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The Joint Influencing Mechanism of Proximities and Knowledge Base on Multinational Companies' Global Innovation Networks

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Abstract

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JEL codes: O32, F23, M16, L60

Keywords: Global innovation network, Multinational company, Knowledge base, Geographical proximity, Organisational proximity, Social network analysis

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1. INTRODUCTION

Networks at all geographical scales, ranging from the local, the national, to the global, have been promoted as new modes of governance to boost innovation by economic geographers, international business scholars, innovation researchers, as well as policy makers (Cooke and Morgan 1993, Amin and Thrift 1995, Sheppard 2002, von Hippel and von Krogh 2003, Capaldo 2007, Dhanaraj and Parkhe 2006, Fritsch and Kauffeld-Monz 2010, Tallman and Chacar 2011, Gupta and Polonsky 2014, Bathelt and Li 2014). Firms' global innovation networks (GINs) in which firms and non-firm actors engage for the development and diffusion of innovations has become an interesting phenomenon in the time of globalisation. Nevertheless, our understanding of how GINs are organised as the outcome of firms' strategic choices and why they are organised in certain patterns still remains limited.

Globalisation is characterised by extensive geographical spread of activities and high degree of integration of functions which was traditionally organised within the boundary of an organisation (Dickens 2007). This implies that globalisation is not only a geographical phenomenon but also an organisational occurrence which is orchestrated by firm's global strategy. The MNCs' globalisation of R&D activities is mainly driven by knowledge-seeking strategies (Brusoni, Prencipe and Pavitt 2001, Dunning and Lundan 2009). Thus, the success of a MNC's GIN depends on whether it can effectively and efficiently seek and transfer knowledge via its relations across spatial and organisational boundaries. The effectiveness and efficiency of knowledge seeking is determined by two factors, that is proximity and knowledge base (Mattes 2012). Proximity facilitates interactive learning (Gertler 1995, Storper 1992, Storper and Venables 2004) and the dominant knowledge base (Asheim, Coenen and Vang 2007) of the learning activities influences the extent to which proximities are needed. (Asheim and Coenen 2005, Asheim and Gertler 2005, Moodysson, Coenen and Asheim 2008). The proximity-and-knowledge-base framework has significantly contributed to our understanding of the global distribution of innovation activities.

One of the main challenges that the proximity-and-knowledge-base framework confronts is to understand the joint influences of different types of proximities on different networks dominated by different knowledge base. Economic geographers has long suggested that besides of geographical proximity it was important to study the other dimensions of proximity (such as organisational proximity, cognitive proximity, institutional proximity, social proximity, etc.) for better understanding interactive learning and innovation (Bunnell and Coe 2001, Gertler 2003). Geographical proximity is essential for interactive learning but in certain cases it can be substitute by other proximities (Rallet and Torre 1999, Morgan 2004, Hansen 2014). When different dimensions of proximities meet, it creates a complex dynamics to interactive learning (Mattes 2012). Such complexity brings great ambiguity to our understanding of the relation between knowledge base and the relational pattern of MNCs' GINs. Thanks to the complexity, with a few exceptions (e.g. Asheim, Ebersberger and Herstad 2011), research that adopts multidimensional proximity and knowledge base perspective is still rare among the literatures on GIN in the field of economic geography. To address the challenge, the paper tries to reduce the complexity of multidimensional proximity by changing the analytical level from the conventionally applied industry and regional level to firm level. At firm level, the

existence of a network relation in a GIN implies that cognitive proximity, institutional proximity and social proximity have already been sufficient for forming and maintaining the relations. Therefore, for the purpose of understanding how and why a firm's GIN is organised in a certain pattern, the cognitive, institutional, and social proximity are not necessarily in the centre of the analysis. Instead the joint influence of geographical and organisational proximity comes under the spotlight.

The paper suggests a theoretical framework combining a two-dimensional proximity concept, namely geographical and organisational proximity, and the knowledge base approach for understanding how and why MNCs' GINs are organised in specifically different ways. An in-depth comparative case study with social network analysis on the GINs of two MNCs dominated by different knowledge bases is used as a prototype to illustrate the applicability of the framework.

The paper tries to answer the following research question: what is the joint influencing mechanism of the two-dimensional proximity and knowledge base on the relational pattern of the MNCs' GINs? It is found that the joint influence of geographical and organisational proximity on the relational pattern of GINs is through their influence on the knowledge benefit and the cost of learning. Knowledge base only plays a moderating role in part of a GIN, that is the global external relations of the GIN.

The contribution of the paper is threefold. Theoretically, it extends the conventional proximity-and-knowledge-base framework in economic geography literature from single-dimensional proximity to two-dimensional proximity. Methodologically, it uses primary relational data to map the MNCs' GINs instead of using secondary data such as co-patenting, co-publication, or project collaboration data which have unavoidable limitation to represent innovation networks (see Ter Wal and Boschma 2009 for review). Practically, the paper provides fine-grained firm level analysis on MNCs' strategy and decision of organising their GINs for better understanding the local embeddedness of the MNCs and their impact on the host regions and to generate insights for policy making.

The rest of the paper is organised in five sections. The second part reviews related literature and suggests the two-dimensional-proximity-and-knowledge-base framework. The third section presents methods including why and how the case study is used in the paper. The fourth part explains how the case GINs are organised in different ways and applies the suggested theoretical framework to elaborate the joint influencing mechanism of geographical and organisational proximity and knowledge base on the relational pattern of the GINs. The fifth part discusses the theoretical and policy implications of the paper and concludes the paper.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 GINs as social networks formed under firms' strategies

In this paper, a GIN is defined as a set of relations among the focal firm and other firms and non-firm organisations aiming at developing or diffusing product and process innovation. The nodes of the GINs are the actors, such as firms (most importantly an MNC's headquarter, affiliates and R&D labs, but also independent suppliers, customers, etc.), universities, research institutes, government agencies etc. The ties in the GINs are the relationships for innovation, such as access to openly available information, acquisition of technology and knowledge and active participation in joint innovation projects (Oslo Manuel 2005). Furthermore, a MNC's GIN is an ego network in which the MNC is the focal and other firms and non-firm organisations are the alters. The relations of a GIN includes the direct relation between the focal and the alters as well as the relations among the alters.

A MNC's GIN is a social network as the outcome of the firm's strategic choices. A social network is a social structure consists of a set of nodes and a set of the dyadic ties among the actors (Wasserman and Faust 1994). In social network theory, there are two approaches to explain the formation of a social network, one take the network as an outcome of choice, the other as of chance (Jackson and Wolinsky 1996). The former considers that the network is formed based on the individual actors' incentives (benefit verses cost). The latter believes that the observed network is just one realisation of all possible network configurations and relational patterns and the specific realisation is determined by the distribution of probabilities or the random processes. In the specific case of GINs, the formation of a GIN is under the strategic guide of the focal firm rather than a random process. From a social network perspective, the GIN can be considered as an outcome of the focal firms' choice.

The choice of establishing and maintaining a certain relation in the GIN depends on the trade-off between its knowledge benefit and learning cost that the individual actor gains and pays. One of the main incentives of globalisation of innovation is acquiring heterogeneous knowledge (Brusoni et al. 2001) which can be product or process knowledge embedded in local market of hosting countries (Patel and Vega 1999) or local intellectual output of the local research system (Florida 1997). Heterogeneous knowledge may also be found in other organizations (e. g. Customers, suppliers, universities), irrespective of spatial distances. Global knowledge pool may serve the need of firms' innovation but learning and acquiring the knowledge from other organisations, particularly those from abroad, can be very costly.

In this paper, the knowledge benefit is related to the availability of heterogeneous knowledge. Innovation needs heterogeneous knowledge which may only be available outside of the firm and outside of the area where the firm is located. Thus, in spatial terms, firms need to reach out regionally, nationally, and increasingly, globally to acquire the heterogeneous knowledge needed (Cantwell 1995, Gertler 1995, Zander 1999, Bathelt, Malmberg and Maskell 2004, Gertler and Levitte 2005, Moodysson and Jonsson 2007). The learning cost in this paper refers to the investment in interactive learning. It is not only related to communication, visit and meeting (Bresman, Birkinshaw and Nobel 1999, Almeida and Kogut 1999) but also to other

inter-organisational factors such as mutual trust (Dodgson 1993, Inkpen and Tsang 2005) and the support from partners (Lyles and Salk 1996), etc..

2.2 The joint influence of the two-dimensional proximities on a firm's GIN

2.2.1 The two-dimensional proximity and the GIN

Proximity is in general considered as a precondition of knowledge sharing, knowledge transfer, and technology acquisition (Gertler 1995), or in other words, the most conducive condition of interactive learning (Oinas, 1999). Economic geographer has suggested a multidimensional concept of proximity including geographical proximity, organisational proximity, cognitive proximity, institutional proximity, social proximity, etc. Among all the proximities, cognitive proximity is a prerequisite for interactive learning process (Boschma 2005). Once the cognitive proximity is set up the other proximities which provide mechanism to bring actors together for interactive learning join into the game. Geographical proximity has long been commonly recognised as an important influencing factor in innovation networks (Knoben and Oerlemans 2006, Moodysson and Jonsson 2007). Nevertheless, in terms of organisational proximity and institutional/social proximity, a theoretical divide is identified between the interactionists and the institutionalists (Carrincazeaux and Coris 2011). The interactionists use the concept of organisational proximity which focuses on the coordination between actors in the networks. Organisational proximity refers to the extent to which relations are shared in a common organisational arrangement in a very broad sense (Torre and Rallett 2005). The institutionalists adopt the institutional/social proximity concept and are more interested in the territorial effects of proximity relations. Institutional proximity is related to institutional environment at macro-level (North 1990) which enables interactive learning in stable conditions based on laws and rules as well as shared values and norms while social proximity is associated with social embeddedness at micro-level (Granovetter 1985) which facilitate trust based on friendship, kinship and experiences.

In this paper, we reduce the complexity of five different proximities to two proximities, that is geographical and organisational proximity, by focusing our analysis on firm level and analyse the existing GIN relations of the case MNCs. The existence of the relations implies that the cognitive, institutional, and social proximity have been sufficient for the emergence and maintenance of the relations and thus retreat to the background of the analysis while geographical and organisational proximity come under the spotlight. The geographical and organisational proximity as the two-dimensional proximity framework is the most suitable for explaining the economical and spatial dispersion of the individual or collective agents endowed with various resources in the context of globalisation (Rallet and Torre 1999, Knoben and Oerlemans 2006).

2.2.2 The influence of geographical proximity on the GINs

In this paper, geographical proximity is defined as 'the spatial or physical distance between economic actors, both in its absolute and relative meaning' (Boschma 2005) Geographical proximity accounts for learning and innovation facilitated by spatial closeness (Torre and Gilly 2000, Howells 2002, Meister and Werker 2004, Morgan 2004, Lorentzen 2008). Nevertheless, economic geographers also pointed out that geographical proximity per se is not a prerequisite for collaboration (Boschma 2005;

Knoben and Oerlemans 2006) and the selection of collaborators for innovation is mainly based on other factors (Laursen, Reichstein and Salter 2011, Drejer and Vinding 2007, Moodysson and Jonsson 2007). At the same time too much geographical proximity can also be unfavourable to innovation thanks to the lock-in in limited local knowledge and competences (Boschma 2005).

Geographical proximity decreases knowledge benefit. Too much geographical proximity may undermine the availability of heterogeneous knowledge which is the so called 'spatial lock-in' particularly in some highly specialised regions. The reason is not because of geographical proximity per se but the convergence of knowledge and competence of firms who are geographically too proximate (Boschma 2004). When such homogenisation of knowledge and competence happens in a region, firms has to go global for heterogeneous knowledge thanks to the unavailability of such knowledge and technology competence in the geographically proximate area (Cantwell 1995, Zander 1999, Gertler 1995, Bathelt et al. 2004, Gertler and Levitte 2005, Moodysson and Jonsson 2007). In this case, geographical distance tends to favour the heterogeneity of knowledge.

Geographical proximity decreases learning cost thanks to spatial closeness (Meister and Werker 2004) which enable face-to-face interaction. On the one hand, face-to-face interaction is the most efficient way to exchange tacit knowledge (Storper and Venables 2004, Johnson, Lorenz and Lundvall 2002) which is considered to be crucial for innovation. On the other hand, face-to-face interaction foster trust (Lane and Bachmann 1996, Lublinski 2003) which can only be built up by regular interaction over time (Morgan 1997) and which is the most demanded for interactive learning (Lundvall 2005). This is considered to be the main reason why geographical proximity has positive influence on innovation in knowledge spillover literature (Jaffe, Trajtenberg and Henderson 1993, Maurseth and Verspagen 2002, Sonn and Storper 2008) and industrial cluster literature (Baptista and Swann 1998, Keeble and Wilkinson 1999, Iammarino and McCann 2006).

2.2.3 The influence of organisational proximity on the GINs

Organisational proximity refers to the extent to which relations are shared in the same organisational hierarchy. This means actors belong to the same organisational hierarchy, such as the organisational structure of a MNC, enjoy organisational proximity rather than with those actors who do not belong to the same organisation, such as customers and suppliers¹. Organisational proximity facilitate knowledge exchange and learning among individuals within the same organisational (e.g.Kogut and Zander 1992) and among the different units within the same corporate or business group (e.g.Lam 2003). Organisational proximity, which is strictly defined to reflect the ownership-based intra-firm ties that exist between the MNC headquarters and subsidiaries of all geographical scales, is related to the degree of autonomy of the actors and control in the network relations. The facilitating effect of organisational

¹ This definition is strictly based on what Torre and Gilly (2000) called the adherent logic and similarity logic. According to adherent logic, the organisationally proximate actors shared in an organisational arrangement (Boschma 2005) which is in the form of a firm (Schamp, Rentmeister et al. 2004). The paper excludes other form such as community (Brown and Duguid 1991) and a network (Kirat and Lung 1999). According to the similarity logic, the organisationally proximate actors are alike in terms of having the same reference space and share the same knowledge. Even though similarity occurs between actors from different organisations but actors belong to the same organisation share more similarity in terms of organisational knowledge and routines.

proximity on interactive learning is explained by its provision of strong control mechanisms to ensure intellectual property rights, sufficient rewards for own investment in innovation, and persistent effort in innovation collaboration within the organisation (Boschma 2005). It is also based on the fact that organisational proximity offers shared values, beliefs, rules and routines of behaviour which effectively smooth interaction within the same organisation (Torre and Rallett 2005). Nevertheless, too much organisational proximity can also hinder innovation because of the homogeneity of the knowledge and competences exist in the same organisation and the inflexibility of the organisation (Boschma 2005). Rivalry among subsidiaries competing for future investment adds to this phenomenon as does the not-invented-here syndrome (Szulanski 1996).

Organisational proximity decreases knowledge benefit. Too much organisational proximity may lead to unavailability of heterogeneous knowledge. This is because of the 'organisational lock-in' thanks to strong ties (Granovetter 1985). First, intra-firm relations in the form of strong ties may evolve to a self-closed system where knowledge and competence becomes homogeneous and incentives to search for external knowledge becomes weak (Gargiulo and Benassi 2000). Second, in an organisation, even though there is a certain degree of heterogeneity in terms of knowledge, but facing the rapid change of technology, such heterogeneity is still very limited. That is the reason why firms collaborate with customers, suppliers, universities outside of the company for acquiring the heterogeneous knowledge which is not available within the organisation (Cassiman and Veugelers 2006, Tsai 2001). In other words, organisational distance tends to favour the heterogeneity of knowledge.

Organisational proximity decreases learning cost in four ways. Firstly, organisational proximity existing in a hierarchical organisational structure, such as a MNC, nourishes trust (Casson and Singh 1993) which further facilitates transactions by reducing transaction costs, such as information searching, negotiation, monitoring, and enforcing transactions according to transaction cost economics (Williamson 1981). Secondly, organisational proximity existing in a hierarchical organisational structure allows coordination without having to define beforehand how to do so. It ensures coordinated behaviour in accordance with the shared organisational routines, values, beliefs, language, performance measurements system and so on (Meister and Werker 2004, Rallet and Torre 1999). Thus it may mitigate the conflicts in coordinating. Thirdly, organisational proximity enables strong control mechanism to reduce uncertainty and opportunism (Boschma 2005), which are the common risk of innovation, to ensure intellectual property rights, sufficient rewards for the R&D investment of the firm, as well as persistent efforts to collaborate for innovation. Fourth, organisational proximity promote intra-firm learning process, such as learning through job rotation (Edström and Galbraith 1977) and inter-unit training, trips and visits, transnational teams and task forces (Björkman, Barner-Rasmussen and Li 2004) (Subramaniam and Venkatraman 2001, Persson 2006).

2.2.4 The joint influence of two-dimensional proximity on the GINs

The distribution of geographical and organisational proximity in a MNC's GIN can be stylised as Figure 1. One can clearly see that different relations in a MNC's GIN enjoy different combination of geographical and organisational proximity.

The combination of geographical and organisational proximity and its joint influence on knowledge and innovation has been empirically studied and theoretically discussed

(e.g. Aguilera, Lethiais and Rallet 2012, Legendijk and Lorentzen 2007, Mattes 2012, Torre and Rallett 2005, Capaldo and Petruzzelli 2014). This strand of literature emphasises the complementary and substituting effect of these two dimensions of proximities. For example, Torre and Rallet (2005) uses MNCs' internal networks as the example to explain how big organisations manage the global disperse of their units in which organisational proximity is mobilised to overcome the drawbacks of the presence as well as the absence of geographical proximity. Similarly, (Liefner, Wei and Zeng 2013) show how intensive within-firm collaboration helps geographically distant subsidiaries to reach higher levels of technological effectiveness. Aguilera, Lethiais and Rallet's (2012) findings also endorses the thesis that organisational proximity can substitute for geographical proximity in the coordination between remote partners. However, these literatures do not try to identify consistent patterns that explain which factors determine the way that geographical and organisational proximity/distance interact.

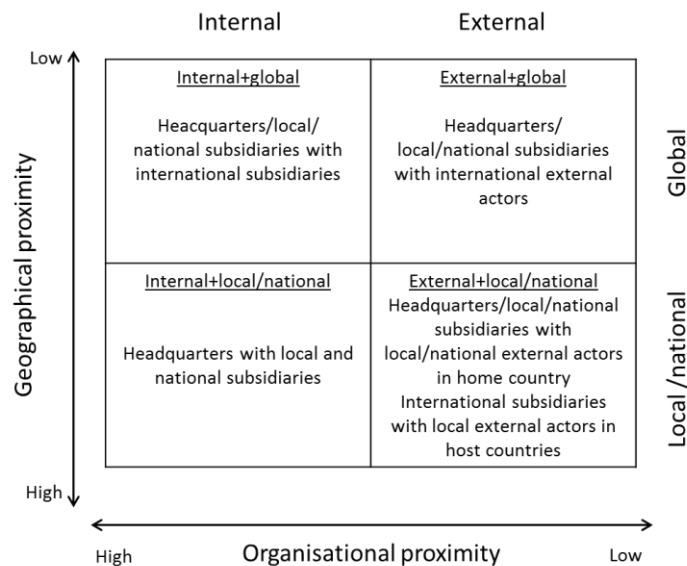


Figure 1. Distribution of geographical and organisational proximity in a MNC's GIN

A network relation emerges and lasts only when knowledge benefit exceeds learning cost. Therefore, we expect that MNCs' GINs are organised in the pattern as shown in Figure 2. The intra-firm relations, who enjoy the low learning cost created by high organisational proximity, are globally organised in order to leverage the high knowledge benefit offered by low geographical proximity. We also expect that MNCs' external linkages, who enjoy the high knowledge benefit created by low organisational proximity, are locally organised in order to take use of the low learning cost provided by high geographical proximity. Nevertheless, when it comes to global and external relation where knowledge benefit is high while learning cost is also high, the proximity framework cannot predict. In this case, ambiguity comes into play because it is not a priori clear what weighs more, the chance of accessing external and

global knowledge or the cost of managing such a link. As the proximity framework does not endogenously provide an order of factors to be considered, there is evident need to include other factors beyond the proximity framework.

The issue of global and external linkages concerns the value of innovation-related knowledge, and the organisational task of integrating this knowledge. Hence, factors that explain and predict whether these linkages will be established and used should be rooted in the MNCs' types of knowledge sought for innovation and the fundamental ways of applying this knowledge, i.e. they should be founded in the MNCs' knowledge bases.

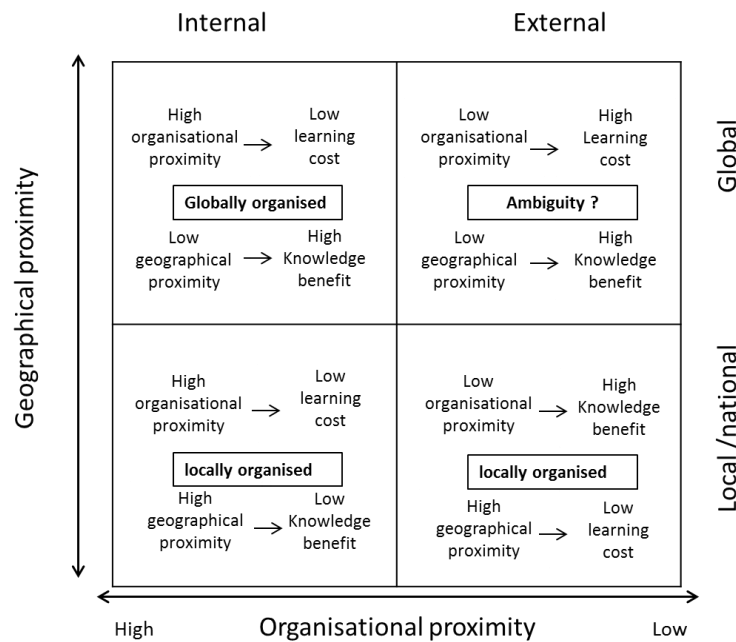


Figure 2. Stylised expected relational pattern of a MNC's GIN

2.3 The influence of knowledge base on the GIN

Knowledge base perspective has been introduced to the study of the geography of innovation. Literatures in economic geography argue that the geographic distribution of networks is influenced by the different nature of knowledge base. The most frequently discussed nature is the stickiness of knowledge. There has been a long debate about which matters, global or local. At the beginning of globalisation, stricken by the new phenomenon of globalisation fuelled by the rapid development and wide diffusion of ICT, especially the instant communication tools based on internet, some scholars and industry practitioners announced the “death of geography” (Ohmae 1990, Martin 1996, Cairncross 1997). After more years of observation and study, scholars found that even ICT helped to shorten the distance between individuals, organisations, regions, and nations, there is still some knowledge which is sticky to the individuals, organisations, communities in the local area. One main reason is the low transferability of tacit knowledge. It was also found that “local” and “global”

does not have to be mutually contradictory or exclusive, the local sticky and global ubiquitous knowledge can be integrated together to take use of the complementarity and creates synergy. Asheim and Isaksen (2002) studied three Nordic regional clusters of three different industries and found external contacts are crucial in innovation process even though the place-specific and contextual knowledge of both tacit and codified nature is still rather geographically immobile.

Asheim distinguished three different types of knowledge base, namely analytical, synthetic and symbolic knowledge base. This paper will only focus on the first two types that is the analytic and synthetic knowledge. Analytic knowledge refers to industrial settings, where scientific knowledge is highly important, and where knowledge creation is often based on cognitive and rational processes, or on formal modes. While synthetic knowledge refers to industrial settings, where the innovation takes place mainly through the application of existing knowledge or through new combinations of knowledge.

Empirical study has showed that the geographic distribution of a network is related to the knowledge base it builds on. It was found that geographic proximity benefit the networks for sourcing and exchanging synthetic knowledge rather than benefit those for exchanging analytic knowledge (Asheim and Coenen 2005, Moodysson et al. 2008, Martin and Moodysson 2011). The reason is the interpretation of the synthetic knowledge tends to differ from place to place, while the analytic knowledge is more codified, abstract and universal. Hence, one can propose that networks rely on synthetic knowledge base tend to be more local, while networks rely on analytic knowledge base has more potential to be global. These empirical researches added important contribution for understanding how knowledge base influences the extent to which the proximity is needed in an innovation network. Nevertheless, one inevitable limitation of these researches is the adoption of single (geographical) proximity concept.

2.4 The two-dimensional-proximity-and-knowledge-base framework

The paper suggests a theoretical framework based on a two-dimensional proximity concept and the knowledge base approach. The joint influence of geographical and organisational proximity on the GINs is through their influences on the knowledge benefit and learning cost. Knowledge base acts as an moderating role through its influence on learning cost. The existence of a GIN relation depends on the trade-off between knowledge benefit and learning cost of that relation. Under this framework, the joint influencing mechanism of the two-dimensional proximity and knowledge base on the firms' GINs can be illustrated as Figure 3.

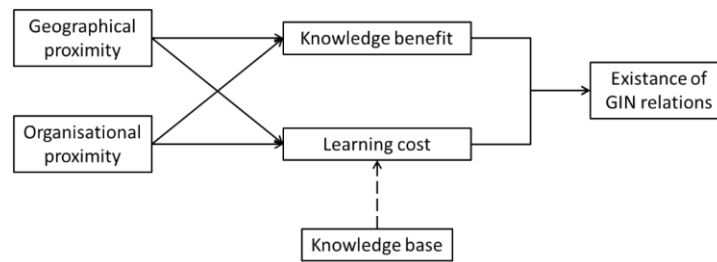


Figure 3. Stylised joint influencing mechanism of the two-dimensional proximity and knowledge base on a MNC's GIN

3. METHODS

The paper uses an in-depth comparative case study with social network analysis on the ego network of two case MNCs' GINs to illustrate the applicability of the suggested framework. The case study explores how the intra-firm relations and external linkages of MNCs' GIN are organised and how geographical and organisational proximities influence the relational pattern of these two groups of relations in a MNCs' GIN with knowledge base as a moderator. The design of the cast study tries to represent the notion of GIN as accurate as possible by restricting the network actors only to those that are relevant for innovation.

3.1 Selection of case MNCs

Case selection is based on the MNC's geographical spread, its organisational arrangement, and dominant knowledge base.

The paper selected two multinational companies². The two MNCs have very similar geographical spread and organisational arrangement. Both companies are headquartered in the same region of Scandinavia and have many global subsidiaries in most of the countries and regions in Europe, Asia and Pacific, North and South America, as well as some countries in Africa.

The two MNCs operate in different industries. One is in telecommunication industry and one in automobile safety industry. The telecommunication industry is mainly dominated by analytic knowledge base while the automobile safety industry synthetic knowledge base.

Both case MNCs have strong innovation capabilities. TELE is a world-leading provider of telecommunications equipment. It's patents comprise one of the industry's strongest portfolios. AUTO is also a world-leading automobile component company. It's patent portfolio is very extensive, ranking at the top of the automobile components industry.

3.2 Collection of GIN data

Data sources of this paper include semi-structured interviews, archives, websites, internal reports, internal documents, press news, and academic publications of case studies on the same case firms. Multiple data sources provide more accurate information and improve the robustness of the results (Jick 1979).

² Thanks to the anonymous request from both companies, the paper uses TELE to name the telecommunication case company and AUTO to name the mobile safety case.

For collecting relational data, one questionnaire used to elicit responses from two middle managers and from the VP for research in these two companies. The interviews were done in 2010 and 2011 in both the headquarters in Stockholm and their branches in Gothenburg and other locations. They were recorded and lasted from one to three hours. To ensure that the data collected fits the definition of the GIN, the informants were reminded constantly that all the relationships should be relevant to the companies' technological innovation activities. Potential informant bias is addressed in three ways. First, the author selected highly knowledgeable informants from multiple hierarchical levels of the firms. The data collected was triangulated with published information when available. Second, the author used "courtroom questioning" technique to focus on factual accounts (Lipton 1977, Huber and Power 1985). The author asked the informants to specify what kind of activities have been carrying on in each specific relationship so as to ensure that the informant did not mix the relationship for innovation with any other activities. Third, the author gave anonymity to the informants and their firms on request to encourage candour.

For collecting in-depth details to understand how innovation in the telecommunication industry and automobile safety industry works and how the case MNCs organise their GINs, the author had informal talks to engineers and managers in the case companies and their competitors. The author also studied archives such as annual reports in the company websites, articles in industrial association websites, internal reports, news from the case company websites as well as in social medias, and academic publications of case studies on the same case firms. Thanks to the confidentiality agreement that we reached with the case firms, the sources of these materials are not able to be presented in the paper so as to avoid revealing of the case firms' names.

3.3 Mapping and analysing the case MNCs' GINs

The case companies' GINs are weighted and undirected ego networks. GIN in this paper refers to a set of relationships of the case company aiming at technological innovation including both product and process innovation. Provision of services and innovation of services are both excluded in this research.

Actors of GINs are identified into two groups. One is the actors of the intra-firm network which refers to the set of relations among the functional departments or groups within the company's headquarters. These functions are production, R&D, marketing, financial, human resource, and purchasing/sourcing of which the taxonomy follows Porter's (1985) value chain analysis. The others are the actors of the external network which refers to the set of relations among the focal firm and the outside firms and organisations. The paper identified three geographical levels, namely local, national, and international levels. Local level refers to the region where the case companies are headquartered. National level refers to the rest of the country excluding headquarters' region. International level refers to the rest of the world excluding the home country. There are two types of actors at the local, national and international level. One is the outside firms and organisations namely customers, suppliers, competitors, universities and research institutes, and government agencies. This taxonomy follows the literature of Lundvall (2007) and the OECD (1999) taxonomy about the actors in innovation system. The other is the case companies' subsidiaries for production, R&D, and marketing that locate in headquarters' region (local), other regions in home country (national), and other countries in the world (international). These three groups of subsidiaries are the main types of subsidiaries

for the case companies' global operation.

Ties of the GINs are relations for innovation. The relational data of the ties were collected through a roster recall method (Wasserman and Faust, 1994). The ties are weighted according to the intensity, frequency, and trust of the relation.

Based on the primary relational data of the case MNCs' GINs, the paper uses social network analysis to analyse the relational pattern of both intra-firm relations and external linkages of the two MNCs' GINs. The tool of NetDraw multidimensional scanning (MDS) with principal component layout³ is used to visualise the relational pattern of the networks. In the maps of the network visualised by this method, when a group of nodes are close to each other, it means they are structurally equivalent nodes who have similar pattern of ties. They are connected with the same nodes and they have similar geodesic distance to all other nodes. By analysing who are structurally equivalent actors in the network one can reveal the information about how the actors are connected in the network and how the network is organised. By analysing the geographical location of the actors who are structurally equivalent, one can see if the network relations are globally or locally organised.

4. THE IN-DEPTH COMPARATIVE CASE STUDY

The paper uses an in-depth comparative case study to illustrate the application of the suggested two-dimensional-proximity-and-knowledge-base framework. In this paper, relations in a GIN are conceptually divided into two groups, namely the intra-firm relations and external linkages. After mapping and analysing the patterns of these two groups of relations which enjoy different combinations of geographical and organisational proximity (see Figure 1), the paper explores the joint influencing mechanism of the two-dimensional proximity and knowledge base on the relational patterns.

4.1 The joint influencing mechanism of geographical and organisational proximity on the relational pattern of intra-firm relations

Intra-firm relations include the relations among headquarters' departments, local, national, and international subsidiaries. In both case MNCs' GINs, it is found that *intra-firm relations are globally organised* (see Figure 4).

It is found that, first, the headquarters departments have similar connections to each other. Second, the subsidiaries for marketing, research, and production of all geographical level, namely local, national, and international, are closely located in the map drawn by MDS method. This means they are similarly connected and organised in the network. It can be clearly seen in the map that the aggregated actors serve the same function, such as R&D, production, and marketing. This implies no matter the subsidiaries are located in headquarters region (local level), in the rest of the home country (national level), or in foreign host countries (international level), as long as they serve the same function (such as R&D or production or marketing facilities) they have similar connections and thus are organised in a similar pattern in the intra-firm innovation network. In other words, the intra-firm relations in the GINs are globally organised.

³ Using the principal component option in the software of Netdraw to visualise the similarity of structural characteristic of actors can be found in bibliometric research, such as Yang, Liu et al. (2010), and Park and Leydesdorff (2013), etc.

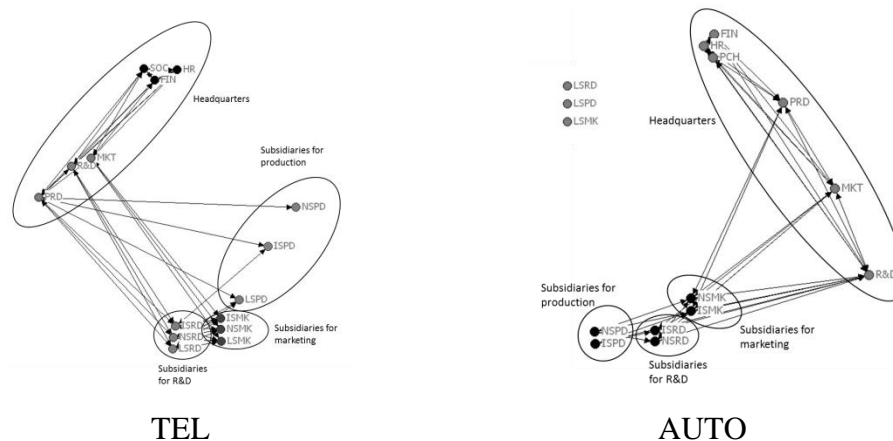


Figure 4. The pattern of intra-firm relations in the case MNCs' GINs⁴

The globally organised intra-firm relational pattern was explained by the VP of both case MNCs.

The VP of TELE said:

“We globalise product development...if an idea is developed in a subsidiary, it is usually sent to the headquarters where the core research is. The headquarters therefore takes the control...this idea is starting to be spread worldwide. The coordination between headquarters and the subsidiaries is done at central level.”

The VP of AUTO commented:

“.....The relations between the headquarters and our subsidiaries in this country and in other countries are the same. It doesn't matter where they are.”

The joint influencing mechanism of geographical and organisational proximity is identified by the interviews. In both case GINs, it is found that *geographical distance favours the availability of heterogeneous knowledge, particularly local competences and market-related knowledge.*

The VP of TELE says:

“We have many R&D sites and they are close to related stations in Europe, in North America, and in Asia. They do R&D for the whole corporation. The reason for setting up R&D sites abroad is mainly to get close to the market as well as the competences (knowledge, skills, and human resources) of that country. From an innovation point of view it is impossible to be here (in the headquarters) and find out how the equipment should be done in other countries.”

The VP of AUTO comments:

“We locate our R&D and engineering abroad to follow our customer, the main stream car makers, in order to satisfy their

⁴ The pictures of GINs in this paper are all drawn by the tool of NetDraw MDS with principal component layout. In these drawings, when a group of nodes are close to each other, it means they have similar pattern of ties which means they are connected with the same nodes and they have similar number of connections and similar geodesic distance to all other nodes. The isolated node refer to the actors who are not connected in the network.

needs. The developing centres in different countries are serving the specific demand there. For example, the two developing centres we have in Asia are good examples of how the presence in this type of emerging economies has generated new ideas for new product.”

The practices of both TELE and AUTO to internally transfer knowledge confirms the findings of previous research which found that MNCs’ subsidiary knowledge transfer was positively and significantly related to the employment of corporate socialisation practices such as international training programs, international task team and committees, and internal cross unit visits (Gupta and Govindarajan 2000, Björkman et al. 2004). It also echoes the findings by (Keupp, Palmié and Gassmann 2011) that the parent firm can effectively integrate subsidiaries by encouraging knowledge asset transfer through managerial infrastructure and tools.

4.2 The joint influencing mechanism of geographical and organisational proximity on the relational pattern of external linkages

External linkages refer to the linkages cross organisational boundary. They are the relations between a MNC’s headquarters departments/subsidiaries at all geographical levels, and external actors at all geographical levels. The relations among external actors at all geographical levels are also included.⁵ External linkages of the two MNCs’ GINs are found to have different pattern of relations. *TELE’s external linkages are globally-organised while AUTO’s external linkages are locally-organised.*

For TELE, a functionally aggregated pattern is clearly shown in the left map of Figure 5. There are six clusters of actors aggregating together. These six groups of aggregated actors are actually six functional groups, namely R&D facilities, marketing facilities, suppliers, competitors, government agencies, and universities and research institutes. In the network map drawn by MDS method, aggregated actors have the same or similar connections with the same other actors. This means no matter the actors are located in headquarters region (local level), the rest of the home country (national level), or foreign host countries (international level), as long as they serve the same function as R&D or marketing facilities, or they are suppliers or competitors or government agencies or universities and research institutes, they are globally organised in a similar pattern.

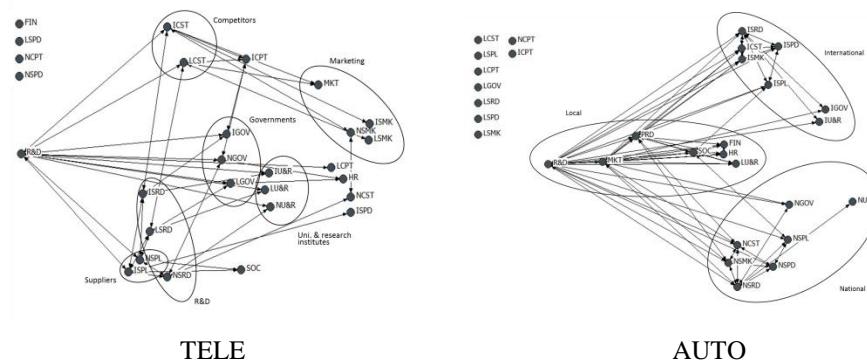


Figure 5 Pattern of external linkages in the case MNCs’ GINs

The globally-organised characteristic of TELE’s external linkages in its GIN is

⁵ The paper does not distinguish the geographical location of different actors within a host country or between different host countries. Nevertheless, when talking about the international subsidiaries and the international external actors, the paper refers to those in the same host country.

explained by the VP :

“Taking the relationship between R&D and the suppliers as an example, our suppliers are global. So it is “all-talk-to-all”. An R&D branch in the headquarters will talk to all levels of suppliers within their product line. (...) it becomes the same thing for any R&D site regardless if it is in the European headquarters or in Beijing. If they are responsible for product development, they need to talk to, for example, all the marketing units at all levels who can provide relevant information. That’s why it becomes a global ‘mess’.”

To globalise the innovation generated from a specific location, TELE implemented a *decentralised decision making process* combined with *cross-regional sub-networks* for innovation. TELE has an *internal innovation market*. Regional offices have the autonomy to decide what new products or services to develop for the local customers even though their innovative ideas are not selected at the corporate level. When developing new products and services for local market, the R&D staff are required to make it as much as possible to be replicable in other regions. Thus they need to contact relevant internal and external users and suppliers. The newly developed innovation can be sold internally to other regional offices.

For AUTO, a geographically aggregated pattern can be seen in the right map of Figure 3. This means geographically co-located actors have same or similar pattern of relations with the others. It suggests that no matter what function the actors serve (e.g. an R&D facility, or a production factor, or a customer, or a university, or a government agency), as long as they are co-located in the same area, they have same or similar pattern of relations and are locally organised in the same or similar pattern. This implies that the external linkages of AUTO are locally organised.

The locally-organised characteristic of external linkages in AUTO’s GINs is also verified by the VP. He gave an example of such localisation of external linkages in the global innovation of AUTO:

“For innovation, Sweden is not the only centre, particularly for development and engineering of new product and process. If we have a production facility, we have application engineers there. (...) We have an executive management team that basically consists of people from all the functions. (...) We have one for Asia, one for North America and one for Europe. (...) If you look into the map of our locations, you will see (for example) we have a bag facility in North America which supplies the needs of North America. They are buying from their internal suppliers in their regions. Our main (internal) suppliers are the closest to the customers (in their specific regions).”

Evidently, even though the two case MNCs both have built up IT supported infrastructures and have implemented procedures and protocols for knowledge sharing and transferring with external actors worldwide, they do not do it in the same way. TELE’s external linkages for innovation are organised in a global pattern while AUTO’s are organised in a local pattern. Such difference is attributed to the different dominant knowledge base of the two case firms.

TELE is a telecommunication equipment manufacturer. The dominant knowledge in telecommunication industry is more *science-based*. Technologies that are

dominantly used in this industry, such as digital communications technology, program-controlled switching technology, information transmission technology, communication networks, data communications and data networks, are mainly based on scientific knowledge. It is more codifiable and transferable not only because of the science-based nature of the technologies but also because of the well-developed standardisation of the industry. According to an internal report, TELE has adopted a strategy of turning local innovation into global technologies. The decentralised decision making process for innovation and the internal market for innovation link internal and external actors worldwide.

AUTO is an automobile safety product producer. The dominant technologies in this industry are more *engineering-based* technologies. According to an empirical research conducted in AUTO (Lövsund and Spiegelberg 2002), when describing the characteristics of the knowledge that the company use most, most of the respondents in AUTO referred it to ‘something that you have learned through past *experiences* and something that is *difficult to codify* thanks to the strong relation with the complicated context’. This does not mean that science-based knowledge is excluded the in the industry. Automobile safety industry has many science-based technologies such as radar and vision technology for monitoring the environment and pretension and load limiting technology for improving the performance of seat belt. But what is fundamentally important in this industry is engineering-based learning process by which scientific knowledge is integrated with applied, problem-solving related knowledge for innovation. It is context-specific and has a strong tacit component which is mainly transferred through face-to-face interactions with local customers and suppliers. This implies that in automobile safety industry, locally developed innovation, which has strong relation with the local context, is less applicable and transferable to other global locations. Different than the traditional terminology of R&D in many companies, AUTO names its innovation activities as R&D&E which emphasises the importance of engineering to R&D. Such engineering process usually happens locally together with the local actors.

Therefore we understand *the different pattern of external relations in the case MNCs’ GINs is due to the different nature of the dominant knowledge base in their industry*. This finding is in line with Yokura, Matsubara and Sternberg’s (2013) findings about the spatial patterns of R&D networks of joint research projects in Japan. Their empirical research shows that science-based technical fields are more often involved in long distance cooperation while cooperation in manufacturing (low tech) are primarily restricted to local partners.

The joint influencing mechanism of geographical and organisational proximity on the relational pattern of the case MNCs’ GINs is summarised in Table 3.

Table 3. Summary of the joint influencing mechanism on the relational patter of case GINs

Relational pattern		Joint influencing mechanism		Evidences in practice
Intra-firm relations	Both cases---globally organised	High knowledge benefit created by geographical distance and low learning cost created by organisational proximity promote interactive learning to be effective	Low geographical proximity favours the heterogeneity of knowledge owned by intra-firm units in different regions and countries	<ul style="list-style-type: none"> • Globally dispersed intra-firm units have access to local competences of different regions and countries • Globally dispersed intra-firm units have access to local market-related knowledge of different regions and countries

		and efficient	High organisational proximity facilitates interactive learning among intra-firm units	<ul style="list-style-type: none"> • Central controlled R&D system ensures the ownership of IPR and persistent effort to collaborate across countries for innovation, lowers the R&D costs by coordinating innovation all over the world • Globally-shared intra-firm IT platforms play an important role in sharing new ideas and developing innovations. • Intra-firm learning programs improve internal knowledge transfer and smoothen internal communication
External linkages	TELE--- globally organised	Both low geographical and organisational proximity creates high knowledge benefit and high learning cost (The accompanying high learning cost is mitigated by the high transferability and applicability of the dominant analytic knowledge)	Low geographical and organisational proximity both favour the heterogeneity of knowledge owned by external actors in different regions and countries	<ul style="list-style-type: none"> • Decentralised decision making process and customer-oriented innovation approach leverage globally spread R&D competences and knowledge from external actors in different regions and countries • IT platform, such as ConsumerLab, bridges the company and the external actors for innovation in different regions and countries
			Low geographic and organisational proximity both lead to high learning cost but such high cost is mitigated by the high transferability and applicability of dominant knowledge in the industry	<ul style="list-style-type: none"> • Internal innovation market plus high applicability and transferability of science-based knowledge encourages and enables interactive learning over distance • Successful practice of turning local innovation into global technologies by ‘core-wrapper’ approach (locally developed ‘core’ can be applied globally after developing localised ‘wrapper’) • The emphasis on replicability at the early stage of R&D requires local developers to talk to any relevant internal and external actors
	AUTO--- locally organised	High knowledge benefit created by low organisational proximity and low learning cost created by high geographical proximity promotes interactive learning to be effective and efficient	Low organisational proximity favours the heterogeneity of knowledge owned by external actors in the same regions and countries High geographical proximity facilitates interactive learning	<ul style="list-style-type: none"> • Collaboration with external actors in developed country with long experience in the industry are to access the local competence and market related knowledge through local connections • Collaboration with external actors in emerging countries are to better understand local market through local connections

5. DISCUSSION AND CONCLUSION

The recent trend of globalisation has been characterised by the emergence of MNCs’ GINs. Understanding the MNCs’ global distribution of innovation activities and its impact on the host regions’ innovativeness calls for careful firm level investigation to see how the MNCs’ GINs are organised.

The paper suggests an extended theoretical framework based on a two-dimensional proximity concept and the knowledge base approach. It identifies the influencing factors, namely the knowledge benefit and learning cost, and explores the joint influencing mechanism of the two-dimensional proximity, namely geographical and organisational proximity, and knowledge base on the relational pattern of the MNCs’ GINs. It uses an in-depth comparative case study to illustrate the applicability of the framework.

The contribution of the paper is threefold. First, theoretically, the paper extends the conventional proximity and knowledge base discourse from single dimension to two dimensions. It suggests a theoretical framework for understanding the joint influencing mechanism of proximities and knowledge base on firms’ GINs. Second, methodologically, it uses primary relational data to map the MNCs’ GINs instead of

using secondary data such as co-patenting, co-publication, or project collaboration data which have unavoidable limitation to represent innovation networks (see Ter Wal and Boschma 2009 for review). Third, practically, it generates new insights for regional policy based on firm level analysis.

It is found that the joint influence of geographical and organisational proximity on the relational pattern of GINs is through their influence on the knowledge benefit and the cost of learning. Knowledge base only plays a moderating role in part of a GIN, namely the global external relations of the GIN. MNCs in analytical knowledge-based industries organize their external innovation collaboration globally, whereas MNCs in synthetic knowledge-based industries do this at the local scale.

Thus, MNCs' innovation in GINs is different from the organization of mainly scientific and pre-application knowledge, as global epistemic community networks are known for sharing similar properties across different knowledge bases (Hennemann, Rybski and Liefner 2012). It can hence be concluded that the need for either organizational or proximity in synthetic knowledge-based industries comes into play in the context of creating an innovation, not in pre-innovative science or research.

Critics may hence argue that the main findings of this paper - i.e. 'all-talk-to-all'-type innovation in analytic knowledge based-industries and close interaction-type innovation in synthetic knowledge-based industries – might be too abstracted. This is in fact a limitation of this analysis as it cannot be ruled out that TELE's truly global GIN may be an expression of the dynamics of global standardization in this industry, and AUTO's localized approach might simply reflect the regional market segmentation found in the automobile industry. More case studies and if possible survey-based analyses of the interaction of knowledge base and proximities in GINs are thus necessary in the future.

Other limitations of the paper lie in its limited dimension of the proximity concept, the limited empirical evidence, and the static nature of the network analysis. The paper only discussed the geographical and organisational proximity leaving other dimensions of proximities as given background condition. It limits the framework's capacity of understanding the joint influence of multidimensional proximities. The paper just has two cases which certainly leaves big space for future research. The paper only takes snapshot of existing GINs and ignores the network dynamics which may have important implications relates to firm's network management and regional and industrial path creation and change.

Despite these limitations and the evident need for future research on this matter, this paper's major findings have important policy implications, in particular for regional political entities and administrators: Regional economies dominated by firms in the analytical knowledge-based industries have easier access to distant knowledge bodies and thus great opportunities with globalisation. However, their unique knowledge advantage, which may translate into a key competence in the competition among

regions, may be more susceptible to a rapid loss and transfer, due to the unbound knowledge mobility in GINs. Regions with a specialization in synthetic knowledge-based industries, in contrast, face more impediments towards a globalization of innovation. Established local clusters in these industries, however, may also involve a more long-term structural stability.

In a similar vein, knowledge spillover stemming from innovation-oriented inward FDI may be stronger in synthetic industries, which rely on close interaction at the regional scale; for analytic knowledge base industries, however, FDI-related knowledge spillover may not benefit the region where the MNCs are located.

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