characteristics, challenges, and opportunities (entrepreneurship, skills, absorption of innovation). Specifically, "place-sensitive policies – which combine strong guidelines derived from development theory, while remaining sufficiently malleable to respond and adapt to the specific characteristics and challenges of every territory – are needed to maximise each territory's development potential, creating greater opportunities for its population. Place-sensitive policies tap into the potential of every territory, generating and spreading development throughout" (p. 27).

networks may be powerful instruments to understand and reinforce the diffusion of (novel) knowledge from different sources. Particularly, investigations of this thesis suggest that policies drawn to stimulate knowledge diffusion among local firms with different status may give the possibility to both high and low-status firms to receive and transfer novel knowledge (as investigated in Chapter III) and to prevent the system from the risk of having negative lock-ins.

Current local and regional policies are mainly focused on innovation since they are designed for places where knowledge plays a fundamental role for the learning process (Hassink and Klaerding, 2011) and its updating or transformation is a critical aspect to be considered for long-term development (Boschma and Frenken, 2007). Chapter II and III explicitly focused on a few determinants of knowledge diffusion within places. However, it is possible to doubt about the effectiveness of policies fostering collaborative actions among competitors; thus, place-based policies drawn on context-specific and firms' specific needs may be a useful instrument to overcome this potential problem, as well as policies that incentive the creation of spin-offs and support labour mobility (Boschma, 2008). In fact, "for the successful implementation of place-based development interventions in highly heterogeneous contexts, it is necessary to ensure that the incentives for behaviour of all partners and collaborators are correctly aligned" (Barca et al., 2012, p. 148).

At the same time, as suggested by the analysis in Chapter II, different actors interact through different networks; thus, policies may take into consideration different relational settings comprised of both formal and informal, as well as economic and social, relationships. Moreover, due to the fact that also inward-looking policies may be extremely dangerous for the economic development of places (Hassink, 2005), policies should be designed taking into consideration also actors external to the local system (as analysed in Chapter II for external consultants, external institutions, and external research centres and universities), their capacity to interact with local ones, possibilities of the latter to understand new pieces of knowledge from non-local actors, and eventually creating agents of intermediation between local and extra-local actors (Barca et al., 2012). In this vein, Tödtling and Trippl (2005) added that such policies should not only foster "brokering activities, but also [strength] the 'absorption capacity' of regional firms" (Tödtling and Trippl, 2005, p. 1214) since they should be capable to individuate, understand and absorb pieces of knowledge from external actors.

However, such policies need to face also issue related to the different scales local systems are embedded in or influenced by (Hassink et al., 2016). From an evolutionary perspective, the co-evolution of local systems' components belonging to different scales (e.g. firms, industries, local, national and extra-national institutions) affect regional and local economies (Hassink and Klaerding, 2011). Similarly, "the governance arrangements are not seen as unidirectional. On the contrary, there will be a need to stress the importance of fostering collaboration between and engagement by different levels of governance, as is appropriate for the policy being adopted. Such "multilevel governance" arrangements must be vertical, in other words, they must genuinely traverse the traditional demarcation lines between local, regional, and national government, and also horizontal, in that they must genuinely traverse the demarcation lines between cross-jurisdictional areas, and also between the public sector, the private sector, and the non-profit sector from civil society" (Barca et al., 2012, p. 148). In this vein, on the one hand, their interrelatedness may be taken into consideration by policymakers in order to design multi-scalar policies; on the other hand, policymakers should have a high level of awareness about local specificities, weaknesses, and strengths.

Furthermore, it is important to note that a network in a local system may be considered a form of institution with both written and unwritten rules. This is especially true in the case of wine regions and particularly, in the two wine production systems investigated in Chapter II and Chapter III where wineries adhere to strict local and extra-local formal regulations, but, at the same time, they operate and they take decisions taking into account the effects they have on other co-located actors and their possible reactions. In this vein, on the one hand, a policy fostering trust may be a critical instrument to avoid a declining phase or to drive a local system to sustainable and successful performance (for example with the establishment of a local wine-related consortium); on the other, it may promote a place-based identity and a sense of belonging that are critical aspects for firms' success in such an industry. In this vein, Tödtling and Trippl, 2005 argued that policy formulation and implementation "is the result of intensive communication, close interaction and consensus building between all regional stakeholders in policy networks. Policymakers are just one actor amongst others in these networks. Consequently, the key role governments play in encouraging learning and innovation shifts from direct intervention towards stimulation, intermediation, brokering, promoting regional dialogue and building up social capital" (Tödtling and Trippl, 2005, p.1212).

Finally, from a general point of view, it is possible to argue that policies should not only try to follow objectives related to competitiveness and that emerge from the issue 'how local growth can be stimulated', but, they should also focus on ways to improve cohesion within places starting from the issue 'how benefits due to local development can be distributed' and they should design policies that decrease socio-economic imbalances across different places.

3. Limitations

A first critical theoretical problem is a definitory problem among several different typologies of local systems. For example, this thesis mainly assumed a cluster context as the reference for the two empirical analysis; however, attributes that emerged over the three chapters may be sometimes more similar or more different to other concepts. For example, wine regions in Italy may be considered to be clusters for some aspects or industrial districts for others. This stimulated a debate that never brought to a largely accepted conclusion.

A second issue is the role of institutions and their identifications. Even if Chapter I recognized that they are critical components for local systems and their development, Chapter II and Chapter III mainly focused on other actors and particularly on firms. However, once they are considered as factors related to rules and incentives, also networks as such may be interpreted as a typology of institutions. Particularly, a few local systems (for example wine regions) are strictly influenced by both formal and informal networks and, consequently, by formal and informal rules and incentives that critically affect actors' behaviours.

A third critical aspect is that a network theory for local development may be a relevant scientific tool from both a theoretical and qualitative point of view, and not only from a quantitative (and sometimes data-driven) one as it is increasingly investigated in the economic debate. Introduction and Chapter I underlined a few gaps in this vein and several other suggestions for future research.

A fourth problem is that network perspectives, and particularly SNA, are powerful instruments to go deeper in the investigations of structures and mechanisms within local systems, but they are a part of the story. With this thesis, we aimed to exploit this approach, even if we need to highlight its limitations. Going into details, network approaches, and particularly their quantitative applications, need data that are not easily available and collectable. Moreover, even if this thesis investigated networks with two advanced methodologies, more effort is still needed in order to implement multilevel analysis that

simultaneously takes into consideration different categories of actors affecting or being affected by relationships (e.g. institutions, universities, research centres, government agencies, etc.), as well as other important industries operating in the region or impacting on it from outside, other than multiple networks (as empirically investigated in Chapter II) and network evolution over time (as empirically investigated in Chapter III).

A fifth issue is related to the fact that causal relations, endogeneity issues, and generalizability are critical problems that emerged in the two empirical chapters. Causal relations and endogeneity need to be even more taken into consideration with network related analysis where independent variables are never entirely independent among themselves and sometimes, as in the case of Chapter II, from the response variable. Moreover, complex systems as local systems may be affected in their structures and mechanisms by several elements that are hardly measurable or embeddable in models. Furthermore, results, their interpretations, and chapters' conclusions are strictly related to both the theoretical framework and the empirical setting. A specific focus on local development with a network perspective and the wine industry as the empirical field do not imply that different disciplines and other regions or industries should lead to the same conclusions.

A sixth argument concerns the interaction of local systems with the globalization process. Even if globalization has increased the relevance of places for economic prosperity (Rodriguez-Pose, 2010) and, thus, it has led places to be "more rather than less important" (Barca et al., 2012, p. 136), this thesis does not investigate this relation. However, two main points indirectly have emerged. On the one hand, several studies argued that global impacts on local places play a critical role in local systems' development (among others, Amin and Thrift, 1995). This is even more interesting from a network point of view, particularly regarding knowledge networks and innovation networks, since other than the local exchange of knowledge, also external contacts often complement local ones (Tödtling and Trippl, 2005). On the other hand, at the best of our knowledge, little research effort has been made in exploring impacts of local systems dynamics on global trends. Consequently, further research may also take into consideration investigating global implications of local decisions with a multi-scalar perspective.

Finally, surveys implemented in the Introduction and in Chapter I for the identification of the state of the art of studies about knowledge networks within local systems presents a few criticalities. On the one hand, a scientific paper with a high number of citations is often an indicator of good quality, but, it does not mean that it may be

considered better than one with a lower number of citations (and vice-versa); on the other, the analysis is implemented on a database that includes only scientific contributions published on a portion of journals and mainly written in English. The latter point is extremely critical for local development studies that – at least in the past – were largely written in other languages as, for example, Italian, Spanish, German, or French (for a comment on this problem, see Hassink, 2007).

4. Avenues for further research

Findings and limitations all over the three chapters may be interpreted as a stimulus for future research related to three of the research gaps presented in the Introduction of the thesis. In fact, possibilities offered by a heterogeneous relational perspective, prospects of analysis on relational multiplicity, and context-dependent explanatory opportunities and problems, were directly explored over the thesis' chapters. Even if not directly addressed in this work, we also briefly suggest a few avenues for further research for scholars interested in studies on local development, as they indirectly emerged from this research.

First, as explored over all the thesis, a network perspective allows us to have a new picture of different kinds of local systems and their evolution over time. Despite this and even if a few scholars made a few theoretical attempts in drawing ideal levels of relational connectedness/fragmentation of local networks over time (e.g. Martin and Sunley, 2011), the exploration of the most common (knowledge) networks structures and evolutionary routes at different stages of the life cycle of a local system is still missing. Moreover, which are the most relevant network mechanisms that influence underperforming or declining local systems is a field of research at the very beginning (Giuliani et al., 2018). Both those issues should have the attention of future research of network scholars, as well as researchers investigating local systems and their development.

Second, one of the relevant issues of such investigations is that they are context-dependent. In this vein, Hassink et al. (2016) highlighted potentialities of place-based analysis (and eventually related policies) to avoid investigations that explore space-neutral cases, where space is interpreted as a container. In this vein, researches implementing network analysis in concrete places are at risk of not adequately considering context specificities too, leading to an investigation of place-blinded relational spaces. To avoid this risk, we argue that networks can be useful instruments to relatively represent also context-dependent local characteristics as cultural, social, institutional settings to the extent that relational "means to put emphasis on actor networks and interrelations, power, social

agency, socio-cultural embeddedness of actors in multiple networks, and the interrelatedness between scales at individual level" (Hassink et al., 2016, p. 4). In this vein, more research is needed in order to understand to what extent investigations based on a relational approach may properly represent and/or interpret multiple aspects of real-world situations.

Third, we call for more analysis based on comparative approaches in order to explore to what extent results valid in one place may be confirmed or refuted in other ones and to understand which are the main determinants at the basis of their similarities and differences. For example, Chapter II and Chapter III may stimulate similar research on different typologies of actors, other kinds of relationships, and in different regions and industries, in order to compare findings here obtained. Moreover, implementing similar analysis in the future in the same places can be interesting to investigate the same local systems in a different stage of development.

Fourth, related to the second and the third point, another research avenue emerges and it takes into account multiplicity (both as a research methodology and a way of investigating). In fact, in Chapter II we underlined that network multiplicity is an underdeveloped research area. We here add that more research effort should be useful in exploring to what extent different networks may explain the impact of the economic activity on (and to what extend it is affected by) social, institutional, cultural local specificities.

Fifth, Chapter II and Chapter III presented quantitative empirical studies to the extent that they are based on quantitative data and they implement quantitative methodologies. Even if quantitative studies are often supposed of having high levels of robustness, we recall the contribution by Hassink et al. (2016) when they suggest integrating a qualitative analysis with the quantitative one to represent more concrete real-world situations. In this vein, we include a section about the context in both chapters (Section 3.2 Chapter II and Sections 3.1-3.2 Chapter III) and we highlighted in the Introduction (Section 2) reasons why places and the industry under study are satisfactory choices for the general aims of this work. However, more qualitative research might be implemented in the future in order to better understand quantitative results, particularly administering qualitative surveys to actors critically affecting networks' structures and dynamics of the cases under empirical study. For example, regarding Chapter II, open ended questions to isolated actors about intrinsic reasons why they do not interact with others through any kind of relation may be administered, as well as to interacting actors about intrinsic reasons why they interact with one kind of relation (e.g. a more social one) and not through another kind (e.g. a more

economic one). Regarding Chapter III open ended questions to selected high (low) status actors investigating inherent reasons why they are more likely to interact with high (low) status others should be administered directly on the field.

Sixth, focusing on policies and in order to prevent a decline and to sustain in the long-term viability of different local systems, in the Introduction we suggested that impact evaluation investigations are only partially implemented even if they could be satisfactory methodologies to drive interventions' decisions *ex-ante*. We here add that future research should investigate the impact of network-driven policies that take into considerations firms' needs, as well as institutions, local contexts, and external environment, and the phase the local system is going through in terms of its life cycle and the ones of its most critical industries at large. More to the point, we follow the *relational politics of place* proposed by Asheim (2004) when he claims "I want to argue that a relational reading of cities and regions offers a very different reading of place politics, one that is neither a-spatial (i.e. where the local is reduced to a mere stage) nor territorial (i.e. where the geographical local is all), but topological (i.e. where the local brings together different scales of practice/social action)" (Asheim, 2004, p. 38).

In this vein, networks can be interpreted as crucial tools to understand heterogenous patterns of local development. In fact, they offer instruments to measure and interpret interactions between local actors belonging to the same organizational category (e.g. interactions among firms) and across different organizations (e.g. interactions among firms, institutions, research centers, etc.). But, at the same time they offer a lens to understand (if not interpret) also systematic relational architectures (e.g. structural network level mechanisms) and interactions with organizations outside the local system at different scales. Moreover, they now allow us to investigate also changes over time of all those aspects. This should be considered a relevant issue, since local systems can be deeply explored with a study of their transformations over time, with and identification of the main determinants of these changes, and with a measurement of effects they have on the socio-economic level of places.

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