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A Case Study on Multinational Companies' Global Innovation Networks and Global Production Networks: Toward a Theoretical Conceptualisation

Ju Liu (ju.liu@circle.lu.se)
CIRCLE, Lund University

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Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

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JEL codes: O32, F61, M16

Keywords: Global innovation network, Global production network, multinational companies, Social network analysis

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JU LIU[1]
CIRCLE, Lund University, Lund, Sweden

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JEL: O32, F610, M160

[1] Ju Liu is a researcher in CIRCLE (Centre for Innovation, Research and Competence in the Learning Economy), Lund University. Mail address: P.O. Box 117, SE-221 00 Lund, Sweden. Email: ju.liu@circle.lu.se Tel: +46 46 222 3370

1. INTRODUCTION

One of the most distinctive characteristics of the recent wave of globalisation has been the increased number of MNCs' cross-border production networks (Kogut and Kulatilaka 1994, Gereffi and Korzeniewicz 1994, Sturgeon 1997, Borrus and Zysman 1997, Henderson et al. 2002a, Coe, Dicken and Hess 2008) as well as the increasing formation of international joint ventures and strategic alliances for R&D (George 1995, Bowonder and Miyake 1995, Zander 1999, Hagedoorn 2002, Oxley and Sampson 2004) and cross-border R&D investment (Castelli and Castellani 2013).

Theoretically, the distinction between global production network (GPN) and global innovation network (GIN) is quite blurry and the discussion of GIN-GPN relation is often based on theoretical assumptions rather than on sound evidences. The possible causes of this conceptual ambiguity are twofold. First, the globalisation of production started much earlier than the globalisation of innovation; thus, with few exceptions (Audretsch and Feldman 1996, Mariani 2002), most research implicitly assumes that GINs evolved from GPNs. Second, the tendency to add innovation as another function developed within the framework of GPNs (Ernst 2002) blurs the distinction between the two kinds of networks. Conceptually taking innovation as a later emerged or add-on function of GPN and assuming that innovation happens within the same structure as GPN is flawed for different reasons. First, the different tasks and motivations of globalisation of innovation and production imply that the actors in GINs and GPNs can be different and the network structure of GINs and GPNs can also differ. Production and innovation are two different activities in firm's value creation process. This has been long discussed in the value chain research (see Kaplinsky and Morris 2001 for review) and widely used in the global value chain literature. Production involves producing and distributing products based on existing designs and technologies to create current value. Innovation involves researching and developing new knowledge or technologies for future production to create future value. At the same time, the globalisation of innovation has different motivations compared with the globalisation of production. The globalisation of innovation is mainly driven by knowledge-seeking strategies (Brusoni, Prencipe and Pavitt 2001, Dunning and Lundan 2009a) while the globalisation of production is mainly driven by efficiency-seeking (Ghoshal 1987) or market-seeking strategies (Ferdows 1997). Second, the relation between production and innovation as two interacted processes of value creation implies that the GIN and GPN may interact and may share certain commonalities. On the one hand, the production infrastructure and process have to be created or adjusted in order to fit the need to produce new products or implement a new process. On the other hand, innovation should plan for future production or

should solve a specific problem in current production, so the condition of the current production infrastructure and process is usually taken into account. Thus, actors in production networks can be involved in the process of innovation and actors in innovation networks can also engage in the production processes. Therefore, it is important to study the interaction, differences, and commonalities of GINs and GPNs in the real world so as to reach conceptual clarity for better theoretical development.

Methodologically, existing literatures mainly adopt whole network perspective and study GINs and GPNs separately which is improper for understanding the impact of simultaneous GIN-GPN involvement on the actions and outcomes of a focal firm. First, most of the existing researches on GINs and GPNs focus on whole network within a territorial or industrial boundary (e.g. Hanson, Mataloni and Slaughter 2005, Schilling and Phelps 2007, Shibata et al. 2008, Cassi, Morrison and Ter Wal 2012, Brooks 2013, Binz, Truffer and Coenen 2014) and there is a lack of research at ego-centric or individual organisation level. Ego-centric network analysis explains how involvement of an actor in a network affects its actions and outcomes (Provan, Fish and Sydow 2007). For understanding the impact of MNCs' involvement in GINs and GPNs on their innovation and production, ego-centric network research is more appropriate than whole network analysis. Second, existing research does not attempt to simultaneously capture the GIN and GPN of a particular company. Instead, they focus on either firms' GINs (e.g. Allen, James and Gamlen 2007, Smith-Doerr, Manev and Rizova 2004) or GPNs (e.g. Hanson, Mataloni Jr and Slaughter 2005), or just generally refers to firms' intra-organisational networks (e.g. Tsai 2002) or inter-organisational networks (e.g. Ghoshal and Bartlett 1990, Powell et al. 2005) in terms of knowledge sharing. For MNCs involve in both GIN and GPN, separating the study on the two networks or ignoring the difference between them may miss the interactive dynamics of the GIN and GPN in the globalisation of the firms. Hence, studying MNCs' globalisation of innovation and production calls for analysis on the ego-centric network of both GINs and GPNs at the same time.

This paper aims to address these research gaps by exploring the GIN-GPN interaction, differences, and commonalities based on primary relational data of two case MNCs' GINs and GPNs. The GINs and GPNs include both internal players (headquarters and subsidiaries) and external collaborators (customers, suppliers, universities, government agencies etc.) in different geographical scopes, namely local, national and international. Using social network analysis, this explorative paper answers the following questions:

1. Do the MNCs' GINs and GPNs interact? If so, how?
2. What are the differences and commonalities between the MNCs' GINs and

GPNs?

3. What are the implications for theory?

It is found that the case MNCs' GINs and GPNs interact via shared actors. The network composition and the network centralisation of the GINs and GPNs are different. Nevertheless, GINs and GPNs have similar pattern of ties. The findings imply that GIN and GPN are two different but interwoven layers of the MNCs' global value creation networks. Furthermore, the GIN-GPN interaction, the differences and the commonalities clearly present firm or industrial differences which may result from the different knowledge base that is involved.

The contribution of the explorative paper is twofold. First, it clarifies the current ambiguous conceptualisation of the GIN and GPN. Second, it suggests a knowledge base perspective in future research for better understanding the dynamics of globalisation of innovation and production.

The rest of the paper is presented in six sections. The second part contains the conceptual framework in which the concept of GIN and GPN are defined, the relevant literature is reviewed, and the main propositions are discussed. The third section explains methods, including the selection of the case MNCs, the collection of data, and the analytical framework for mapping the MNCs' GINs and GPNs and studying the interaction, differences, and commonalities of them. The fourth part presents the main findings. The fifth section discusses the theoretical implication of the findings and suggestions to future research. The sixth part concludes the paper.

2. CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

The term global production network (GPN) emerged in the international business literature to capture a major organisational innovation in global operations at the end of the 1990s (Ernst and Kim 2002a, Dicken et al. 2001, Henderson et al. 2002b). The concept of GPN was explicitly suggested as an alternative to global value chain (GVC), which is a linear model, to highlight the networked character of production and its global geographical scope.

In this paper GPN is defined, following Coe and Yeung et al. (2004), as "the globally organized nexus of interconnected functions and operations by firms and non-firm institutions through which goods and services are produced and distributed". One of the main characteristics of a GPN is that it involves both a high degree of geographical dispersion worldwide and a high degree of concentration in few specialised local clusters, thus pointing to the strong relationship between the local

and the global (Bathelt 2005, Giuliani 2004, Giuliani 2007, Giuliani, Pietrobelli and Rabellotti 2005).

The research on global innovation networks (GINs) started with techno-globalism (Ostry and Nelson 1995), the global research village (OECD 1998), and the internationalisation of R&D (Gammeltoft 2006, Gassler and Nones 2008, Von Zedtwitz and Gassmann 2002, Patel and Pavitt 1998, Criscuolo, Narula and Verspagen 2005, Van Beers, Berghäll and Poot 2008, Dunning and Lundan 2009b). Different from the concept of international R&D organisation/alliance (Oxley and Sampson 2004, Gassmann and Von Zedtwitz 1999) the concept of GIN emphases that the relations among actors include all the connections that are related to the creation of innovation, not just R&D. For example, it includes the connection between firms and government agencies for standardisation or co-funding of research, the connection between firms and universities for recruiting and hiring talent to develop new products and processes, and the informal connection among students and knowledge workers (Ernst 2009) etc.

In this paper, GIN is defined, following Barnard and Chaminade (2011), as "a globally organised network of interconnected and integrated functions and operations by firms and non-firm organizations engaged in the development or diffusion of innovations". This definition captures the truly global character istics of a GIN, that is, the variety of actors engaged in innovation (both firms and non-firm organisations), the integration of internal and external networks, and the high degree of functional integration.

We consider a firm's GIN and GPN to be two different but interwoven layers of the firm's global value creation network. It has been argued recently that a firm's production network and innovation network could be considered as two layers of the firm's value creation network in which the production network creates current value while the innovation network works on future value (Vermeulen and Kok 2013). Since production activities and innovation activities of a firm are repeatedly, simultaneously, and mutually antecedently processes with shared and different actors (Vermeulen and Kok 2013), it is theoretically more proper and clearer to consider a firm's production network and innovation network to be two different but interwoven layers of the firm's network for value creation rather than to treat them as two separate networks or one single network with two embedded functions.

We expect that our case MNCs' GINs and GPNs interact. Research in international business and innovation systems (Ernst 2002; Malerba 2002; Lundvall 2009) implies that actors in a firm's collaborative network can engage in both production and

innovation activities. It is found that the production–R&D interface is a key component of the innovation process (Ginn and Rubenstein 1986, Nihtilä 1999, Cheng, Shi and Johansen 2012). Empirical evidence also shows that there is always some innovation occurring in the production process, and as a consequence, there is a certain interaction between GINs and GPNs (Mariani 2002), or in other words, a co-location of production and innovation (Ekholm and Hakkala 2007, Ketokivi and Ali‐Yrkkö 2009). In this line of research, Mariani (2002), using data on Japanese subsidiaries in Europe, suggests that innovation tends to follow production and the more R&D intensive the firm is, the more likely they will establish R&D units independent from production. Firms or industries with higher technology intensity will be more likely to have innovation independent of production. *We therefore expect that the interaction between GINs and GPNs will be higher in low- and medium-tech industries (like automotive) than in high-tech industries (like ICT).*

We expect a firm's GIN and GPN have some differences since production and innovation are two different activities in the value creation process in a firm. To begin with, innovation is more related to creating new knowledge or new combinations of existing knowledge and relies more on the interaction between heterogeneous knowledge sources (Laursen and Salter 2006), while production is more related to exploiting existing knowledge and is to a larger extent based on existing design, in which a relatively smaller scope of actors is involved. *We expect that higher variety in the network composition might be characteristic of GINs in contrast to GPNs*. Furthermore, innovation entails more complex-problem-solving, which bears high uncertainty, ambiguity and complexity, while production involves more simple-problem-solving, which is more routinised and consequently more certain. Observing the relation between the centralisation of the innovation network and the outcome of innovation projects, some researchers found that centralised networks limit the provision of innovation (Fleming and Koppelman 1996, Hennessey and Amabile 1988, Leenders, van Engelen and Kratzer 2003). Experimental research on innovation networks also shows that high network centralisation is more conducive to simple-problem-solving than to complex-problem-solving (Leavitt 1951). *Thus, we expect that GPNs are more centralised than GINs*.

However we also expect that a firm's GIN and GPN share certain common characteristics. In terms of the pattern of ties, it is widely argued in network literature that the formation of network is to access different resources and the pattern of ties of a network provide opportunities and constrains to actors in the network to access resources (Wellman 1983). No doubt that the formation of GINs and GPNs is to access different resources. The formation of GPN is for efficiency (Ghoshal 1987) or

market access (Ferdows 1997) while that of GIN is for knowledge and competences (Brusoni et al. 2001, Dunning and Lundan 2009a). But such difference does not necessarily lead to different pattern of ties of the two networks. On the contrary, the pattern of ties of GIN and GPN may converge under certain conditions. First, when the market resources for production and knowledge resources for innovation agglomerate together, the pattern of ties of the GIN and GPN aiming at these two types of resources may converge. Second, production and innovation are also interrelated processes mainly initiated and coordinated by the focal firm. Many of the activities actually are coordinated by the same actor and conducted at the same site. *Thus, we have reason to expect that GIN and GPN share similar pattern of ties*.

The interaction, differences, and commonalities between the GIN and GPN will be explored by looking at the structure of both networks in the same case firm. Using social network analysis we are able to investigate the composition of both networks in terms of actors as well as the structural characteristics of the networks. The method used for the analysis is described next.

3. METHODS

3.1 Selection of case companies

Firm selection is based on four criteria, namely the firm's global presence, its production and innovation capabilities, its size, and the market structure in which it operates. These four criteria were chosen from the perspective of geography, firm character, and market character, which have a fundamental influence on a firm's production and innovation processes. Based on these four criteria, we selected a company in the telecommunication industry and one in the automobile safety industry. Due to the request for anonymity from both companies, we use TELE to refer to the former and AUTO to refer to the latter.

Both companies are headquartered in the same region of Sweden and have a strong global presence in most of the countries and regions in Europe, Asia and the Pacific, and North and South America, as well as some countries in Africa. The case MNCs' strong global presence gives us a great opportunity to observe and collect data on their broad global distribution of production and innovation activities. Both MNCs have strong production and innovation capabilities, are large companies, and operate in oligopoly markets in which a small number of sellers dominate.

3.2 Collection of data

Data sources of this paper include interviews, questionnaires, archives, websites, internal reports, internal documents and press news. Multiple data sources provide more accurate information and improve the robustness of the results (Jick 1979). A semi-structured questionnaire was developed and administered to elicit responses from the middle managers and top management team members in the two case companies. Four interviews were conducted. Each interview lasted from one to three hours. All interviews were recorded. The interviews were conducted in 2010 and 2011 in both the companies' headquarters and their branches in other locations in Sweden. Further information was collected after the interview through multiple sources.

Potential informant bias is addressed in three ways. First, we selected highly knowledgeable informants. At AUTO we interviewed the vice president (VP) of research twice. He was also previously the manager of engineering of AUTO for five years and the VP of engineering of AUTO for eleven years. At TELE we interviewed the VP of research twice. After the first interview he was assigned as the head of corporate strategy of TELE. He was also previously the head of the largest business unit of TELE for many years. Both of our informants not only have rich knowledge about innovation activities in the company but also are familiar with the production activities of the firm. Second, we used a "courtroom questioning" technique to focus on factual accounts (Lipton 1977, Huber and Power 1985, Porter 1985). We asked the informants to specify what kinds of activities are carried out in each specific relationship so as to ensure that the informant did not mix up the relationships for innovation or production or any other activities. It was also helpful for informants to avoid confusion between what really happened and what should happen. Third, we granted anonymity to the informants.

Despite the great efforts to triangulate the information collected during the interview with archives, websites, internal reports, internal documents, press news and scientific publications, the limited number of interviews conducted in each of the case MNCs seriously limits the extent to which the observed patterns can be generalised to other companies, and thus this study can only be considered explorative.

The case companies' GINs and GPNs are weighted and undirected networks. GPN in this paper refers to the set of relationships of the case company aimed at manufacturing products. GIN in this paper refers to the set of relationships of the case company aimed at technological innovation, including both product and process innovation. Provision of services and service innovations are excluded from this research to facilitate the comparison between networks and between firms.

We identified two groups of actors in GINs and GPNs. One is the group of internal actors, including the functional departments or groups in the company's headquarters and the company's subsidiaries. The functional departments/groups include the department/groups for production, R&D, marketing, finances, human resources, and purchasing/sourcing, the taxonomy of which follows Porter's (1985) value chain analysis. The subsidiaries include the company's sub-organisations for R&D, production and marketing. These three groups of subsidiaries are the main types of subsidiaries for the case companies' global operation. The other group is the external actors, which includes the outside organisations, namely customers, suppliers, universities, research institutes, competitors and government agencies, who are the main actors in the production and innovation system (Lundvall et al. 2002). The differentiation between internal and external networks was done to better observe whether the core of the networks for production and innovation lay within the firm or outside of it.

We identified three different geographic levels of GIN and GPN: local, national and international. Local level refers to the Swedish region where the case companies are headquartered. National level refers to the rest of Sweden excluding the headquarters region. International level refers to the rest of the world excluding Sweden.

The names and abbreviations of the actors in both the GINs and GPNs are shown in Table 1. We used one initial letter to distinguish the different geographic locations of external actors: L, N, and I representing Local, National, and International respectively. For example, LCST refers to Local CuSTomers in the headquarters region. NGOV refers to National GOVernment agencies in the rest of Sweden excluding the headquarters region. ISRD refers to International Subsidiaries for R&D located in other countries.

Table 1. Names and abbreviations of internal and external actors of production networks and innovation networks

Internal Actors		External Actors	
R&D	R&D Department	CST	Customers
PRD	Production coordinator[2]	SPL	Suppliers
HR	Human Resource	CPT	Competitors
MKT	Marketing Department	U&R	Universities and research institutes
FIN	Financial Department		

[2] In both case companies' headquarters, there is not a production department but a person/group who acts as the production coordinator. We still consider it a function of the headquarters even though just one or several persons are in charge.

PCH/ SOC	Purchasing Department/ Sourcing Department	GOV	Government agencies
SPD	Subsidiaries for production		
SRD	Subsidiaries for R&D		
SMK	Subsidiaries for marketing		

The relational data on the ties between actors was collected through a roster recall method (Wasserman and Faust 1994). Each case company was presented with a complete list (roster) of the actors in the network and was asked the following questions:

Q1: Do the following actors contact each other for your company's production or innovation activities?

Q2: If so, what are the types of these connections: for production, for innovation, or for both?

Q3: What is the strength of these connections in terms of the intensity with which they contact each other, the frequency with which they contact each other, and the level of mutual trust? Please give a score to represent the strength of the connections:

Strength	Very strong	Strong	Normal	Weak	Very weak	No connection
Score	5	4	3	2	1	0

We mapped the GINs and GPNs of the two case companies using UCINET social network analysis software.

3.3 Analysing GIN and GPN

The analysis of the networks presented in this paper was done using social network analysis (SNA). SNA facilitates the comparison of different layers of a network – for example, to understand how the same actors can configure different networks to convey different types of knowledge (Giuliani and Pietrobelli 2011) . Using SNA we can clearly see the GINs and GPNs as two different but interwoven layers of the global value creation networks of the case MNCs.

Based on the literature review, first, we explore the interaction between GINs and GPNs of the case MNCs by analysing the composition of the two networks and the joint membership of the actors. We particularly pay attention to the joint membership of the highly connected actors. If two networks share the same highly connected actors, the two networks interact through these actors and the knowledge that is carried by these actors has high propensity to be shared between these two networks.

To identify the highly connected actors in both the GINs and GPNs, we calculate the Freeman degree of each actor. The Freeman degree is a measure of the connectedness of a specific actor in a local environment. It measures the centrality of the node in the network and shows the potential of the node's positional power.

Second, we investigate the differences between GINs and GPNs of the case MNCs by examining the network composition in terms of the variety of actors and network centralisation of the two networks. We analyse the type of actors in the GINs and GPNs to see how diverse the actors are and we calculate the network centralisation to see how centralised the GINs and GPNs are.

Third, we study the commonalities between the GINs and GPNs of the case MNCs by visualising the pattern of ties of the two networks. We use NetDraw with a principal components layout (Borgatti, Everett and Freeman 2002) to visualise the pattern of ties of the networks. Such layout assigns locations to actors according to their similarity in terms of pattern of ties. Actors having similar patterns of ties are located close to each other in the map of the network. Actors with exactly the same pattern of ties are located in the same position (one on the top of the other) in the graph. In order to see all the overlapped nodes, we slightly separate them so as to make them visible in the maps.

4. MAIN FINDINGS

4.1 GPN interacts with GIN in both cases but such interaction shows firm/industrial difference.

GIN interacts with GPN through the shared actors. Around 90% of the actors work for both GIN and GPN in the two cases (see Figure 1 and Figure 2) though the shared actors have different connectedness in the GIN and GPN respectively. In the case of TELE there are 26 out of 29 GIN actors also work for GPN except local competitor (LCPT), international competitor (ICPT) and international government (IGOV). In the case of AUTO there are 21 out of 23 GIN actors also work for GPN except national and international universities and research institutes (NU&R and IU&R). Shared membership implies the knowledge that the actor carries has high propensity to be shared in both networks. Both case MNCs confirmed during the interviews that R&D and production personnel work together for both innovation and production.

Nevertheless, the content of GIN-GPN interaction differs between the two case MNCs. TELE's GIN and GPN interact more for R&D-related knowledge while AUTO's GIN and GPN interact more for market-related knowledge.

In the case of TELE, the GIN and GPN share four highly connected actors, namely headquarters' R&D department (R&D), local R&D subsidiaries (LSRD), national R&D subsidiaries (NSRD) and international R&D subsidiaries (ISRD), which are all R&D-related actors (see Figure 1). The more connections an actor has in a network, the bigger role it plays in the network. This implies that R&D-related actors are key actors in both the GIN and GPN of TELE. We assume that R&D-related actors are main carriers of R&D-related knowledge, we thus argue that in TELE the GIN and GPN interact more for R&D-related knowledge. This argument is confirmed by the interviewees in TELE.

In the case of AUTO, the market-related actors – that is, headquarters marketing department (MKT), national marketing subsidiary (NSMK), international marketing subsidiaries (ISMK) and national customer (NCST), international customer (ICST) – have equally high connectedness in both the GIN and the GPN (see Figure 2). This implies that market-related actors are important actors in both GIN and GPN of AUTO. Market-related knowledge is the main content of GIN-GPN interaction in the case of AUTO. This finding is also confirmed by the interviewee of AUTO.

The different contents of GIN-GPN interaction in the two MNCs arise questions for further research.

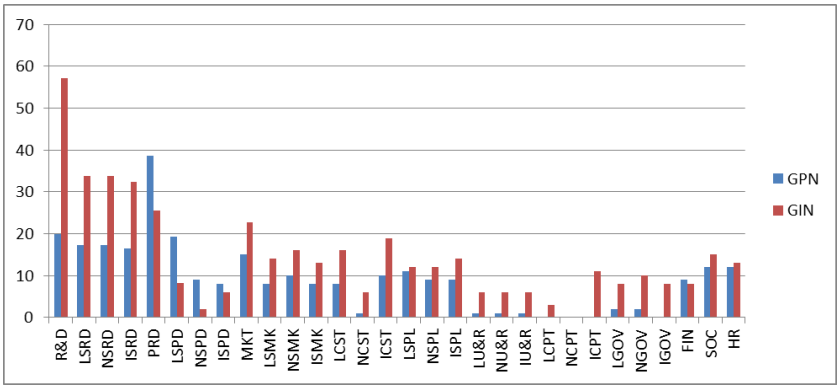


Figure 1. TELE's GIN and GPN actors' Freeman degrees

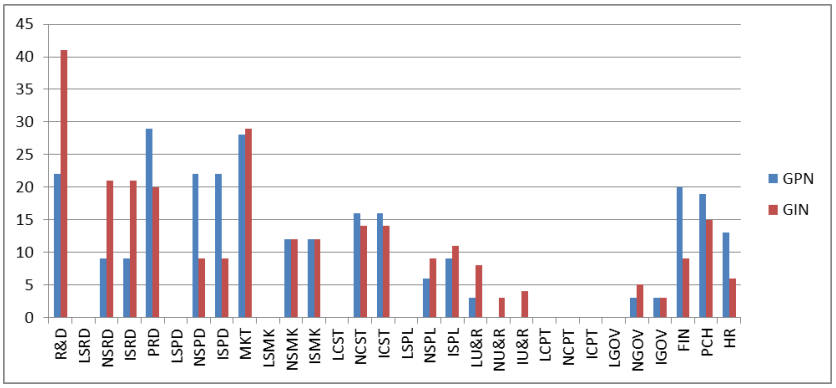
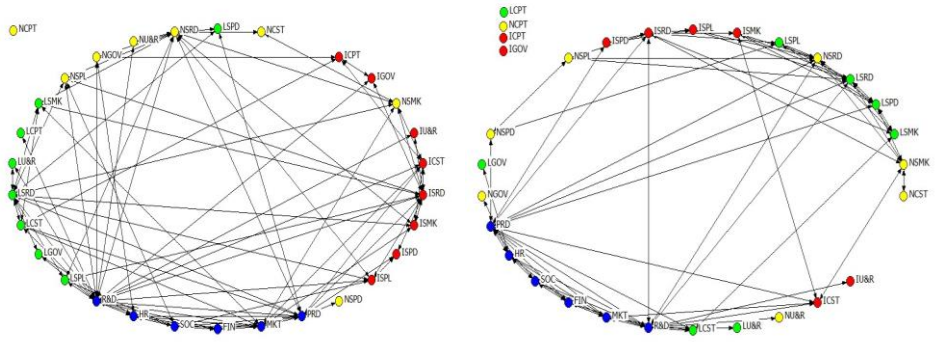


Figure 2. AUTO's GIN and GPN actors' Freeman degrees

4.2 GINs have higher actor variety than GPNs in both cases though the actor variety shows firm/industrial difference

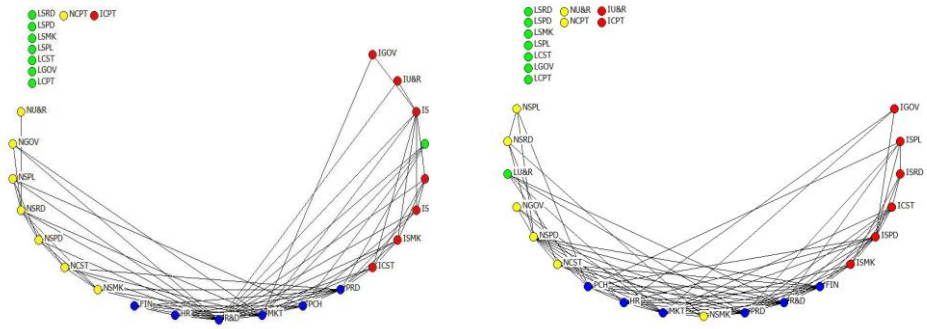
Both case companies' GINs have more different actors than their GPNs (see Figure 3 and Figure 4). TELE has three more types of actors in GIN than in GPN, namely the local competitor (LCP), international competitor (ICP), and international government (IGOV). The connections with these actors are all for the purpose of negotiating new standards. This finding shows that the composition of an ICT firm's GIN reflects the importance of industrial standards for innovation in the industry (Dittrich and Duysters 2007, Ehrhardt 2004, Soh 2010), as well as the important role of government and competitors in the standard-setting alliance (Funk 2009, Fontana 2008). AUTO has two more types of actors in GIN than in GPN, they are national universities and research institutes and international universities and research institutes (NU&R and IU&R). This finding echoes the empirical findings of many other researches which stresses the important role of universities and research institutes as heterogeneous knowledge sources in innovation networks (e.g. Hemmert 2004, Spencer 2003, Chen and Kenney 2007).

Nevertheless, TELE's GIN and GPN both have higher variety of actors than have AUTO's. TELE's GIN and GPN has 29 and 26 types of actors respectively while AUTO's has 23 and 21. Whether this is firm or industrial difference calls for further research.



TELE GIN **TELE GPN**

Figure 3. TELE's GIN and GPN



AUTO GIN **AUTO GPN**

Figure 4. AUTO's GIN and GPN

4.3 GINs are more centralised than GPNs in both cases and the centralisation also shows firm or industrial difference

Both case companies' GINs have higher network centralisation than their GPNs (see Table 2), which does not confirm the literature about the negative influence of centralised network structure on innovation performance. Network centralisation indicates the extent to which network positional power is concentrated in a small group of actors. Centralisation facilitates coordination and integration (Provan and Milward 1995), though it limits the accessibility of information to peripheral actors in the network. The higher network centralisation of the GINs compare to the GPNs implies that globalisation of innovation needs more integration and coordination among its actors than does globalisation of production, which may result from the greater complexity, uncertainty and ambiguity of innovation. Two case MNCs' interviewees both confirmed their central controlled R&D system during the interviews.

Table 2. Network centralisation of GINs and GPNs (%)

	GPN	GIN
TELE	30.44	44.09
AUTO	21.23	33.62

Noticeably, the GIN and GPN of TELE are more centralised than the GIN and GPN of AUTO respectively. Again, whether the difference is firm- or industry-specific needs further research.

4.4 GIN and GPN share same pattern of ties of the two cases respectively but the pattern differs between the two MNCs or industries.

Both case companies' GINs and GPNs have same pattern of ties. We mapped the two case MNCs' GINs and GPNs using NetDraw with the principal components layout (see Figure 5 and Figure 6). In these maps, actors who are closely located have similar geodesic distances to all other actors, while actors who overlap have exactly the same ties to the same actors. We slightly separated the overlapping nodes in the map so as to make them visible. As shown in the map, there are several aggregations in the GINs and GPNs. Actors in the same aggregation have the same or similar pattern of ties. It can be clearly seen that the aggregations in each of the case companies' GINs and GPNs are organised in the same way. In both the GIN and GPN of TELE (see Figure 5), the actors aggregated together are for the same function, such as R&D, marketing, suppliers, customers, government agencies, competitors etc. However, for AUTO (see Figure 6), the actors aggregated together in both the GIN and GPN are in the same geographic scope, such as headquarters, local, national and international.

The fact that the GIN and GPN in the same company have the same pattern of ties is in line with the fact that production and innovation are highly integrated value creation processes coordinated by the focal firm, according to the interviews in the two MNCs. The integration of production and innovation becomes more important when innovation is strongly related to customer or market-specific knowledge as mentioned by the interviewees. Under such condition, market resources that attract GPN and knowledge resources attract GIN agglomerate together to the same location which leads to the convergence of the pattern of ties of the GINs and GPNs.

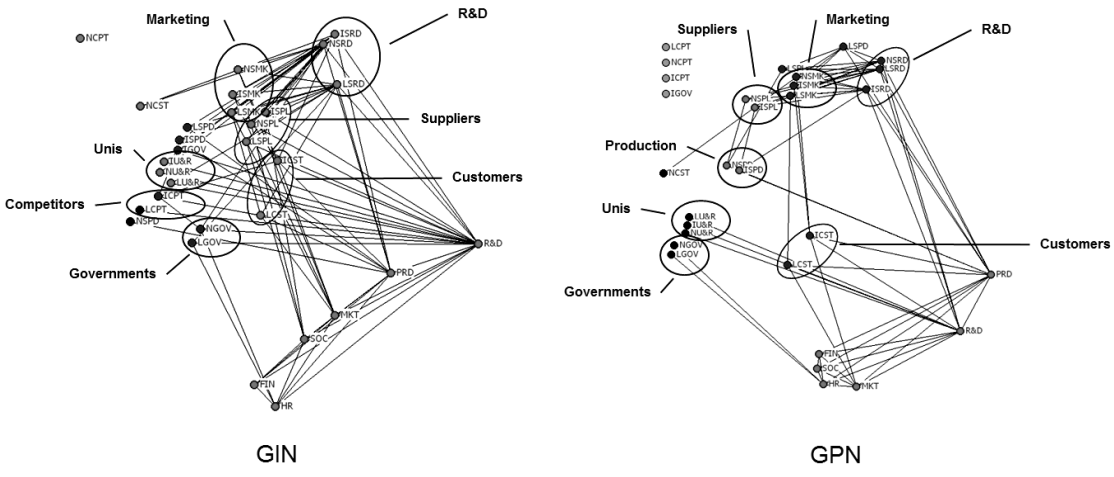


Figure 5. TELE's GIN and GPN

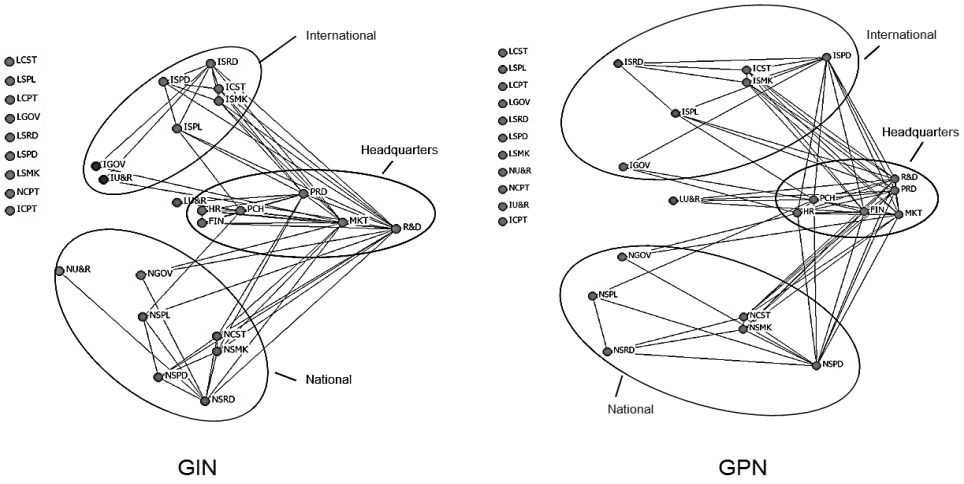


Figure 6. AUTO's GIN and GPN

In both case MNCs, their GIN and GPN have a similar pattern of ties; however, such pattern is different between two different MNCs in different industries. We found that the GIN and GPN of TELE are more globally organised, while those of AUTO are more locally organised. The global vs. local organisation model reflects the effect of the different feasibility and necessity of long-distance knowledge transfer on the organisation of the networks of the case MNCs (Liu, Chaminade and Asheim 2013). But if the difference lies in the firm level or industry level needs further research.

5. DISCUSSION

Based on the findings about the GIN and GPN of the case MNCs (see Table 3), we argue that theoretically considering GIN and GPN as two different but interwoven layers of a firm's global value creation network may provide better conceptual clarity for theoretical development.

Table 3. Summary of the GIN-GPN interaction, differences, and commonalities

Interaction		
Finding	Network structural characteristics	Explanations
GINs and GPNs interact	To both case MNCs, GIN and GPN share most of the actors.	The interaction between GIN and GPN reflects the interconnection between innovation and production processes in the value creation process.
Differences		
Findings	Network structural characteristics	Explanations
GINs have higher actor variety than have GPNs	GINs have more types of actors than GPNs. 1) For TELE, government agencies and competitors of all geographical levels are involved in GIN rather than in GPN. 2) For AUTO, international universities and research institutes are involved in GIN rather than in GPN.	1) The important role of government agencies and competitors in standards-setting for innovation in the ICT industry. 2) The greater importance of knowledge sourcing from universities and research institutions for innovation than for production in automotive industry.

GINs are more centralised than GPNs	Network centralisation of GINs are higher than that of GPNs	GIN needs more integration and coordination, which is facilitated by network centralisation, than does GPN thanks to the greater complexity, uncertainty and ambiguity of innovation.
Commonality		
Finding	Network structural characteristics	Explanations
GINs and GPNs have a similar pattern of ties	TELE's GIN and GPN are both globally organised while AUTO's are both locally organised.	Innovation and production processes are inherently interconnected, which is reflected in their similar pattern of ties.

The clear evidence of the differences in terms of network composition and network centralisation between the GINs and GPNs of the case MNCs suggest that it is improper to treat innovation as an add-on function of GPN assuming that innovation happens in the same structure of GPN. Existent literature has heavily discussed the different motivations for globalisation of production and innovation, arguing the former is mainly to seek low cost or market advantage while the latter is mainly for knowledge competences (Ghoshal 1987, Ferdows 1997, Brusoni and Prencipe 2001, Dunning and Lundan 2009a). The argument is also confirmed by our interviews in both case MNCs. However, despite the differences in motivation and tasks undertaken in GINs and GPNs, we still see a convergence in the pattern of ties of the two networks. The way that the GIN and GPN are organised, or the way that the actors in the two networks are interconnected, is found to be the same in both cases. The shared pattern of ties of the GIN and GPN indicates the strong inherent connection between the production and innovation processes. It reflects the simultaneity and interdependence of production and innovation activities particularly when market resources for production and market-specific knowledge for innovation agglomerate to the same location. Thus, we argue that it is important to conceptually consider the GIN and GPN as two different but interwoven layers of the same global value creation network of a firm rather than two separate ones or one hiding in another.

This conceptualisation has important implications for better understand the MNCs' globalisation of innovation and production in reality and for further theoretical development. For example, the establishment of a specific dyadic relation between two specific actors may have different impact on production and innovation as the relation is differently embedded in the different structures of the GIN and GPN respectively. The emergence or change of a specific actor may have impact on both innovation and production but to different extent and in different ways. The change of GPN may leads to the change of GIN and vice versa. Thus GIN and GPN co-evloves.

Besides of the findings about GIN-GPN interaction, differences, and commonality, noticeable differences between the two case MNCs or the industries of the two MNCs are also found (see Table 4). Whether the difference is firm- or industry-specific needs

further research. In this paper, we suggest a knowledge-based approach to explore the cause of the differences. It has been argued that due to the different nature of the knowledge bases (analytic, synthetic, symbolic) (Asheim and Coenen 2005), firms and industries are likely to differ in the degree of globalization of innovation networks (Asheim and Coenen 2005, Asheim and Gertler 2005, Moodysson, Coenen and Asheim 2008). The authors has found that knowledge base has clear influence on the two case MNCs' GINs (Liu et al. 2013) and it may also have similar influence on the MNCs' GPNs as well. The reason is that different forms of knowledge have been one of the most important dynamics of globalisation of production (Coe 2012, Ernst and Kim 2002b, Dyer and Nobeoka 2002). Nevertheless the difference lies in the firm level or industrial level is still an unanswered question. Possible explanations based on knowledge base perspective are presented in Table 4.

Table 4. Comparison between the two cases MNCs' GIN-GPN interaction, differences and commonalities

Interaction		
Finding	Network structural characteristics	Possible explanations
TELE's GIN-GPN interaction is for R&D-related knowledge while in AUTO is for market-related knowledge.	The TELE's shared highly connected actors between GIN and GPN are R&D related actors while AUTO's are market-related actors.	TELE's dominant knowledge base is more science-based while that of AUTO is more market- and engineering- based.
Differences		
Findings	Network structural characteristics	Possible explanations
TELE's GIN and GPN have higher actor variety than AUTO's	TELE's GIN and GPN have 29 and 26 types of actors while AUTO's have 23 and 21.	TELE's dominant knowledge base is more complex and thus TELE needs more diverse actors to provide heterogeneous knowledge source than AUTO.
TELE's GIN and GPN are more centralised than AUTO's	Network centralisation of TELE's GIN and GPN are higher than that of AUTO's	TELE's dominant knowledge base is more heterogeneous and thus TELE needs more coordination among actors than AUTO.
Commonality		
Finding	Network structural characteristics	Possible explanations
TELE's GIN and GPN are similarly organised in one way and AUTO's are similarly organised in another way.	AUTO's GIN and GPN are both locally organised while TELE's are both globally organised.	TELE's dominant knowledge base is more science-based thus the knowledge is more codifiable and transferrable across space while AUTO's is more market- and engineering-based thus the knowledge is more "sticky" to the local area.

6. CONCLUSIONS

This paper is an explorative study about the interaction, differences, and commonalities between the GINs and GPNs of two multinational companies

We find that 1) the interaction between GINs and GPNs of the case MNCs can be observed in the joint membership of most of the actors in the networks. The

interaction between GIN and GPN reflects the interconnection between production and innovation as two different but intertwined processes of value creation in the case companies. 2) The differences between the GINs and GPNs of the case MNCs lie in the degree of actor variety and the centralisation of the networks. The two case MNCs' GINs are formed by a larger number of diverse actors and are more centralised than are the GPNs. These differences can be explained by the differences between innovation and production, that is, innovation is more complex, uncertain, and ambiguous and needs more coordination than production. 3) The commonality between both MNCs' GINs and GPNs is that they share the same pattern of ties. This reflects the strong inherent interconnection between production and innovation processes as two different parts of the same value creation process that is coordinated by the focal firm and further enhanced by the agglomeration of market resources for GPN and knowledge resources for GIN to the same location.

The interaction, differences, and commonality between GINs and GPNs that we find in this case study bring forth important theoretical implications. GINs and GPNs have different characteristics in terms of network composition and network structure. At the same time they also share common attributes and they interact. Thus, it is improper to consider GIN and GPN as two separate networks or to consider GIN as an extension of GPN. Instead, regarding GIN and GPN as two different but interwoven layers of the global value creation network of a firm may provide better conceptual clarity for reality interpretation and theoretical development.

Furthermore, we also find firm/industrial differences when comparing the two case MNCs' GINs and GPNs. 1) TELE's GIN and GPN interacts for R&D-related knowledge while AUTO's for market-related knowledge; 2) TELE's GIN and GPN have more diverse actors than AUTO's; 3) TELE's GIN and GPN are more centralised than AUTO's; 4) TELE's GPN and GIN are globally organised while AUTO's are locally organised. Whether these differences are explained by their belonging to different industries or by different firm strategies remains to be studied. The authors suggest a knowledge base perspective and provide preliminary explanation for further research.

The value of the study is in the exploratory purpose that it serves, which is providing some evidence based on primary data and suggesting theoretical perspectives for further development of theories.

As with any exploratory analysis using novel, dedicated qualitative data, the paper has inevitable limitations. The first limitation is the limited number of interviews. To reduce possible informant bias, the interviewees were carefully selected (top

managers – vice president of research with extensive previous experience serving as vice president of engineering or as the head of the largest business unit), concepts were clearly defined, one interview questionnaire were used, follow-up interviews were conducted to collect missing information of the previous ones, all interviews were recorded, and data was triangulated with published information when available. The second limitation is the static nature of the data, which does not allow us to investigate whether GINs evolve from GPNs, as the extant literature argues, or how GINs and GPNs co-evolve, which can be of great theoretical importance.

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