Influence of Geographical Proximity on Cooperation and Competition in Innovation Networks

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Abstract

The role of proximity in innovation networks has increasingly become a topic of interest in management studies, organizational studies, economic geography, etc. (Lazzaretti & Capone, 2016). Close proximity brings firms together (Boschma, 2005), granting them access to assets that they do not own but are necessary for developing certain activities (Quintana-Garcia and Benavides-Velasco, 2004). These benefits result from cooperation between the firms in knowledge creation and innovation, but the driving force behind networks of firms is competition (Newlands, 2002). Competition and cooperation complement each other through a process called "coopetition" (Kim, 2020). The aim of this research is to investigate the degree to which geographical proximity influences the cooperation and simultaneous competition among firms in an innovation network. The Umbria E-mobility Network was used as a case study in order to conduct this research. Quantitative research methods were used and resulted insignificant, suggesting that, in the case of the Umbria E-mobility Network, geographical proximity does not influence competition and cooperation.

1. Introduction

The role of proximity in innovation networks has increasingly become a topic of interest in management studies, organizational studies, economic geography, etc. (Lazzaretti & Capone, 2016). The study of proximity started when economic geographers, such as Alfred Marshall, observed that the concentration of firms in close geographical proximity benefited the firms (Newlands, 2002) and the region that they are co-located in (Boschma, 2005). Close proximity brings firms together (Boschma, 2005), granting them access to assets that they do not own but are necessary for developing certain activities (Quintana-Garcia and Benavides-Velasco, 2004). As a result, these firms benefit from large-scale industrial production, and technical and organizational innovations (Newlands, 2002), which lead to knowledge creation, and economic, technical and market growth (Quintana-Garcia & Benavides-Velasco, 2004).

These benefits result from cooperation between the firms in knowledge creation and innovation, but the driving force behind networks of firms is competition (Newlands, 2002). Competition avoids complacency and keeps a creative tension within firms (Quintana-Garcia & Benavides-Velasco, 2004). This ensures meaningful initiatives and efficiency of the network, allowing the network to secure internal economies of scale and external benefits (Newlands, 2002). But how can competition and cooperation take place at the same time? They seem polar opposites but in reality they are not (Kim, 2020; Newlands, 2002). Firms cooperate in order to enhance their performance through the sharing of knowledge and resources (Bouncken et al., 2015). However, firms will still have conflict with rivals over market share, with customers over price and with suppliers over cost (Nalebuff & Brandenburger, 1997) and thus will be in competition. Therefore, a firm has to create and capture value at the same time in order to engage in “coopetition”, which is the term that combines competition and cooperation (Nalebuff & Brandenburger, 1997). Firms have a greater capacity to gain knowledge and innovate if they engage in coopetition rather than when both strategies are engaged separately (Quintana-Garcia & Benavides-Velasco, 2004).

1.1 *Societal relevance*

Well-functioning networks, where the member firms benefit from the advantages of being part of, are characterized by a balance between competition and cooperation (Newlands, 2002). This is because customer interests (Bouncken et al., 2015) and the performance and survival of firms (Quintana-Garcia & Benavides-Velasco, 2004) is dependent on the balance between competition and cooperation. A firm's primary aim is to maximize profits, which entails maximizing revenue and minimizing costs. On one side, competition may increase a firm’s innovative capacity, which increases its knowledge and economic, technical and market growth (Quintana-Garcia & Benavides-Velasco, 2004). On the other, cooperation can stimulate knowledge creation and utilization, increase the volume of production, improve the quality of goods and services, expand markets (Quintana-Garcia & Benavides-Velasco, 2004) and reduce costs (Felzensztein et al., 2018), which may lead to price drops (Bouncken et al., 2015). Achieving this balance is particularly important in today’s economic environment as it is dynamic and uncertain (Bouncken et al., 2015). As a result, firms have to keep up with the changes in the economic environment in order to remain competitive (Bouncken et al., 2015).

Since this balance may foster innovation (Quintana-Garcia & Benavides-Velasco, 2004), well-functioning innovation networks can be an engine of regional economic growth (Felzensztein et al., 2018). Innovation leads to sustained economic growth, which is one of the macroeconomic goals. This is because economic growth benefits society by improving standards of living, lowering unemployment and possibly leading to a more equitable income distribution. Therefore, understanding the degree that geographical proximity influences the competitive and cooperative environment of innovation networks matters in how the member firms maximize their profits and how such networks assist in the economic growth of a region where the local society can benefit from.

1.2 *Academic relevance*

Much research has been done on the impact of different forms of proximity on learning, knowledge creation and innovation (Boschma, 2005). Researchers have investigated how proximity leads to (Lazzaretti & Capone, 2016) or inhibits (Ben Letaifa & Rabeau, 2013) innovation. However, not a lot of research has been done regarding the impact of proximity on the forces, i.e. competition and cooperation, that lead to innovation. The ones that have been done, such as the study by Chetty and Michailova (2011), focus on either competition or cooperation (Quintana-Garcia & Benavides-Velasco, 2004), not both in the simultaneous process known as coopetition. According to Bouncken et al. (2015) coopetition research is still infant as most studies are conceptual or qualitative with the aim of theory development instead of theory extension. There is a limited amount of empirical work on coopetition, such as the paper by Quintana-Garcia & Benavides-Velasco (2004). More research is needed to explore the impacts of coopetition engagement (Bouncken et al., 2015). Only the works of Chetty and Michailova (2011) and Newlands (2002) were found, but both are theoretical. This indicates a research gap regarding the degree to which different forms of proximity influence competition and cooperation between firms in an innovation network. Scholars and managers have recognized that engaging in coopetition is important for the performance of the innovation process (Quintana-Garcia & Benavides-Velasco, 2004). Therefore, the management and business literature has gained interest in the topic of coopetition (Bouncken et al., 2015), which is why the identified research gap should be addressed.

1.3 *Research problem*

As a result, the aim of this research is to investigate the degree to which geographical proximity influences the cooperation and simultaneous competition among firms in an innovation network. Therefore, the research aims to answer the following research question:

> *"To what extent does geographical proximity influence* ***coopetition*** *among* firms *in an innovation network?"*

To answer the research question, the following two subsidiary questions have to be answered:

1. *"To what extent does geographical proximity influence* ***cooperation*** *among* firms *in an innovation network?"*
2. *"To what extent does geographical proximity influence* ***competition*** *among* firms *in an innovation network?"*

1.4 *Reading guide*

This study is made up of six chapters. The core concepts and theories are discussed in chapter two. Then chapter three explains the choice of the case study and describes the variables and how they were collected. It also discusses the quality of the data collected and how it will be analyzed in chapter four. Chapter four presents the results for the Umbria E-mobility Network case study, which are then analyzed. Chapter five will answer the main research question, describe the study's theoretical implications and reflect on the study's weaknesses based on which recommendations for further research are made.

2 Theoretical framework

2.1 *Innovation networks*

Innovation networks are a collection of atomistic firms, meaning many small firms in a perfectly competitive market, who compete with each other but cooperate (Newlands, 2002) in the development of scientific or technological innovations (Lazzaretti & Capone, 2016). They do so through networks in research and development, strategic alliances, etc., which are created through subcontracting relationships, alliances or research consortia (Lazzaretti & Capone, 2016). The aim of innovation networks is to gain, transfer and create knowledge (Corsaro et al., 2012). Therefore, firms associate with such networks in order to gain access to the knowledge that they do not have (Quintana-Garcia & Benavides-Velasco, 2004). They will operationalize the knowledge through the implementation of a new or significantly improved idea, strategy, or good or service in order to innovate (Ben Hassen, 2018). This process of innovation occurs at any aggregation level: regional, national and supranational (Corsaro et al., 2012).

2.2 *Coopetition*

"Coopetition" is a term coined by Raymond Noorda, the CEO of Novell, to describe a relationship between firms that combines "cooperation" and "competition" (Bouncken et al., 2015). Based on their research, Bouncken et al. defines coopetition as *"a strategic and dynamic process in which economic actors jointly create value through cooperative interaction, while they simultaneously compete to capture part of that value"* (2015, p. 591). Value creation is the process where firms generate value, which can be new technical skills, capabilities and knowledge (Kim, 2020), from cooperative relationships with other firms (Lavie, 2009). The joint creation of value is the cooperative process of coopetition. Cooperation is the joint pursuit of common benefits by different firms (Kim, 2020) in order to enhance their performance, as their effectiveness and efficiency increases (Bouncken et al., 2015), and achieve a cooperative advantage (Kim, 2020). It can take the form of strategic alliances, networks and other partnerships (Bouncken et al., 2015), thus including innovation networks. Cooperative advantages in innovation networks occur through the development of shared inputs (Newlands, 2002) as this increases productivity and thus reduces production costs. The development of shared inputs is achieved through the exchange, sharing or codevelopment of products, technologies or services (Gimeno, 2004). These may take place through joint ventures, cooperative R&D projects and joint marketing engagements (Lavie, 2009).

After the value has been created, it is shared (Lavie, 2009) among the member firms of the network. This leads to competition between the firms as they competitively attempt to increase their share of the value created (Lavie, 2009). Competition is the individual pursuit by a firm of its own goals by beating competitors in the search of limited resources (Gimeno, 2004) and in the market (Kim, 2020). Therefore, competition is embedded in cooperative relationships, since the joint pursuit of common benefits is a strategy for firms to pursue their own goals. As a result, firms may adopt value-capturing strategies (Lavie, 2009), which may take the form of, for example, offloading costs to partners (Kim, 2020), negotiating higher license fees and limiting the sharing of one's own proprietary knowledge with partners (Lavie, 2009). The choice of which value-capturing strategy the firm will use depends on whether the cooperative relationship is vertical or horizontal. If the cooperative relationship were to be vertical, which is between actors at different stages of the value chain (Gimeno, 2004), then the various actors would compete to gain the largest monetary share (Kim, 2020). On the other hand, if the cooperative relationship were to be horizontal, which is between direct competitors (Quintana-Garcia & Benavides-Velasco, 2004), then the various actors would compete to gain the largest market share (Bouncken et al., 2015).

Even though the vertical relationship plays a significant role, this research will focus on the horizontal one because coopetition is generally associated with cooperation between direct competitors (Kim, 2020). Competing firms tend to have a more common or similar knowledge base than non-competitors (Bouncken et al., 2015). This enables them to share and integrate knowledge more easily (Bouncken et al., 2015) as competitors can provide more specific and relevant knowledge, than non-competitors (Kim, 2020). Toyota and General Motors came together in order to use each other's resources, competencies and knowledge bases to jointly develop fuel cell-powered cars (Bouncken et al., 2015). Furthermore, competitors face similar market conditions, customer needs and uncertainty problems (Bouncken et al., 2015). Therefore, they also have similar production behaviors (Kim, 2020), which is characterized by a common perception of future changes (Bouncken et al., 2015).

2.3 *Geographical proximity*

Proximity is often seen as a precondition for knowledge sharing, transfer (Chetty & Michailova, 2011) and creation, and thus innovation (Boschma, 2005). Usually proximity is associated with geographical proximity, but other forms have been identified and may complement or even substitute the geographical one (Boschma, 2005). Boschma (2005) presented five forms of proximity in his paper: geographical, cognitive, organizational, social and institutional proximity. This research will focus on geographical proximity, even though it has been questioned regarding its necessity in innovation networks in the era of the global economy. Nevertheless, geographical proximity still plays an important role in the knowledge transfer and innovation process of innovation networks (Ben Hassen, 2018). If geographical proximity did not play an important role, then why and how are agglomerations of firms in close geographical proximity, such as Silicon Valley, still attracting new entrants and playing a major role in regional, national and global economies?

Geographical proximity is defined by Boschma as *"the spatial or physical distance between economic actors"* (2005, p. 69). This distance determines the opportunity provided to firms to access and acquire knowledge from other firms and thus attain knowledge-based benefits (Chetty & Michailova, 2011). Since innovation networks are knowledge-based (Corsaro et al., 2012), geographical proximity is necessary for the functioning and success of innovation networks (Rallet & Torre, 1999). Knowledge can be categorized as tacit and codified knowledge (Ben Hassen, 2018). Tacit knowledge is knowledge that has not been explicitly formulated, thus it cannot be easily transferred between actors as it requires a certain degree of geographical proximity (Rallet & Torre, 1999). Codified knowledge is knowledge reduced into messages that can be easily transferred through information and communication technologies (Rallet & Torre, 1999). Research and innovative activities are tacit knowledge intensive activities and additional scientific and technological developments lead to more tacit knowledge (Rallet & Torre, 1999). Such knowledge is transmitted best through face-to-face interactions (Chetty & Michailova, 2011), which firms are more likely to have if they are geographically proximate (Boschma, 2005). Transmission of tacit knowledge over longer distances is more costly and probably less efficient (Chetty & Michailova, 2011).

Moreover, geographical proximity may enhance knowledge transfer and creation by building and strengthening social, organizational, institutional and cognitive proximity (Boschma, 2005). If geographical proximity complements the other forms of proximity, it arranges the competitive and cooperative relations between the firms within an innovation network, as seen in figure 1. Geographical proximity may stimulate the formation and evolution of institutions (Boschma, 2005), where an active management system for the innovation network can be set up. Firms need to set up such a management system in order to define ''what to share, with whom, when and under which conditions'' (Levy et al. 2003, cited by Bouncken et al. 2015, p. 587). This enables and establishes knowledge integration and a common understanding about the project (Bouncken et al., 2015). This implies that the firms separate pre-competitive and competitive stages of the innovation process, such as managing the exchange of information, knowledge and competencies (Bouncken et al., 2015). Firms have to individually prevent the imitation of ideas and the unintended sharing of information, knowledge and competencies (Bouncken et al., 2015). There needs to be a balance between knowledge sharing and maintaining uniqueness in order for firms to achieve a desirable balance between competition and cooperation (Bouncken et al., 2015), which is important for the functioning of the network (Newlands, 2002). Therefore, a network needs an active management system, as seen in figure 1, in order to balance competition and cooperation so that it functions effectively and efficiently, which allows the individual firms to benefit from it.

Furthermore, geographically proximate firms are more likely to have face-to-face interactions (Boschma, 2005) and “emotional closeness”, which build up trust between them (Chetty & Michailova, 2011). Trust is required for creating and sustaining cooperation between firms in a network (Newlands, 2002), as seen in figure 1. This is because firms are social actors as their behaviors regarding their competitiveness and cooperativeness in a network are determined by socially embedded relationships (Kim, 2020), which in turn are determined by trust (Boschma, 2005). Non-proximate firms are less likely to have face-to-face interactions and emotional closeness, making it difficult for them to build trust among themselves. Therefore, larger distances between firms hinders cooperation between them. Cooperation between non-proximate firms are likely to result in unequal access to and distribution of information, differences in interpretation of information and misunderstandings while communicating (Chetty & Michailova, 2011). In sum, geographically proximate firms are more likely than geographically non-proximate firms to cooperate with each other.

> **H1.** Geographical proximity positively influences **cooperation** between firms in an innovation network.

Competition will emerge over time from cooperative activities based on geographical proximity (Chetty & Michailova, 2011), since the value created from these activities will have to be shared (Lavie, 2009) among the member firms of the network, as seen in figure 1. The firms will competitively attempt to increase their share of the value created (Lavie, 2009). This competition will be reinforced by close geographical proximity. Geographically proximate firms in the same network will have to share the limited resources available in the region and participate in the same local, regional or national market. Since firms’ primary aim is to maximize profits, which entails minimizing costs and maximizing revenue, they will attempt to beat the other firms in the search of limited resources (Gimeno, 2004) and in the market (Kim, 2020). Therefore, firms may see the other firms as their competitors (Ben Letaifa & Rabeau, 2013), regardless of whether they cooperate in the network. Hence, close geographical proximity indirectly influences competition, through its influence on cooperation, but also directly influences it, as seen in figure 1. As a result, geographically proximate firms are more likely than geographically non-proximate firms to compete with each other.

> **H2.** Geographical proximity positively influences **competition** between firms in an innovation network.

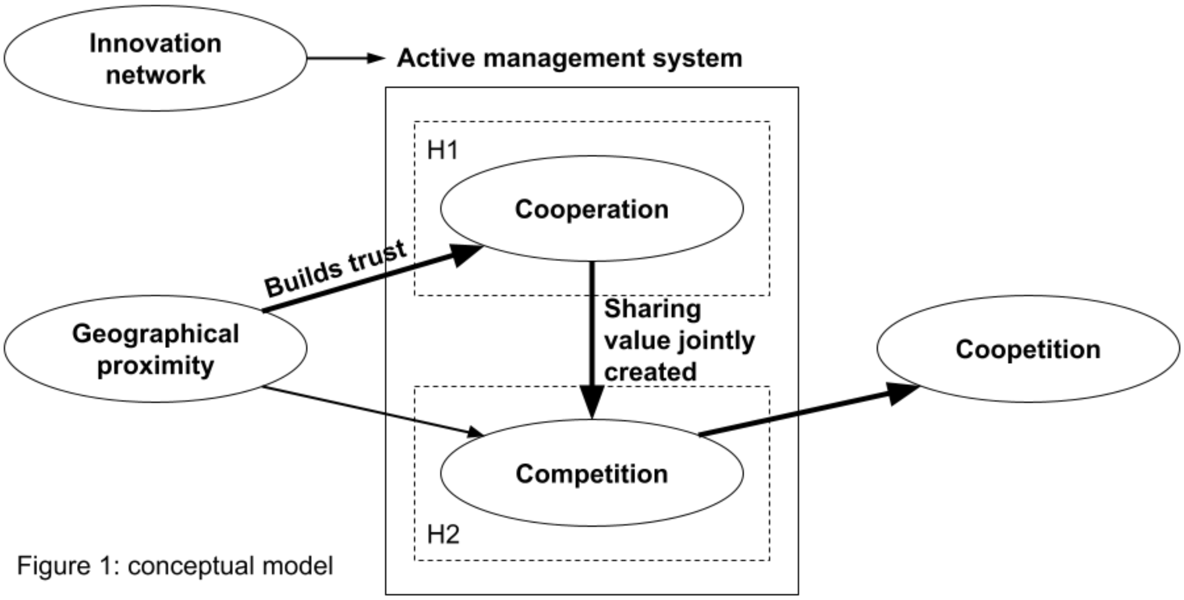


Figure 1: conceptual model

3 Methodology

3.1 *Umbria (Italy) E-mobility Network*

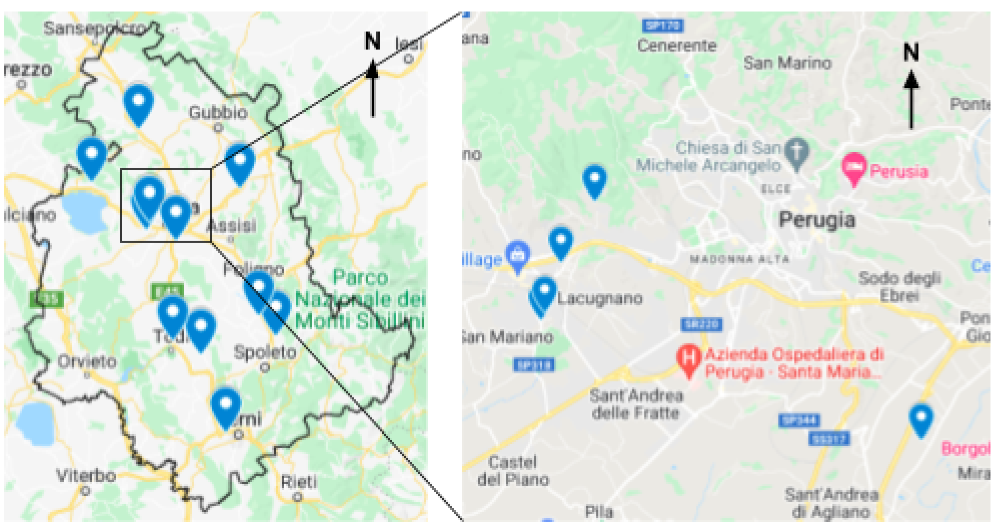


Figure 2: map of Umbria with locations of member firms

Figure 3: map of Perugia with locations of member firms

The Umbria E-mobility Network is an innovation network of firms operating in the supply chains of goods and services in the field of electric/sustainable mobility (Umbria E-mobility Network, 2022). It was established in February of 2019 in Umbria (figure 2), a region in central Italy, by five firms operating in the field of sustainable mobility (Umbria E-mobility Network, 2022). Throughout the years, the network has expanded as more and more firms joined the network. Currently there are fourteen firms in the network but more are expected to join as time passes.

Not only the size of the network increased but also the intricacy and comprehensiveness increased in order to achieve a certain degree of integration between the firms, which is the aim of the network. Firms in the network have to share their innovative projects and technological solutions (Umbria E-mobility Network, 2022) in order to act together as an integrated entity. This implies the network, as a whole, offering packages, made up of several goods and services supplied by the various members of the network, to the E-mobility market.

The selection of this case study is based on its relevance to the research objective. First of all, this case study is representative of the concept of coopetition due to the nature of the network. The network emerged with the coming together of firms that operate in the supply chains of goods and services in the market of electric/sustainable mobility (Umbria E-mobility Network, 2022). Its strategy is to adopt scientific, industrial and business cooperation (Umbria E-mobility Network, 2022). Therefore, since the member firms operate in the same supply chain and market, and the network's strategy is cooperation, there is a certain degree of bilateral, i.e. horizontal and vertical, competition and cooperation between the firms. Second, all of the firms in the network, apart from one, are located in Umbria (figure 2), therefore the network is location specific, meaning that the knowledge spillovers are geographically localized and thus geographical proximity becomes a necessity (Boschma, 2005). The firms are located in different areas of the region as some of them are located in urban centers, for example there is a relatively high concentration of firms in Perugia (figure 3), the capital of Umbria, whilst others are located in more rural areas. Therefore, geographical proximity within the network should be relatively heterogeneous, which should improve the variance of the data when run through a statistical test. This is optimal because it will show how different levels of proximity influence cooperation, competition and thus coopetition.

With the use of the case study, primary and secondary quantitative data was collected in order to obtain the data necessary to achieve the study's research aim. Quantitative data was chosen over qualitative data because the data can be statistically analyzed in order to precisely find the effect of the independent variables towards the dependent variables. Secondly, the data is made up of many cases and the nature of some of the variables, in particular geographical proximity, calls for a quantitative approach. Primary data was collected because the Umbria (Italy) E-mobility network is a relatively new network, meaning that not a lot of data about it will have been collected or published. In addition, some of the data required is not available due to their particularity and specificity. Secondary data was also used as some of the data needed is officially documented and thus is already available.

3.2 *Sampling strategy*

To collect the data from this case study, a purposeful sampling strategy was adopted in order to choose the firms that best serve the purpose of finding the relationship between geographical proximity and cooperation, on the one hand, and competition, on the other. Only the firms that are located in the region of Umbria (figure 2) will be included in the sample. This is because the study takes place at the regional level due to the importance of innovation networks towards the individual firms at that level (Cooke, 2001). Innovation networks at the regional level may be seen as advantage-generating “superfirm” groups as member firms share and together create knowledge (Tallman et al., 2004). They are cooperative in nature but competition plays a significant role as the member firms competitively attempt to gain the largest share possible of the value generated in the network (Lavie, 2009). As a result, all of the firms in the network, apart from one, which is located outside Umbria, have been included in the sample.

3.3 *Variable construction*

3.3.1 *Dependent variable*

Since the study seeks to find the relationship between geographical proximity and cooperation, on the one hand, and competition, on the other, the analysis is divided into two parts, one for each force in order to answer the two subsidiary questions separately. The first part focuses on answering the first subsidiary question where the dependent variable is cooperation (COOP), as it is the variable that is to be explained. Cooperation is treated as a binary variable since the outcome can only be two possibilities: there is cooperation or there is no cooperation. Also Quintana-Garcia & Benavides-Velasco (2004) treated cooperation as a binary variable in their empirical study on the effect of cooperation on technological diversity and new product development by European biotechnology firms.

Due to the particularity and specificity of cooperation as a variable, primary data had to be collected for this variable. The leader of the Umbria E-mobility network, who has knowledge of the network as he overviewed it since the establishment, was asked whether or not the member firms cooperated with each other. In other words, each firm is viewed as whether or not it participated in joint ventures, cooperative R&D projects and joint marketing engagements (Lavie, 2009) with the other firms within the network.

The second part focuses on answering the second subsidiary question where the dependent variable is competition (COMP), as it is the variable that is to be explained. Competition is also treated as a binary variable since the outcome can only be two possibilities: there is competition or there is no competition. Also in the study of Quintana-Garcia & Benavides-Velasco (2004) competition is treated as a binary variable.

In the case of competition primary data had to be collected due to its particularity and specificity. This variable was constructed using the Ateco codes for each firm in the network, which were sent by the main consultant/moderator, who acts as the initiator and facilitator, of the network. Ateco is the classification of economic activities used by Istat (2022), which is the Italian National Institute of Statistics. The code is a six digit number, where each combination of numbers signifies a certain economic activity. The process of deriving whether or not the firms compete with each other from the Ateco codes is similar to what Janssen & Abbasiharofteh (2022) did in their research to measure cognitive proximity using NACE codes. Since this research focuses on the horizontal dimension, competition is about beating direct competitors in the market (Kim, 2020). Therefore, the Ateco codes are directly compared to determine whether the firms participate in the same economic activities and thus market. If the two firms have the same Ateco code, then they are direct competitors. Only the first two digits of the code were used in order to improve the variance of the data when run through a statistical test.

3.3.2 *Independent variable*

The independent variable that is used for both parts is the geographical proximity (GEO) of the firms in the network. This is because the aim of the research is to investigate the extent that this form of proximity influences cooperation and competition among firms in a network. Therefore, it is treated as the variable that explains the outcome of the two dependent variables: cooperation and competition.

Geographical proximity is measured as the road distance in kilometers (km) between each member firm, thus it will be treated as a ratio variable. First off, this is because, according to Boschma (2005), the key dimension of geographical proximity is distance. It also ensures relatively granular data and the modifiable areal unit problem does not influence it (Janssen & Abbasiharofteh, 2022). Furthermore, the idea behind geographical proximity is the spatial accessibility of the firms in order for them to transfer and create knowledge (Chetty & Michailova, 2011). Therefore, this form of distance was picked over any other form, such as aerial distance, because the main mode of transportation in Umbria, and thus to reach the member firms, is the car due to the region's mountainous terrain.

Primary data was collected for the geographical proximity of the firms in the network. First the addresses of the member firms were found using the official Umbria E-mobility network website[1] and recorded. Then the road distances were measured between each address using Google Maps. Since Google maps provides different routes, the fastest one, which does not necessarily mean the shortest one, was picked because time is valuable for firms as they aim for efficiency.

3.3.3 *Control variable*

The control variables that are also used for both parts include the firm's years of experience (EXPC), size in 2020 (SIZE) and revenue in 2020 (REV). These variables are controlled due to their potential impact on a firm's ability to influence the network's competitive and cooperative environment. A firm's years of experience determines its amount of resources, relationships and market presence (Bouncken et al., 2015). It will be treated as a ratio variable because it is measured in years. To calculate it, first the years in which each member firm was founded was searched on the official Umbria E-mobility network website. Then each year of founding was subtracted from the current year, 2022.

Also a firm's size determines its amount of resources, relationships and market presence (Bouncken et al., 2015). Size was constructed using the total number of employees, which is also how Quintana-Garcia & Benavides-Velasco (2004) measured it in their study, thus it will be

[1] https://www.umbriaemobilitynetwork.it/en/home-en/

treated as a ratio variable. The secondary data for this variable was provided by the main consultant/moderator of the network for the year of 2020.

The last control variable is a firm's revenue because it determines a firm's ability to decide whether to make-or-buy the things needed and to build a new factory in order to yield more output (Levmore, 1998). This variable will also be treated as a ratio variable because it is measured using the disposable income, in euros (€), that the firm earned in a year. Also, the secondary data for this variable was provided by the main consultant/moderator of the network for the year of 2020.

3.4 *Quality of data*

Table 1: Descriptive statistics

Statistic	N	Mean	St. Dev	Min	Pctl(25)	Median	Pctl(75)	Max
GEO	78	48.613	25.9981	0.4	33.100	45.300	63.775	116.0
COOP	78	0.1154	0.32155	0.00	0.0000	0.0000	0.0000	1.00
COMP	78	0.1410	0.35030	0.00	0.0000	0.0000	0.0000	1.00
EXPC1	78	35.54	25.451	8	12.00	22.00	70.00	76
EXPC2	78	25.69	19.426	8	11.75	16.00	48.00	76
SIZE1	78	68.47	78.172	6	11.00	26.00	103.00	350
SIZE2	78	101.37	114.664	6	11.00	95.00	118.00	350
REV1	78	9409.05	12624.300	48	874.00	2887.00	15037.00	64614
REV2	78	16684.18	21057.288	48	874.00	14180.00	22214.00	64614

Table 2: Correlation matrix

Statistic	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
GEO (1)	1								
COOP (2)	-0.201	1							
COMP (3)	0.059	-0.031	1						
EXPC1 (4)	0.197	-0.119	0.124	1					
EXPC2 (5)	0.202	-0.198	0.115	-0.041	1				
SIZE1 (6)	0.190	-0.097	-0.122	-0.004	-0.093	1			
SIZE2 (7)	0.207	-0.168	0.190	-0.044	0.652	-0.061	1		
REV1 (8)	0.200	-0.140	-0.101	0.025	-0.111	0.927	-0.039	1	
REV2 (9)	0.199	-0.188	0.193	-0.052	0.620	-0.065	0.986	-0.048	1

Table 1 illustrates the descriptive statistics of the collected data. 78 observations were made, which is a relatively large sample size, meaning that the estimates of the process parameters should be more precise. The mean distance between the firms in the Umbria E-mobility Network is 48.61km, whereas the median is 45.3km. Since the mean is greater than the median, the data may appear skewed to the right. However, since the mean and the median are relatively close to each other, the data is normally distributed as shown by the black bell curve shaped line in figure 4. This means that the distances between the firms in the network tend to be around 48.61km. The standard deviation is 26km, meaning that most distances between the firms are spread within 13km on each side of the mean.

Figure 4: histogram of geographical proximity

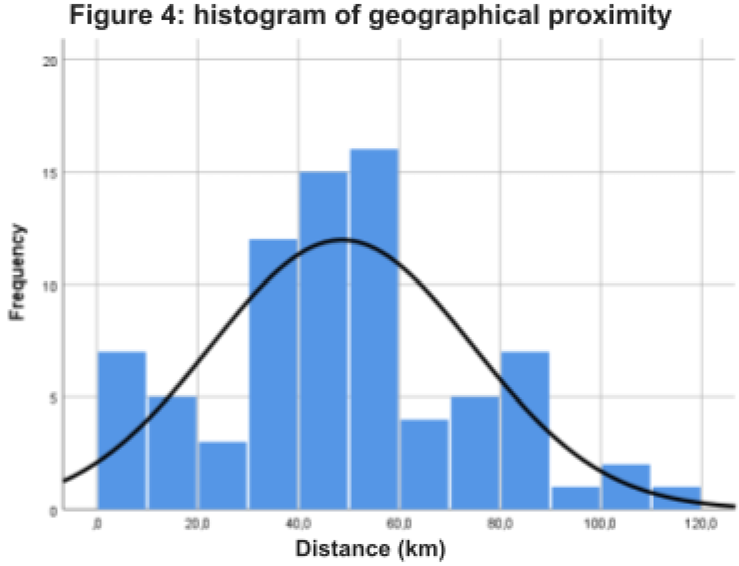


Table 2 shows that there is a weak negative linear relationship, -0.201, between GEO and COOP. Since GEO is measured using distance, this relationship implies that as distance increases, cooperation decreases. This means that as geographical proximity between firms increases, cooperation increases between them, which suggests that the data, pre-analysis, supports H1. Furthermore, the matrix (table 2) also shows that there is a very weak linear relationship, 0.059, between GEO and COMP and thus a negative relationship between geographical proximity. Therefore, based on the correlation matrix, the data does not support H2. Moreover, according to the matrix (table 2), some of the variables are strongly correlated with each other, such as EXPC2 and SIZE2, and some are even extremely correlated with each other, such as SIZE1 and REV2. Hence, there may be an issue of multicollinearity but these variables are all control variables. The independent variable (GEO) is only weakly correlated with the other variables, thus this should not be an issue.

3.3 *Data analysis*

To see whether these relationships exist between geographical proximity and cooperation, on the one hand, and competition, on the other, two binary logistic regressions were run using SPSS, a statistical software. The knowledge to run binary logistic regressions using SPSS was gained in the “Statistics 2” course. This statistical test was used for both parts of the analysis because both dependent variables are binary and the independent variable is a ratio variable. If the tests result significant, using the conventional 95% confidence level, meaning that the significance value is below 0.05, there is a relationship between the variables. As a result, the strength of the relationships can be assessed and the effect size of geographical proximity on cooperation and competition can be investigated. Furthermore, the following logistic regression models can be used to estimate the probability of cooperation (COOP) and competition (COMP):

$$\ln(P_{COOP1\,2} / 1 - P_{COOP1\,2}) = \alpha + \beta_1 GEO_{1\,2} + \beta_2 Node_1 + \beta_3 Node_2 + u_{1\,2}$$

$$\ln(P_{COMP1\,2} / 1 - P_{COMP1\,2}) = \alpha + \beta_1 GEO_{1\,2} + \beta_2 Node_1 + \beta_3 Node_2 + u_{1\,2}$$

$P_{COOP1\,2}$ denotes the probability of cooperation between firm 1 and firm 2, whereas $P_{COMP1\,2}$ denotes the probability of competition between firm 1 and firm 2. $GEO_{1\,2}$ corresponds to the geographical proximity between firm 1 and firm 2. Node represents the control variables, which include EXPC, SIZE and REV, with reference to firms 1 and 2.

3.4 *Ethical considerations*

In order to act ethically, certain considerations have to be taken during the data collection. The position I took as a researcher was a neutral one as I am an outsider to the case study. However, I had to take into account the emphasis of the leader and main consultant/moderator of the network towards the cooperation that occurs within the network, otherwise the research may be biased towards cooperation. The two respondents are the experts of the case study and thus have significant power as they are the ones providing me with a large part of the data. Nevertheless, I am conducting the research and thus also have significant power, which more or less balances the power relationship.

To keep the privacy of the firms in the network, in order to prevent any possible harm towards the firms' relationships and thus the entire network, the data will be presented without the firms' names. Therefore, the names of the firms have been substituted with letters so that particular cases in the data cannot be associated with one of the firms. Consequently, the data for the firms will be kept anonymous to the extent that still allows me to conduct the research.

4 Results

4.1 *Geographical proximity and cooperation*

Table 3: Regression results for cooperation

Omnibus Tests of Model Coefficients

	Chi-square	df	Sig.
Step	13.732	7	0.056
Block	13.732	7	0.056
Model	13.732	7	0.056

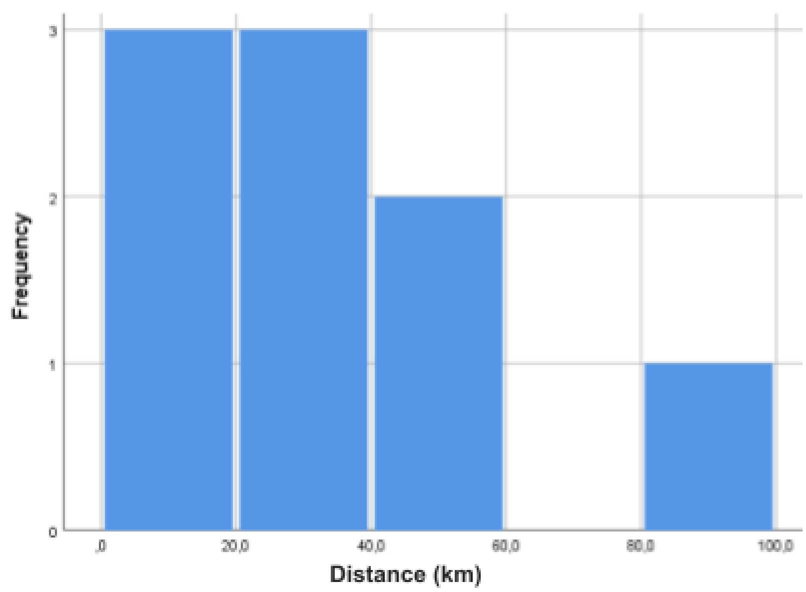
As seen in table 3, the first binary logistic regression resulted in not significant. The row named "model" in table 3 shows that the significance value is 0.056, which is greater than 0.05. This means that there is no relationship between geographical proximity and the probability of cooperation. In other words, geographical proximity does not influence cooperation and thus H1 is not supported.

Whether or not firms cooperate with each other is determined by their level of trust for each other (Newlands, 2002). This research followed the line of thought that geographically proximate firms are more likely to have face-to-face interactions (Boschma, 2005), which builds trust between them (Chetty & Michailova, 2011). However, according to Boschma (2005), trust is the key dimension of social proximity because it is about socially embedded relations between firms, which are determined by trust. Social proximity is the most important form of proximity to facilitate communication, reciprocity and thus attain cooperation between firms (Letaifa & Rabeau, 2003). Therefore, it may act as a substitute for geographical proximity (Boschma, 2005). Consequently, social proximity may possibly influence cooperation in place of geographical proximity. Therefore, geographical proximity is no longer necessary for knowledge transfer and innovation (Boschma, 2005).

This is also due to advanced information and communication technologies that enable firms in remote locations to coordinate (Rallet & Torre, 1999) in order to cooperate. Thus networks do not have to be localized geographically any longer (Boschma, 2005). ICT also provides access to new people and contact opportunities, thus facilitating social networking (Rallet & Torre, 1999) and offering cooperation opportunities. However, the need for geographical proximity for face-to-face contacts in order to exchange tacit knowledge, in order to cooperate, cannot be eliminated by the use of ICT (Rallet & Torre, 1999). Nevertheless, face-to-face contacts can be achieved without a permanent colocation (Rallet & Torre, 1999). These physical interactions can be achieved through the temporary mobility of individuals, in other words travel, thanks to the decrease in transportation costs and the development of high-speed transportation modes (Rallet & Torre, 1999). Consequently, cooperation between firms within a network are becoming less influenced by geographical proximity due to the previously mentioned reasons that are rendering it obsolete.

However, when trying to understand why geographic proximity does not influence cooperation, the histogram of geographical proximity (figure 4) was further analyzed. As a result, three potential peaks were identified, which may suggest that the sample may be multi-modal. This often indicates that important variables have not been accounted for. Therefore, on SPSS, the observations of geographical proximity were classified first into two groups using the cooperation variable: yes cooperation and no cooperation, and then into two groups using the competition variable: yes competition yes and no competition. Then the graphs (figure 5 and 6, and appendix 4 and 5) with groups have been created in order to determine whether cooperation and competition account for the peaks in the data.

Figure 5: yes cooperation graph



As a result, the yes cooperation graph (figure 5) shows, first of all, a linear relationship between cooperation and geographical proximity. This suggests that there may be a possibility that the binary logistic regression that tested the relationship between geographical proximity and cooperation made a type 2 error. The statistical test concluded not significant even though it may have been significant, meaning that the relationship between geographical proximity and the probability of cooperation could possibly exist. Second of all, the relationship is positive because when the distance between the firms decreases, the more firms engage in cooperation. This means that geographical proximity positively influences cooperation between the firms. The correlation matrix (table 2) also shows this positive linear relationship between the two variables, but according to it, the strength of the relationship is weak. However, even though figure 5 supports H1, the sample does not as only 11.5% of the firms in the Umbria E-mobility Network cooperate (appendix 6). This may be because this innovation network is relatively new, thus the firms did not have time to establish cooperative relationships among themselves.

4.2 *Geographical proximity and competition*

Table 4: Regression results for competition

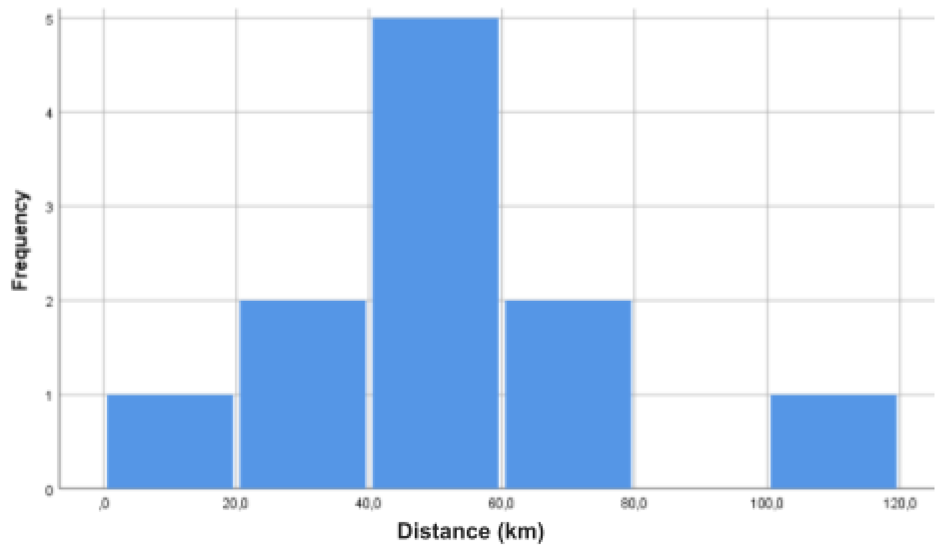
Omnibus Tests of Model Coefficients			
	Chi-square	df	Sig.
Step	5.188	7	0.637
Block	5.188	7	0.637
Model	5.188	7	0.637

The results of the second binary logistic regression also resulted in not significant. The row named “model” in table 4 shows that the significance value is 0.637, which is greater than 0.05. This means that there is no relationship between geographical proximity and the probability of competition. In other words, geographical proximity does not influence competition and thus H2 is not supported.

According to the theory collected, close geographical proximity indirectly influences competition, through its influence on cooperation, but also directly influences it, as seen in figure 1. Geographical proximity indirect influence on competition may not exist for reasons related to the case study. As seen in table 3, geographical proximity does not influence cooperation in the Umbria E-mobility Network. This means that there may have not been any significant cooperative activities that led to the creation of value. If no joint value was created, then there will be no competition between the firms of the network to gain the largest share of the value, resulting in no competition within the network.

Regarding the non-existence of geographical proximity’s direct influence on competition, there is no clear explanation. If firms are very geographically proximate, they may have built trust among themselves to a degree that they are unwilling to compete (Boschma, 2005), thus hindering competition. Therefore, the firms in the Umbria E-mobility Network are very geographically proximate, but this cannot be determined. Furthermore, this level of trust between the firms seems unreachable due to firms’ economic behavior. Brandenburger and Nalebuff (1996) used game theory to analyze competition and cooperation jointly between two firms. Since firms aim to maximize their profits, they use strategic behavior as each firm bases its actions on what it believes the other firm will do. Consequently, this leads to the prisoner’s dilemma, which results in both firms aiming to make themselves as well off as possible by capturing the largest market share, value jointly created or share of limited resources. Another explanation could be that geographical proximity’s indirect influence on competition is more influential than its direct influence. However, also this cannot be determined as it was not analyzed and requires further research.

Figure 6: yes competition graph

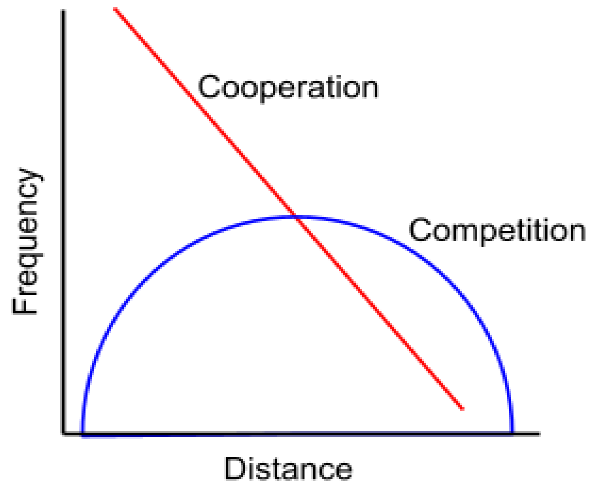


The yes competition graph (figure 6) also does not support H2 but it suggests that there may be an inverted U-relationship between geographical proximity and competition. When the distance between the firms increases at close geographical proximities, more firms engage in competition. However, after a certain distance, which based off of the graph is between 40km and 60km, less firms engage in competition. Therefore, too little and too much geographical proximity may hinder competition. If firms are very geographically proximate, they may have built so much trust between them that they are not willing to compete (Boschma, 2005), thus hindering competition. On the other hand, if firms are geographically far from each other, they may not compete in the same markets, unless it is a global one, thus competition between them will not take place (Ben Letaifa & Rabeau, 2013). However, also in this case, these observations, which account for only 14.1% of the data (appendix 7), are not enough to be representative of the Umbria E-mobility Network.

4.3 *Geographical proximity and coopetition*

Coopetition is a process where competition and cooperation complement each other (Kim, 2020), therefore if one of these forces does not take place, then the entire process does not. In the case of the Umbria E-mobility Network both forces were missing, which implies that the member firms do not engage in coopetition. However, the reason this may be, in terms of coopetition, is research related as the focus of this study was on horizontal relationships. The Umbria E-mobility Network emerged with the coming together of firms that operate in the supply chains of goods and services in the field of electric/sustainable mobility (Umbria E-mobility Network, 2022). Supply chains compromise bilateral relationships but specifically vertical ones, therefore just focusing on the horizontal will not capture the bigger picture of the possible coopetition within the network.

Figure 7: Relationship between geographical proximity and coopetition



Nevertheless, the case study did lead to some interesting but unrepresentative results through the creation of the yes cooperation graph (figure 5) and the yes competition graph (figure 6). If these two graphs are combined, a model (figure 7) can be created that depicts the relationship between geographical proximity and coopetition. The red line represents the relationship between geographical proximity and cooperation, whereas the blue curve represents the relationship between geographical proximity and competition. The point where the red line and blue curve intersect is the equilibrium point where competition and cooperation are balanced. This may partly explain the highest peak in the histogram of geographical proximity (figure 4). Furthermore, the level of geographical proximity that leads to this equilibrium would be the optimal level where potentially a firm's performance and innovative capacity would be maximized in a network.

5 Conclusion

This research set out to investigate the degree to which geographical proximity influences the cooperation and simultaneous competition among firms in an innovation network. Theoretical evidence has shown that geographical proximity favors trust, which in turn positively influences cooperation. It also has shown that close geographical proximity indirectly influences competition, through its influence on cooperation, but also directly influences it. Since the combination between cooperation and competition is described by the process of coopetition, geographical proximity theoretically influences coopetition. This overall process is depicted by the conceptual framework (figure 1).

Two binary logistic regressions were run in order to test whether geographical proximity influences cooperation and competition among firms in the Umbria E-mobility Network. Both statistical tests resulted in not significant, meaning that geographical proximity does not influence cooperation, competition and thus also not coopetition. Therefore, based on the

Umbria E-mobility Network case study, the answer for the two subsidiary questions is the following:

1. *"Geographical proximity influences **cooperation** among firms in an innovation network to no extent"*

2. *"Geographical proximity influences **competition** among firms in an innovation network to no extent"*

And based on these two answers, the main research question can be answered in the following way:

> *"Geographical proximity influences **coopetition** among* firms *in an innovation network to no extent"*

The possible reason why geographical proximity does not influence cooperation is because it is becoming obsolete. Other forms of proximity are substituting it (Boschma, 2005), and there have been improvements in communication technologies and transportation (Rallet & Torre, 1999). As a result, firms do not have to be geographically proximate in order to benefit from the same cooperative advantages obtained from being co-located with other firms. Hence, since geographical proximity did not influence cooperation in the case of the Umbria E-mobility Network, it can be expected that geographical proximity also does not influence competition. If there are no cooperative activities that lead to value creation, then there will be no competition between the firms to gain the largest share of the value.

Nevertheless, interesting findings arose when further analyzing the histogram of geographical proximity (figure 4). Relationships between geographical proximity and cooperation, on the one hand, and competition, on the other, have been identified. Figure 5 shows that there may be a positive linear relationship between geographical proximity and cooperation. Figure 6 shows that there may be an inverted U-relationship between geographical proximity and competition. This led to the development of a model (figure 7) that possibly constructed the relationship between geographical proximity and coopetition. The model depicts the equilibrium point where competition and cooperation are balanced. The level of geographical proximity that leads to this equilibrium would be the optimal level where potentially a firm's performance and innovative capacity would be maximized. However, the observations used to develop the model are not representative of the Umbria E-mobility Network, thus the validity of the model is questionable.

5.1 *Theoretical implications*

Although the findings do not present any significant relationships, this research may still have important theoretical implications in today's dynamic and uncertain economic environment. First off, this research contributes to the literature and wider academic debate on proximity and coopetition. There is a limited amount of empirical work on coopetition and there is not any on the relationship between it and proximity, which is what this research investigates and thus addresses this research gap. Furthermore, this research may be a starting point for combining the field of coopetition and of proximity as the presented results may initiate debates and further research by other parties. In particular, the model (figure 7) that depicts the relationship between geographical proximity and coopetition could be a subject or tool of debate and study. The model can be used to theoretically determine the equilibrium point where cooperation and competition are balanced. Therefore, other parties could use the model to further investigate the relationship by, for example, applying it to different case studies or by exploring causes that may shift the curves and thus lead to different equilibrium points. As a result, the creation of this model could be an important theoretical extension.

5.2 *Shortcomings and further research*

Even though there is theoretical evidence that possibly explains the lack of a relationship between geographical proximity and cooperation, on the one hand, and competition, on the other, the choice of the case study may be partly at fault. The Umbria E-mobility Network emerged with the coming together of firms that operate in the supply chains of goods and services in the field of electric/sustainable mobility (Umbria E-mobility Network, 2022). Supply chains compromise bilateral relationships but specifically vertical ones, therefore just focusing on the horizontal will not capture the bigger picture of the possible coopetition within the network. Furthermore, the Umbria E-mobility Network is also a relatively new network, meaning that the cooperative and competitive ties between the firms may have not yet been established. Depending on how it is viewed, the choice of the case study or the decision of focusing on the horizontal dimension may be a weakness of this research. This leads to two opportunity paths for further research. One can be changing the case study to an older and more established innovation network or cluster, which would be more appropriate when studying geographical proximity. This is because clusters are geographic concentrations of interconnected firms (Newlands, 2002) and innovation networks do not have to be localized geographically (Boschma, 2005). The second option would be including the horizontal dimension in the research in order to capture the bigger picture of the possible coopetition within a network.

Moreover, when attempting to explain why there is no relationship between geographical proximity and cooperation the concept of trust was used. Geographically proximate firms are more likely to have face-to-face interactions (Boschma, 2005) and “emotional closeness”, which build up trust between them (Chetty & Michailova, 2011). However, trust is the key dimension of social proximity because this form of proximity is about socially embedded relations between firms, which are determined by trust (Boschma, 2005). These socially embedded relationships determine the firms’ behavior regarding their competitiveness and cooperativeness (Kim, 2020). Therefore, social proximity should theoretically influence cooperation and competition of firms within a network. This dimension was not considered when constructing the theoretical framework of this research, thus posing a weakness to the study. However, further research in terms of social proximity may address this issue. Hence, a research focused on the influence of social proximity on cooperation and competition in innovation networks can be conducted.

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7 Appendix

Appendix 1: table of results

Firm 1	Firm 2	GEO	COOP	COMP	EXPC1	EXPC2	SIZE1	SIZE2	REV1	REV2
	B	81.4	Yes	No		22		157		13533
	C	57.4	Yes	Yes		11		15		2465
	D	75.4	No	No		76		11		874
	E	13	No	No		34		103		17608
	F	56.4	No	No		8		7		117
	G	57.3	No	Yes		16		11		559
	H	30.6	No	No		20		95		22214
	I	40.5	No	No		56		204		29556
	J	56	No	No		12		6		48
	K	36.1	No	Yes		48		350		64614
	L	90	No	No		16		105		14180
A	M	43.6	No	No	70	9	26	14	2887	951
	C	28.6	Yes	No		11		15		2465
	D	66.8	No	No		76		11		874
	E	71.7	No	No		34		103		17608
	F	28.3	No	Yes		8		7		117
	G	28.5	No	No		16		11		559
B	H	109	No	No	22	20	157	95	13533	22214

	I	85.1	No	No		56		204		29556
	J	32.3	No	No		12		6		48
	K	79.3	No	No		48		350		64614
	L	33.2	No	No		16		105		14180
	M	39.4	Yes	No		9		14		951
	D	41.3	No	No		76		11		874
	E	42.6	Yes	No		34		103		17608
	F	1.6	No	No		8		7		117
	G	0.4	No	Yes		16		11		559
	H	83.1	No	No		20		95		22214
	I	59.6	No	No		56		204		29556
	J	3.4	Yes	No		12		6		48
	K	53.8	No	Yes		48		350		64614
	L	38.6	Yes	No		16		105		14180
C	M	13.9	No	No	11	9	15	14	2465	951
	E	64.9	No	No		34		103		17608
	F	40.6	No	No		8		7		117
	G	41.4	No	No		16		11		559
	H	102	No	Yes		20		95		22214
	I	63.4	No	Yes		56		204		29556
	J	40.1	No	No		12		6		48
	K	57.6	No	No		48		350		64614
	L	56.9	No	No		16		105		14180
D	M	32.8	No	No	76	9	11	14	874	951
	F	45.6	No	No		8		7		117
	G	46.5	No	No		16		11		559
	H	39.7	No	No		20		95		22214
	I	41	No	No		56		204		29556
	J	45.2	No	No		12		6		48
	K	36.6	No	No		48		350		64614
	L	79.2	No	Yes		16		105		14180
E	M	32.8	No	No	34	9	103	14	17608	951
	G	1.4	No	No		16		11		559
	H	81.8	No	No		20		95		22214
	I	58.3	No	No		56		204		29556
	J	2.1	No	No		12		6		48
	K	52.5	No	No		48		350		64614
F	L	37.7	No	No	8	16	7	105	117	14180

	M	12.6	No	No		9		14		951
	H	83	No	No		20		95		22214
	I	59.5	No	No		56		204		29556
	J	3.3	Yes	No		12		6		48
	K	53.7	No	Yes		48		350		64614
	L	38.4	No	No		16		105		14180
G	M	13.8	No	No	16	9	11	14	559	951
	I	44.8	No	Yes		56		204		29556
	J	82.2	No	No		12		6		48
	K	50.6	No	No		48		350		64614
	L	116	No	No		16		105		14180
H	M	69.8	No	No	20	9	95	14	22214	951
	J	58.4	No	No		12		6		48
	K	9.3	No	No		48		350		64614
	L	85.4	No	No		16		105		14180
I	M	51	No	No	56	9	204	14	29556	951
	K	53.5	No	No		48		350		64614
	L	44.4	No	No		16		105		14180
J	M	13.6	Yes	No	12	9	6	14	48	951
	L	79.8	No	No		16		105		14180
K	M	45.4	No	No	48	9	350	14	64614	951
L	M	45	No	No	16	9	105	14	14180	951

Appendix 2: Remaining regression results for cooperation

Model Summary

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
42.058[a]	0.161	0.316

a. Estimation terminated at iteration number 8 because parameter estimates changed by less than 0.001.

Variables in the Equation

Statistic	B	S.E.	Wald	df	Sig.	Exp(B)
GEO	0.012	0.034	0.121	1	0.728	1.012
COOP	-0.026	0.026	1.015	1	0.314	0.974
COMP	-0.043	0.044	0.970	1	0.325	0.958
EXPC1	0.024	0.020	1.496	1	0.221	1.024

EXPC2	0.043	0.027	2.656	1	0.103	1.044
SIZE1	0.000	0.000	1.823	1	0.177	1.000
SIZE2	0.000	0.000	2.465	1	0.116	1.000
Constant (α)	-0.346	0.880	0.155	1	0.694	0.707

Appendix 3: Remaining regression results for competition

Model Summary

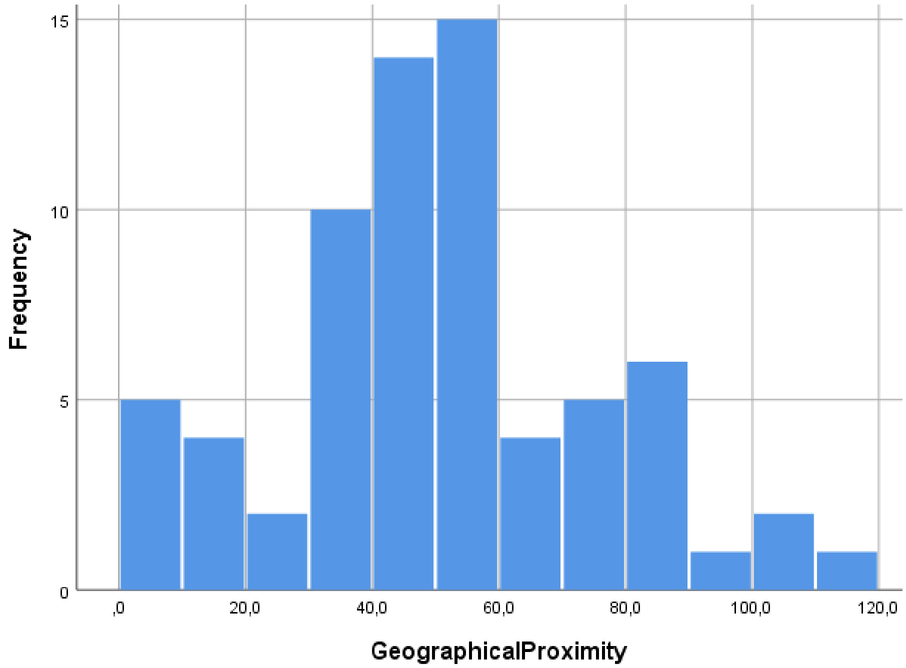
-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
58.276[a]	0.064	0.116

a. Estimation terminated at iteration number 8 because parameter estimates changed by less than 0.001.

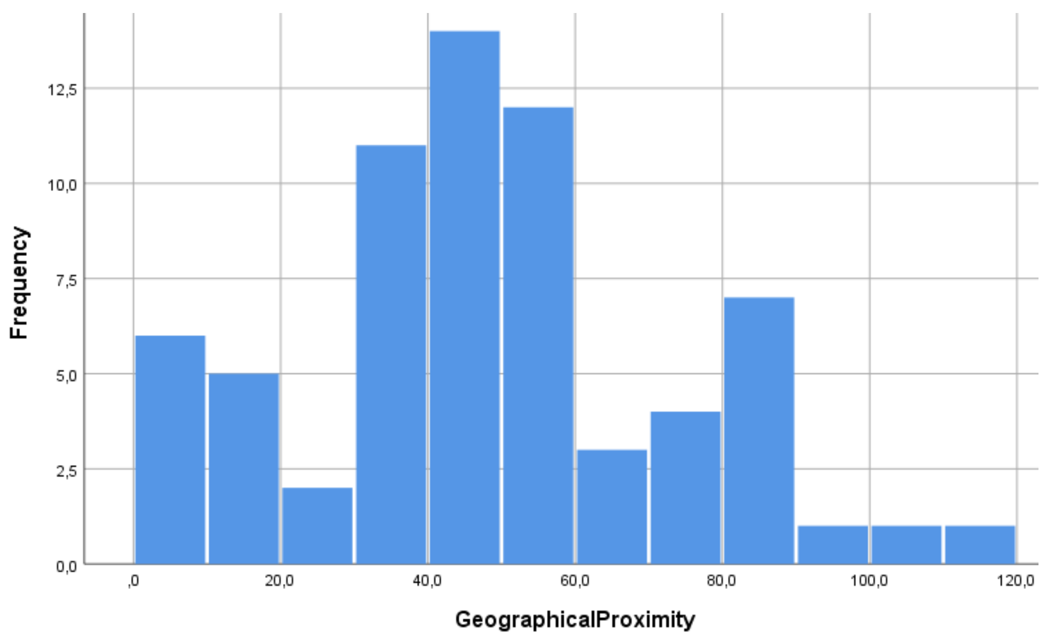
Variables in the Equation

Statistic	B	S.E.	Wald	df	Sig.	Exp(B)
GEO	0.004	0.014	0.086	1	0.769	1.004
COOP	0.013	0.013	1.142	1	0.285	1.014
COMP	-0.002	0.026	0.007	1	0.933	0.998
EXPC1	-0.008	0.015	0.302	1	0.582	0.992
EXPC2	0.001	0.017	0.001	1	0.976	1.001
SIZE1	0.000	0.000	0.043	1	0.835	1.000
SIZE2	0.000	0.000	0.059	1	0.809	1.000
Constant (α)	-2.657	1.083	6.025	1	0.014	0.070

Appendix 4: Histogram of geographic proximity classified into no cooperation



Appendix 5: Histogram of geographic proximity classified into no competition



Appendix 6: Cooperation frequency table

	Frequency	Percent	Valid Percent	Cumulative Percent
No	69	88.5	88.5	88.5
Yes	9	11.5	11.5	100

Total	78	100	100	

Appendix 7: Competition frequency table

	Frequency	Percent	Valid Percent	Cumulative Percent
No	67	85.9	85.9	85.9
Yes	11	14.1	14.1	100
Total	78	100	100	