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Bridge and redundant ties in networks: the impact on innovation in food SMEs

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Abstract

Purpose - The purpose of this research is to study the impact of networks diversity on innovation activity of firms. It aims to review the structural issue in innovation networks and to distinguish different structures of networks for product and process innovation through an empirical research.

Methodology - Using a dataset of 348 European agri-food firms, we study the impact of bridge and redundant ties on product and process innovation of firms. This is an empirical research based on an online survey in five European countries.

Findings - Our finding shows that bridge ties (measured by the number of heterogeneous networks in which firm participates) always facilitate product innovation in firms. We found also that a high number of heterogeneous ties in term of partners (simultaneous presence of redundant and non redundant ties) motivate both product and process innovation in firms. Furthermore, we found a positive impact of network competence on process innovation.

Research limitations - Our measures of bridge ties and redundant ties are indirect measures. This choice is a willing choice. Direct measurement of bridge and redundant ties requires always in depth interviews with firms managers and thereby are limited by the number of observations.

Keywords: innovation network, bridge tie, redundant tie, product innovation, process innovation

1. Introduction

In recent decades the role of networks in firms' innovation activities became increasingly important. Increasing number of networks can change the nature of competition and shift it from direct competition between firms to competition between networks (Gimeno 2004). Innovation activity is always recognised as a high risk activity. Firms, particularly small ones, cannot ensure different resources of this activity. Engaging in a partnership can be considered as a win-win solution for this problem. Researchers suggest different outcomes for networking activity. Risk sharing, facilitating market access, information sharing, knowledge creating and exchanging, and finding complementary skills and resources are among these outcomes (Powell et al. 1996, Pyka and Saviotti 2002, Pittaway et al. 2004).

For firms, particularly SMEs, the networking strategy is an effective strategy for open innovation (Lee et al. 2010). Nowadays the role of networks in creation of new technologies attracts more attention of researchers than their traditional role - that is, outsourcing non-core business activities (Vanhaverbeke et al. 2009). The role of networks in firm's performance, particularly technological performance, is the main topic of several empirical and theoretical researches in the last decade. Network structure has attracted more attention than other concepts in this field (Pittaway et al. 2004, Bergenholtz and Waldstrøm 2011). Networks structure refers to position of firm in a network and to nature of its ties. Empirical researches always give high level of importance to networks structure regarding to knowledge exchange and control. The position of a given firm in a network is an important determinant of its innovation performance (Powell et al. 1999).

Concerning the relationship between innovation activity and network structure, particularly partners and ties selection, researches are diversified. For some of these researches a limited number of strong and redundant (embedded) ties are more appropriated for the networking behaviour of innovative firms (Coleman 1988; Uzzi 1997; Ahuja 2000; Hagedoorn and Duysters 2002). For some other researchers, heterogeneity and non redundancy of ties and partners bring to firms access to a wide range of resource and increase their innovation outputs (Burt 1992; Zaheer and McEvily 1999; Schilling and Phelps 2007; Soda 2011). A third group of researchers suggest that these two types of ties are not in opposition to one another but instead are complementary (Baum et al. 2010; Gising et al. 2007, Gobbo and Olsson 2010).

The purpose of this research is to study the role of bridge and non-redundant ties on innovation activities of firms. We argue the role of bridge and redundant ties in innovation activity of firms is influenced by the nature of innovation. Based on the works of Gilsing et al. (2007), Baum et al. (2010) Gilsing et al. (2008) and Rowley et al. (2000) we propose different network structures (focusing on redundancy of ties) for process and product innovation. This article is structured as following: in section 2 we develop a literature review concerning redundant and non redundant ties. Section 3 presents the research data and description of variables. Section 4 is devoted to empirical results. And finally, the section 5 contains the research's conclusions.

2. Related literature

Non redundant and bridge ties

In this paper we are interested in the position of firms in innovation networks. The diversity and density of ties can determine the position of a given firm in networks. Several researchers have focused on the relationship between firm's position in network and its innovation activity (Tsai 2001; Powell and Grodal 2005; Powell et al. 1999). Different types of ties are studied in empirical and theoretical researches in the domain of innovation networks. Direct vs. indirect ties, formal vs. informal ties, strong vs. weak ties and embedded (redundant) vs. bridge (non redundant) ties are studied as important determinant of firm's performance (Granovetter 1983, Coleman 1988, Burt, 1992; Hansen 1999; Powell and Grodal 2005; Soda 2011).

Bridge ties are consequences of structural holes within a network. This type of ties can be formed when a firm is connected to two or several firms that are not connected to each other (Burt 1992, Ahuja 2000, Bizzi 2013). Bridge ties can also be the result of connections between two or more networks or groups. As a member of different networks or groups, a firm benefit from several bridge ties. A low level of density in a network facilitates the creation of structural holes and bridge ties (Rowley et al. 2000). For Granovetter (1973) weak ties can be created in the presence of bridges. Otherwise they may not exist. Structural holes offer to firms or individuals several advantages. Bridge ties bring to "brokers" the control of information flow between two networks or groups (Burt 2000). Advantages of bridge ties are due to negotiation, arbitrage and control opportunity of brokers (Soda 2011; Burt 1992). Firms can filter information and knowledge and control their flow in different networks. These ties offer firms the access to different knowledge pools and heterogeneous knowledge, and enhance the ability of partners to convey complex ideas (Reagans and McEvily 2003; Soda 2011).

Non redundant ties via social networks give the firm or the entrepreneur non redundant information and enhance its capacity for knowledge creation (Ruef 2002). Non redundant connections give the firm a diversity of knowledge resources (Schilling and Phelps 2007). Zaheer and McEvily (1999) found a positive impact of non-redundant ties on acquisition of complete capability in firms. They define the acquisition of complete capability as a process of opportunity recognising, internalising and implementation of capability. They argue that non redundancy and infrequency of interactions allow firms to create bridge ties. Firms can create these ties with different partners. They can create downstream alliance in which a firm looks for complementary assets from competitors and other firms in the industry in "view of commercialization of technology" (Gilsing et al. 2007; Vanhaverbeke & Cloudt 2006). The other possibility is upstream vertical alliance that links firm to universities or other research institutions and provide new sources of technological expertise (Gilsing et al. 2007).

Bridge ties are not the sources of complete advantage for all types of partnerships. Bizzi (2013) proposes that bridge ties may have negative impacts on individual performance when there are other individuals in group with structural holes position. They argue that the opportunistic behaviour of different brokers and the lack of autonomy can impact individual efforts and decrease their performance. Broking and bridge ties are associated to great risk of uncertainty and costs (Baum et al. 2010). When the efficiency is important and the competition between firms is based on product's price, maintaining contact becomes expensive and a less

dense structure and non-redundant networks are the most effective (Gilsing et al. 2007). These conditions correspond to the mature industry and technology in which dominant designs have emerged, and technological and market uncertainty have decreased (Gilsing & Nooteboom 2005).

Gilsing and Duysters (2008) argue that the nature of learning in innovation process can strongly influence the forms of the network. Based on Granovetter (1973) notion of strong ties, they indicate that in exploration learning, firms have some cognitive distance with their partners in networks. This cognitive distance motivates companies to create strong and redundant ties that bring them with an in-depth understanding of newly created knowledge. This argument confirms Coleman (1988) vision of embedded ties but does not match with Burt (1992) approach in which a wide range of non-redundant relationships with partners and other networks increase the efficiency of firms in innovation activities.

When firms pursue incremental innovation strategy, they benefit more from embedded ties. In the case of disruptive innovation clique-spanning (non-embedded) ties are more useful (Baum et al. 2010). Gilsing et al. (2008) show, when the technological distance is limited, the central position in networks facilitates exploration performance (i. e. innovation activity in new field) of firms. Fritsch and Kauffeld-Monz (2010) found that strong ties facilitate more the exchange of knowledge and information while broker positions are associated with social return. Rowley et al. (2000) propose that structural holes support product innovation. Indeed redundant and strong ties are useful for process innovation. Gilsing et al. (2007) suggest that if firms do not dispose of 'sufficient' redundant ties they cannot profit from the contribution of non-redundant ties in exploration. A composition of a large number of weak ties and a core of strong ties provides firms a "fertile ground" and provide to them a dynamic innovative capability (Capaldo 2007).

For some researchers innovation networks are created through trust and understanding, thereby, non redundant ties do not have an important role in these networks. Ahuja (2000) found a negative impact of structural holes on innovation output of firms. Redundant ties create trust and reputation between partners (Coleman 1988; Uzzi 1997) and this trust allows firms a "heuristic" decision making process rather than calculative one (Uzzi 1997). Redundant ties contribute to tacit knowledge exchange and trust building (Gilsing et al. 2007). Firms can exchange through this type of ties information and knowledge that has holistic structure rather than divisible one (Uzzi 1997). Firms adopting process innovation strategy need specific information and tacit knowledge that may be provided by redundant ties and exploitation networks (Gilsing et al. 2007). These types of ties are efficient in emerging technology or industry. They are sources of information and they provide judgement on meaning and value of knowledge (by triangulation). They are trust-based ties (Gilsing & Nooteboom 2005).

Embedded social ties enhance the asymmetry of information among the partners (Uzzi 1997). Firms with embedded social ties have higher survival chances (Uzzi 1996). They profit from economies of time, efficiency of resource allocation, and good level of risk sharing in their partnership (Uzzi 1997). Embedded ties facilitate the coordination and collective problem solving by repeated exchanges (Coleman 1988). Through repeated exchange networks

members construct routines of negotiation, mutual adjustment and cooperative norms (Granovetter 1992, Uzzi 1997). This type of ties motivate firms to invest more time, energy and effort in networking and knowledge sharing (Reagans and McEvily 2003) Hagedoorn and Duysters (2002) found that in dynamic environment exploration networks in which learning occurs through limited number of redundant links have greater impact on technological performance rather than exploitation network and non-redundant contacts.

This literature shows the importance of both redundant and non redundant ties in innovation networks. Based on reviewed literature, we assume that non redundant and bridge ties are important determinants of product innovation. On the other hand, redundant and embedded ties facilitate process innovation. Therefore, the first and second hypotheses of our research are following:

Hypothesis 1: the number of bridge ties in innovation networks has a positive impact on product innovation of firms.

Hypothesis 2: the high level of attention and importance that firms give to networking activity has a positive impact on process innovation of firms.

Based on previous researches such as Granovetter (1973), Reagans and McEvily (2003) and Gilsing and Duysters (2008), we argue that the time and the attention that firms give to prepare networking activity is an indicator of tie redundancy.

Diversity of partners

In a network firms look for a portfolio of interactions and pursue different sourcing strategies (Steiner and Ploder 2008). There is a lengthy list of potential partners for an innovation partnership. Administrative and academic research institutes, suppliers, buyers, costumers, financing providers like venture capitalists and banks, consultants, competitors may participate in innovation activity of firms. (Ritter and Gemünden 2003, Hagedoorn & Duysters 2002, Freel and de Jong 2009, Nieto and Santamaria 2007, Salavisa et al. 2012, Pyka and Saviotti 2002). Each partner brings different benefits to the innovation activity of firms (Ritter and Gemünden 2003). The number and the diversity of partners in an innovation networks depend on several factors. The nature of innovation, the nature of required resource, and characteristics of industry are identified as determinants of this diversity (Freel and deJong 2009; Salavisa et al. 2012).

Oerlemans et al. (2001) show that the market orientation determines the preference of firms concerning partner selection. Firms oriented to local markets are more interested to create link with buyers. However supplier ties are not impacted by market orientation. These researchers argue that the exchange between firms and supplier concern tacit knowledge and will need informal ties. Huang et al. (2012) found that in business partnership, competitors are a priority. Suppliers and customers are in the next place.

Firms do not rely on unpredictable spillover of knowledge in networks. They select their partners consciously for a high intensity of knowledge exchange (Steiner and Ploder 2008). By comparing biotechnology and software firms Salavisa et al. (2012) found different tendencies

in partner choice for innovation activity in these two sectors. In the first sector firms look for scientific and technological knowledge as well as financial resources. They prefer research institutes, universities and capital venture as network partners. In the second sector the need for technical and problem solving knowledge push firms to engage in partnership with the competitors (Salavisa et al. 2012).

Partner diversity provides firms a variety of instrumental, normative, and procedural information. This variety of information bring to firms a wide set of action-outcome experience. Partner diversity increases also organizational attention to existing information through illustrating differences (Beckman and Haunschild 2002). The number of firms that are reached by a given firm in a network has an important impact on its innovation activity (Schilling and Phelps 2007). Powell et al. (1999) found a decreasing return of diversity of partners and ties concerning innovation activity of firms. They argue that learning through networks has some limits. Network experience has a decreasing return for firm's innovation.

Nieto and Santamaria (2007) show that diversity of partners favours the novel innovations. These novel innovations are always based on new knowledge rather than existing knowledge. It is also the case of complex innovation. When innovation activity required complex complementary skills and competences, the role of networks become more important for generating complex solutions. Freel and deJong (2009) find that network size is a determinant factor in this situation. Large size of networks (measured by number of partners and ties) ensure the access to complex ideas and solutions.

Researchers emphasize the important role of partnership heterogeneity in innovation networks. Heterogeneous partners give a firm the access to heterogeneous resources and information. Based this approach the third hypothesis of our research is the following:

Hypothesis 3: diversity of partners increase the innovation output of firms.

3. Data and variables

In this research we use a dataset of 348 European agri-food firms. This dataset is the result of a survey that is realised through collaboration between 5 universities and research centres in 5 European countries. A questionnaire (see annex number 1) is created, based on innovation network literature and sent to 7695 firms from these five countries in their national languages. Similar models of questionnaire are used to design the questionnaire of this research¹. The validity of questionnaire has been verified and confirmed by 3 experts from each country. The reliability of questionnaire has been tested by Cronbach's alpha test. The Cronbach's alpha coefficient for our questionnaire is 0.75. Based on standardized items, this coefficient reach to 0.8 that means our questionnaire is statistically reliable. The survey took place in 6 months from October 2012 to March 2013. During this survey, we sent the questionnaire to selected firms (in agri-food sector) and reminded it three times by email and telephone. The average rate of

¹ Such as CIS (The Community Innovation Survey) for innovation activities; Ritter et al. (2002) and Ritter and Gemünden (2004) for network competencies; Nietoa and Santamaria (2007) for the diversity of partners.

response was 4.5 percent and the number of returned (finished) questionnaires by each country is as following: Belgium 81, France 126, Ireland 43, Italy 48, and Sweden 50.

We study the impact of network structure on innovation activity of firms. Endogenous variable of our empirical models is the innovation activity of firms. In this study we focus on product and process innovations. Researchers who study innovation in firm's level often use two groups of measures: input measures and output measures of innovation (Rogers 1998). As same as ABS innovation survey and CIS (Community Innovation Survey) we use an output measure of innovation and we asked directly if firms had introduced product and process innovation. We have two ordinal variables for measuring process innovation and product innovation. The value are: 0 if there is no innovation, 1 if there is 1 innovation, 2 if there are 2 innovations, 3 if there are 3, 4 or 5 and 4 if there are 6 or more innovations. We study three exogenous variables concerning redundancy of ties: diversity of network memberships (the number different heterogeneous networks in which the firm has participated), diversity of partners (the number of different heterogeneous partners with which the firm has realised resource exchange in the context of innovation activity) and network competence of firms (measured by number of activities that firm realised for improving its networking behaviour). These three variables measure non-redundancy of ties in innovation networks in this research. The additional determinant variables are the classic ones: firm size, firm growth and dummy variables concerning firm location country and sector of firm activity. Table 1 shows our endogenous and exogenous variables, their definitions and measurement and their corresponding questions in the questionnaire.

Inset table 1 here

The low rate of responses leads us to realise a non-response bias analysis for our data. Our data collecting took place in 6 months from October 2012 to March 2013. During this period, we had three times reminding by using email and telephone and recognised two waves of responses during this period. The first one occurs between the 1st October 2012 and 30th January 2013 during which 110 completed questionnaires were received. The second wave concerns the period of the 1st February 2013 and the end of March 2013. We received 238 completed questionnaires during this period. The t test of mean's difference between the observations of these two waves of responses does not show any significant difference between responders regarding the main variables. Table 2 shows the results of non-response bias analysis for our data.

Inset table 2 here

4. Empirical results

Table 3 shows the correlations between variables. Diversity of network memberships is significantly correlated to both types of product and process innovation while diversity of

partners is correlated only to process innovation. There is a significant relationship between networks competence and process innovation. Results show stronger relationship between network's types and product innovation rather than between network's types and process innovation. Generally French firms are more active and Italian firms are less active in networking than other firms. French and Irish firms participate in business clubs more than other firms. Industry associations are more attractive for French and Italian firms. French firms are less interested in scientific and technological parks. Irish firms have lower level of heterogeneity of ties comparing their partners. Italian firms are less innovative comparing with other firms. French firms propose more product innovations than others.

Insert table 3 here

For testing our hypotheses concerning the impact of diversity of network memberships, partner diversity and network competencies on innovation we use the ordinal logistic regression model. The general equation of this research can be presented as following:

$$Innov = \alpha + \beta_1 Size + \beta_2 NetDvr + \beta_3 PartDvr + \beta_4 NetCmpt + \beta(5) Sector + \beta(6-9) Country + \beta(9-14) NetTyp + e$$

In this equation *Innov* represents innovation measure. As we explained above we have two measures for two types of innovation: product and process innovation. They are ordinal variables. The variable *Size* corresponds to firm's size (employees' number). *NetDvr* and *PartDvr* are two most important variables of our model – that are diversity of network memberships and partner's diversity. The first one measure the heterogeneity of firm membership in different networks and the second one measure the heterogeneity of firm's partners. The variable *NetCmpt* concerns network competence and measured by number of activities that firm realised for improving its networking behaviour. *Sector* is a dummy variable that shows whether the firms belong to food processing sector or not. The variable *Country* is a set of 4 dummy variables showing the country in which firm is located. Finally we integrated the type of network in which the firm participates in our model. We asked about firm membership in five different networks (*NetTyp*) and we wanted to know if the type of network matters in innovation: chambers of commerce, clusters, industry associations, scientific and technological parks and business clubs.

The table 4 shows the empirical results of our estimation. Different tests confirm the reliability of our empirical models. In all models the Likelihood Ratio Chi-Square test for fitness of models are significant ($p < 0.01$). Tests on goodness of fit (Pearson and Deviance Chi-Square) indicate acceptable goodness of fit for all of 8 models ($p > 0.05$) and show that empirical models fit to data. The significance of Chi-Square statistic for the test of parallel lines for all of our models is higher than 0.05. That means the slope coefficients in our models are not the same across response categories. The calculated R^2 for our model is between 0.13 and 0.23. More than 13 percent of variation of dependent variables in our model can be explained through proposed independent variables.

Insert table 4 here

The classic findings of our research are the positive impact of firm size on innovation. It is the case of product innovation as well as process innovation. This finding can be biased by the fact that our dataset contains the small and medium size firms (less than 500 employees). The diversity of partners has always a positive impact on product innovation and process innovation (models 1, 3, 7 and 8). This findings confirms our hypothesis 3 and show the importance of heterogeneous resources in innovation activity of firms and corresponds to results of precedent researches (Beckman and Haunschild 2002; Nieto and Santamaria 2007; Salavisa et al. 2012). We argue that the diversity of partner can be an indicator of presence of non-redundant ties in firm partnerships. In one hand firms cannot handle a high number of redundant ties. This type of ties is always created after a long term relationship between firms. Frequency of contacts and trust issue are important in this type of ties (Coleman 1988; Uzzi 1997, Reagans and McEvily 2003). In other hand redundant ties require a low level of knowledge and experience distance (Gilsing et al. 2008). High level of heterogeneity of ties and partners increase the probability of non redundant ties in firm partnership. However here we cannot present this variable as an indicator of bridge ties.

The diversity of network memberships impacts only the product innovation (model 1, 2 and 3). This result confirms the hypothesis 1. When a firm participate in different heterogeneous networks it can benefit from different advantages of bridge ties. Our finding shows that Burt (1992) approach of efficiency is more reliable for product innovation rather than process innovation. Product innovation require heterogeneous knowledge and complex ideas and bridge ties are the most efficient ties to offer them to firms (Reagans and McEvily 2003; Soda 2011).

Concerning hypothesis 2 an interesting result of our empirical model is the importance of network competence in process innovation (models 4, 5 and 6). Gilsing et al. (2007) argue that firms engaging in process innovation need specific information and tacit knowledge. Therefore they focus more on redundant ties and exploitation networks. We suggest that these firms need a high level of networks capacity for absorbing specific information and tacit knowledge. The impact of network competences (*NetCmpt*) on process innovation of firms is positive and significant. As indicated in variable definitions, network competence is measured by number of activities that the firm realised for improving its networks behaviour. This measure refers to the works of Ritter et al. (2002) and Ritter and Gemünden (2004). Regarding the vision of Granovetter (1973), Reagans and McEvily (2003) and Gilsing and Duysters (2008), this variable can indicate the presence of redundant and embedded ties in firm relations.

For testing the impact of sectoral and national factors we integrate five dummy variables in our models. Our data is collected from five European countries: France; Italy, Belgium, Ireland and Sweden. We integrate four dummy variables for four countries: France, Italy, Belgium and Ireland. Furthermore we integrate one dummy variable concerning the sector of firm activity (food processing sector). These dummy variables improve the quality of our models. As expected, firms that belong to food processing sectors propose more product

innovations (models 2, 3 and 7). Italian firms are significantly less innovative than other firms (models 3 and 6).

Concerning the type of networks, our results confirm the importance of business clubs in product innovation of firms (model 7). We suggest that this kind of networks bring more information and knowledge for firms.

5. Discussion and Conclusion

Concerning the network structure there are two directions of research among scholars: the determinants of network structure and its consequences. Most of the researchers have focused on second direction due to legitimacy needs of this new domain (Borgatti and Foster 2003). Network structure is determined by different factors such as industry characteristics, cultural factors, and appropriability of innovation (Kogut 2000). Complexity of innovation activity and number of problems related to this activity determinate the importance of network and the composition of internal-external resources in innovation process (Oerlemans et al. 2001). Structure of networks and the population of actors in network depend on innovation ability and absorptive capacity of potential members (Cowan 2005). The life cycle of technology determine also the structure of network and the position of partners, particularly the position of small and new ones (Roijsackers and Hagedoorn 2006).

In this research we studied the consequences of network structure, particularly the impact the diversity of ties on firms' innovation. As for Rowley et al. (2000), our findings concerning bridge ties do not confirm totally Burt (1992) theory of structural holes neither that of his rival theory (Coleman 1988, Uzzi 1997; Ahuja 2000; Hagedoorn and Duysters 2002). The role of bridge ties in firm performance always seems ambiguous. For example, density of ties in a group of firms or individuals can impact this relationship. The presence of several structural holes positions in a group of individuals increases the conflict and opportunistic behaviour of brokers and decreases the autonomy and performance of individual (Bizzi 2013).

Bridge ties incite special type of innovation activity in special circumstances. As Gilsing et al. (2007) and Rowley et al. (2000) argue in their works, product innovation is better supported by bridge ties rather than process innovation. The complexity of process innovation pushes firms to engage in redundant and trust-based ties (Gilsing et al. 2007). When industry is a growing industry and is dominated by product innovation, strong and redundant ties increase the firm performance. In a mature and process innovation oriented industry the structural holes are more useful for firms (Rowley et al. 2000). Our results confirm these arguments and show that bridge ties (measured by diversity and heterogeneity of networks in which firms are engaged) incite product innovation. Furthermore, we observe positive impact of network competences (measured by number preparation activities of firm for networking) on process innovation.

Concerning heterogeneity of partners our findings confirm previous researches. We show that heterogeneity of partners has a positive impact on both product and process innovation of firms. We argue that a high number of heterogeneous partners increase the probability of non redundant ties in firm's relations. As strong ties, embedded partnership are characterised by a wide variety of exchange issues, high frequency of interaction, openness and trust and long

term contacts (Granovetter 1973, Reagans and McEvily 2003, Gilsing and Duysters 2008). Managing a high number of this type of partnership is very hard for firms. High number of heterogeneous partnership, thereby, can indicate the presence of both redundant and non redundant ties in the same time. As Capaldo (2007) demonstrates, a mixed of redundant and non redundant ties will increase innovation capacity of firms.

In summary, we found a positive impact of network diversity on innovation activity of firms. Our measure of bridge ties and redundant ties are indirect measures. This choice is a willing choice. Direct measures of bridge and redundant ties always require in depth interviews with firms managers and thereby are limited by the number of observations. Researches on innovation networks at inter-organizational levels are dominated by case studies and are characterized by a limited number of observations. Studying the networking behaviour, particularly tie selection, of a wide range of firms brings additional knowledge in this field of research. As noted by Bergenholtz and Waldstrøm (2011), researches in network fields combine and use different concepts and theories from different fields and different levels of analysis (inter-personal, inter-organizational and inter-networks). This diversity of concepts and theories can lead researchers to confusing results. On the other hand, this diversity proposes a promising avenue for future of researches in this field (Abdirahman et al., 2014). In this study we focused on the inter-organizational level, however, as previous researches, we exploited theoretical bases of other level of analysis.

6. References

- Abdirahman, Z.-Z., Cherni, M., & Sauvée, L. (2014). Networked innovation: a concept for knowledge-based agrifood business. *Journal on Chain and Network Science*, 14(2), 83-93.
- Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, 45(3), 425-455.
- Baum, J. A., Cowan, R., & Jonard, N. (2010). Network-independent partner selection and the evolution of innovation networks. *Management Science*, 56(11), 2094-2110.
- Beckman, C. M., & Haunschild, P. R. (2002). Network learning: The effects of partners' heterogeneity of experience on corporate acquisitions. *Administrative Science Quarterly*, 47(1), 92-124.
- Bergenholtz, C. and Waldstrøm, C. (2011), Inter-organizational Network Studies - A Literature Review. *Industry & Innovation* 18(6): 539-562.
- Bizzi, L. (2013), The Dark Side of Structural Holes: A Multilevel Investigation. *Journal of Management* 39(6): 1554-1578.
- Borgatti, S. P., & Foster, P. C. (2003). The network paradigm in organizational research: A review and typology. *Journal of Management*, 29(6), 991-1013.
- Burt, R. (1992). Structural holes: the social structure of competition, in N. Nohria and R. Eccles (eds.) *Networks and organizations: structure, form and action*. Boston: Harvard Business School Press: 57-91.
- Capaldo, A. (2007). Network structure and innovation: The leveraging of a dual network as a distinctive relational capability. *Strategic Management Journal*, 28(6), 585-608.

- Coleman J.S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, 94: 95-120.
- Cowan, R. (2005). Network models of innovation and knowledge diffusion. *Clusters, networks and innovation*, 29-53.
- Freel, M. and de Jong, J.P.J. (2009). Market novelty, competence-seeking and innovation networking. *Technovation* 29(12): 873-884.
- Fritsch, M., & Kauffeld-Monz, M. (2010). The impact of network structure on knowledge transfer: an application of social network analysis in the context of regional innovation networks. *The Annals of Regional Science*, 44(1), 21-38.
- Gilsing, V. A., Lemmens, C. E., & Duysters, G. (2007). Strategic alliance networks and innovation: a deterministic and voluntaristic view combined. *Technology Analysis & Strategic Management*, 19(2), 227-249.
- Gilsing, V., & Nooteboom, B. (2005). Density and strength of ties in innovation networks: an analysis of multimedia and biotechnology. *European Management Review*, 2(3), 179-197
- Gilsing, V., Nooteboom, B., Vanhaverbeke, W., Duysters, G., & van den Oord, A. (2008). Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Research Policy*, 37(10), 1717-1731.
- Gilsing, V.A., and Duysters, G.M. (2008). "Understanding novelty creation in exploration networks: Structural and relational embeddedness jointly considered, *Technovation*, 28: 693-708.
- Gimeno, J. (2004). Competition within and between networks: The contingent effect of competitive embeddedness on alliance formation. *Academy of Management Journal*, 47(6), 820-842.
- Gobbo, J. A. and Olsson, A. (2010). The transformation between exploration and exploitation applied to inventors of packaging innovations. *Technovation*, 30: 322-331
- Granovetter M. S. (1973). The Strength of Weak Ties, *American Journal of Sociology* Vol. 78, No. 6 pp. 1360-1380
- Granovetter, M. (1992). Problems of explanation in economic sociology." In N. Nohria and R. G. Eccles (eds.), *Networks and Organizations*: 25-56. Boston: Harvard Business School Press.
- Granovetter, M. (1983). The strength of weak ties: A network theory revisited. *Sociological Theory*, 1(1), 201-233.
- Hagedoorn, J., & Duysters, G. (2002). Learning in dynamic inter-firm networks: the efficacy of multiple contacts. *Organization Studies*, 23(4), 525-548.
- Hagedoorn, J., & Duysters, G. (2002). Learning in dynamic inter-firm networks: the efficacy of multiple contacts. *Organization Studies*, 23(4), 525-548.
- Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1), 82-111.
- Huang, H. C., Lai, M. C., & Lo, K. W. (2012). Do founders' own resources matter? The influence of business networks on start-up innovation and performance. *Technovation*, 32(5), 316-327.
- Kogut, B. (2000). The network as knowledge: generative rules and the emergence of structure. *Strategic Management Journal*, 21(3), 405-425.
- Lee, S., Park, G., Yoon, B., & Park, J. (2010). Open innovation in SMEs: An intermediated network model. *Research Policy*, 39(2), 290-300.
- Nieto, M. J., & Santamaria, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, 27(6), 367-377.

- Oerlemans, L., Meeus, M., & Boekema, F. (2001). On the spatial embeddedness of innovation networks: an exploration of the proximity effect. *Tijdschrift voor economische en sociale geografie*, 92(1), 60-75.
- Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2004). Networking and innovation: a systematic review of the evidence. *International Journal of Management Reviews*, 5/6(3&4): 137-168
- Powell, W. W. and Gordal, S. (2005) Networks of Innovation, in Fagerberg J. et al (ed) The Oxford Handbook of Innovation, Oxford University Press, New York, USA, 2005, PP 56-85
- Powell, W. W., Koput, K. W., Smith-Doerr, L., & Owen-Smith, J. (1999). Network position and firm performance: Organizational returns to collaboration in the biotechnology industry. *Research in the Sociology of Organizations*, 16(1), 129-159.
- Powell, W.W., Koput, K.W., and Smith-Doerr, L. (1996). Inter-organizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. *Administrative Science Quarterly*, 41(1): 116-145.
- Pyka, A. and Saviotti, P. (2002). Innovation Networks in the Biotechnology-Based Sectors. in Pyka A. and G. Kupper, Innovation Networks: Theory and Practice, Edward Elgar Publishing Institute Massachusetts, USA: 75-107
- Reagans, R., & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly*, 48(2), 240-267.
- Ritter, T., & Gemünden, H. G. (2003). Network competence: its impact on innovation success and its antecedents. *Journal of Business Research*, 56(9), 745-755.
- Ritter, T., & Gemünden, H. G. (2004). The impact of a company's business strategy on its technological competence, network competence and innovation success. *Journal of Business Research*, 57(5), 548-556.
- Ritter, T., Wilkinson, I. F., & Johnston, W. J. (2002). Measuring network competence: some international evidence. *Journal of Business & Industrial Marketing*, 17(2/3), 119-138
- Rogers, M. (1998). The definition and measurement of innovation. Working paper N° 10/98. Parkville, VIC: Melbourne Institute of Applied Economic and Social Research. ISBN: 07325
- Roijakkers, N., & Hagedoorn, J. (2006). Inter-firm R&D partnering in pharmaceutical biotechnology since 1975: Trends, patterns, and networks. *Research Policy*, 35(3), 431-446.
- Rowley, T. J., Behrens, D. and Krackhardt, D. (2000), Redundant Governance Structures: An Analysis of Structural and Relational Embeddedness in the Steel and Semiconductor industry. *Strategic Management Journal* 21(3): 369-386.
- Ruef, M. (2002). Strong ties, weak ties and islands: structural and cultural predictors of organizational innovation. *Industrial and Corporate Change*, 11(3), 427-449.
- Salavisa I., Sousa, C., and Fontes, M. (2012). Topologies of innovation networks in knowledge-intensive sectors: Sectoral differences in the access to knowledge and complementary assets through formal and informal ties. *Technovation*, 32 380–399
- Schilling, M. A., & Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science*, 53(7), 1113-1126.
- Soda, G., (2011). The management of firms' alliance network positioning: Implications for innovation. *European Management Journal*, 29: 377-388.
- Steiner, M., & Ploder, M. (2008). Structure and strategy within heterogeneity: multiple dimensions of regional networking. *Regional Studies*, 42(6), 793-815.

- Tsai, W. (2001). Knowledge transfer in Intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal*, 44(5), 996-1004
- Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: the network effect, *American Sociological Review*, 61: 674 – 698
- Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly*, 35-67.
- Vanhaverbeke, W., & Cloudt, M. M. A. H. (2006). Open innovation in value networks. *Open innovation: researching a new paradigm*, Ed. H. Chesbrough, WPM Vanhaverbeke, 258-281
- Vanhaverbeke, W., Gilsing, V., Beerkens, B., & Duysters, G. (2009). The Role of Alliance Network Redundancy in the Creation of Core and Non core Technologies. *Journal of Management Studies*, 46(2), 215-244.
- Zaheer, A., & McEvily, B. (1999). Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal*, 20(12), 1133.

Table 1: measurement and definition of variables

Dependent Variables	Definition	Measure	Question référence
Innov (product)	Product innovation	Ordinal value (= 0 if the firme hase 0 innovation, 1 if it has 1 innovation, 2 if it has 2 innvation, 3 if it has 3, 4 or 5 innovation and 4 if it has 6 or mor innovation	Q12-1
Innov (process)	Process innovation	Ordinal value (= 0 if the firme hase 0 innovation, 1 if it has 1 innovation, 2 if it has 2 innvation, 3 if it has 3, 4 or 5 innovation and 4 if it has 6 or mor innovation	Q12-2
Independent Variables			
NetDvr	diversity of network memberships	Number of heterogeneous membership of the firms in five type of networks (value 0 to 5)	Q13
PartDvr	diversity of partners	Number of heterogeneous relationship of the firms with 8 different partners (value 0 to 8)	Q14
Size	Firm size	Number of full time employees	Q37
NetCmpt	Networks competences	Number of the activities that firms realise to improve its capacity of learning from networks	
NetTyp (Bsnssclubs)	Type of network	Number of business clubs in which the firms is member	Q13-5
NetTyp (Techparks)	Type of network	Number of science-techno parks in which the firms is member	Q13-4
NetTyp (Indassociat)	Type of network	Number of industry associations in which the firms is member	Q13-2

Table 2 : Spearman correlation between variables (** correlation is significant at 0,01 level; * correlation is significant at 0,05 level)

	NetDvr	PartDvr	Size	NetCmpt	NetTyp (Bsnsclubs)	NetTyp (Techparks)	NetTyp (Clusters)	NetTyp (Indassociat)	NetTyp (Chembr)	Innov (product)	Innov (process)
NetDvr	1.000 284										
PartDvr	.340** 284	1.000 348									
Size	.284** 279	.234** 341	1.000 341								
NetCmpt	.134* 261	.216** 320	.279** 314	1.000 320							
NetTyp (Bsnsclubs)	.606** 245	.096 305	.059 298	.034 287	1.000 305						
NetTyp (Techparks)	.299** 232	.139* 293	.147* 286	.137* 275	.058 288	1.000 293					
NetTyp (Indassociat)	.624** 260	.163** 323	.308** 316	.089 303	.222** 301	.073 291	.211** 291	1.000 323			
Innov (product)	.220** 267	.220** 330	.306** 323	.102 307	.191** 299	.016 286	.151* 288	.260** 311	.186** 312	1.000 330	
Innov (process)	.106 251	.262** 311	.247** 304	.183** 291	.106 289	.108 280	.186** 282	.212** 296	.104 300	.386** 307	1.000 311

Table 3: empirical results of general equation

Model Variables	Model 1 : Ordinal Logistic Regression	Model 2: Ordinal Logistic Regression	Model 3: Ordinal Logistic Regression	Model 4: Ordinal Logistic Regression
	indep vari: Innov (product)	indep vari: Innov (product)	indep vari: Innov (process)	indep vari: Innov (process)
NetDvr	0,22* 0,1	-0,11 0,2	0,05 0,11	-0,27 0,21
PartDvr	0,10* 0,05	0,17** 0,06	0,13* 0,06	0,17** 0,06
Size	0,27** 0,08	0,33** 0,09	0,26** 0,09	0,25* 0,1
NetCmpt	0,00 0,09	0,01 0,11	0,19* 0,09	0,26* 0,11
NetTyp (Bsnsclubs)		0,27* 0,11		0,15 0,11
NetTyp (Techparks)		-0,16 0,19		0,17 0,2
NetTyp (Indassociat)		-0,11 0,10		0,15 0,11
Overall Model Test (X ²)	32,79**	46,97**	33,52**	36,11**
R ² (Nagelkerke)	0,13	0,22	0,15	0,18
Goodness of fit statistics (Pearson and Deviance)	947,8 (p =0,26) 726,3 (p =1)	784 (p =0,544) 598,88 (p =1)	940,5 (p =0,08) 528,4 (p =1)	874,66 (p =0,06) 458,38 (p =1)
Test of Parallel Lines	16,93 (p=0.15)	30,9 (p=0.08)	18,02 (p=0.12)	24,72 (p=0.26)

** correlation is significant at 0,01 level

* correlation is significant at 0,05 level