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The Global Innovation Networks and Global Production Networks of Firms: Conceptualisation and Implication

Ju Liu¹

Abstract

Today's developments in the literature about the global networks of firms emphasise not only global production networks (GPNs) but also global innovation networks (GINs). However, the differences, commonalities, and interaction between firms' GINs and GPNs have not been theoretically and empirically clarified. Using case studies and social network analysis, this paper aims to capture the network characteristics of two case study firms' GINs and GPNs. The findings show that these firms' GINs and GPNs interact and are different in terms of network composition and network centralisation, but are similar in terms of pattern of ties. Despite this, the GIN-GPN interaction, differences and commonality of one firm clearly differ from that of the other. The paper argues that theoretically considering the GIN and GPN as two different but interwoven layers of a firm's global value creation network may provide better conceptual clarity for understanding management issues in the context of globalisation. In addition, this paper discusses management implications for simultaneously managing firms' globalisation strategy for innovation and production as well as the theoretical implication for international business and globalisation studies. It also suggests a knowledge base perspective for future research to better understand the dynamics of firms' GINs and GPNs.

Keywords: Global innovation network, Global production network, Interaction, Difference, Commonality, Social network analysis.

JEL: O32, F610, M160

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Introduction

One of the most distinctive characteristics of the wave of globalisation has been the increased number of firms' global production networks (GPNs) (Gereffi and Korzeniewicz 1994; Kogut and Kulatilaka 1994; Borras and Zysman 1997; Sturgeon 1997; Henderson, Dicken et al. 2002; Coe, Dicken et al. 2008) as well as the increasing formation of global innovation networks (GINs) such as international joint ventures and strategic alliances for R&D (Zander 1999; Hagedoorn 2002; Oxley and Sampson 2004; Roijakkers and Hagedoorn 2006; Geum, Lee et al. 2013; Herstad, Aslesen et al. 2014; Awate, Larsen et al. 2015; Guan, Zuo et al. 2016). Increasingly more multinational firms have globalised both their innovation networks and production networks. How to simultaneously manage a firm's globalisation for innovation and production to enhance the firm's competences for long-term survival is a great challenge for a company. Also, in GIN and GPN research, theoretical and methodological issues remain unsolved, which hinders the understanding of management issues and the generating of management implications for the firm's global innovation and production.

Theoretically, the distinction between GIN and GPN is quite blurry, and the discussion of GIN-GPN relations is often based on theoretical assumptions rather than sound evidence. The possible causes of this conceptual ambiguity are twofold. First, the globalisation of production started much earlier than the globalisation of innovation; therefore, with few exceptions (Audretsch and Feldman 1996; Mariani 2002; Sachwald 2008; Cheng, Johansen et al. 2015), most research implicitly assumes that GINs evolved from GPNs. Second, conceptually taking innovation as an add-on function of GPNs (e.g. Ernst 2002) and assuming that innovation happens within the same network structure as the GPN blurs the distinction between the two kinds of networks. In this era of globalisation, benefiting from innovation requires the systematic integration of a firm's global networks for innovation and for production (Derick et al. 2010). The ambiguity in the conceptualisation of a firm's GIN and GPN may lead to misunderstanding the dynamics of the two networks. Consequently, this may create difficulties for the development of management implications and theories.

In terms of methodology, existing literature mainly adopts a whole network perspective and studies the GINs and GPNs separately; however, this is not adequate for understanding the impact of simultaneous GIN-GPN involvement in the company's operation as well as its influence on the outcomes of the firm in focus.

First, most of the existing research on GINs and GPNs focus on the whole network within a territorial or industrial boundary (e.g. Hanson, Mataloni et al. 2005; Schilling and Phelps 2007; Shibata, Kajikawa et al. 2008; Cassi, Morrison et al. 2012; Brooks 2013; Binz, Truffer et al. 2014; Hu, Scherngell et al. 2015). The lack of research on an ego-centric or individual organisation level makes it difficult to explain how the involvement of an actor in a network affects its actions and outcomes (Provan, Fish et al. 2007). Second, existing research does not attempt to simultaneously capture the GIN and GPN of a company. Instead, they study either firms' GINs or GPNs separately or simply refer to a firms' intra- or inter-organisational networks in general. Such separation may lead to a lack of knowledge of the interactive dynamics between a firm's GINs and GPNs, which is critical to a firm's innovativeness and productivity.

This paper aims to address these research gaps by exploring the GIN-GPN interaction, differences, and commonalities based on the primary relational data of two case firms' 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 firms' GINs and GPNs interact? If so, how?
2. What are the differences and commonalities between the firms' GINs and GPNs?
3. What are the management implications for firms' R&D management in the context of globalisation?
4. What are the theoretical implications for international business and globalisation studies?

It is found that the case firms' GINs and GPNs interact via shared actors. Also, the network composition and the network centralisation of the GINs and GPNs differ. Nevertheless, the GINs and GPNs have a similar pattern of ties. The findings imply that the GIN and GPN are two different but interwoven layers of the firms' global value creation networks. In addition, the GIN-GPN interaction, the differences and the commonalities clearly present distinctions between the two case firms.

This research paper aims to contribute in three ways. First, it clarifies the current ambiguous conceptualisation of the GIN and GPN in international business and

globalisation studies. Second, it is relevant for management, in particular, for firms to cope with the challenge of simultaneously managing their globalisation for innovation and production. Third, it suggests a knowledge base perspective for future research to better understand the dynamics of firms' global networks for innovation and production and better address the related management issues.

The final part of this paper is presented in six sections. The second section contains the theoretical background and literature review. The third section explains methods, and the fourth presents the main findings. The fifth section discusses management and theoretical implications as well as offers suggestions for future research, and the sixth part concludes the paper.

Theoretical background and literature review

The definition of the GIN and GPN

The term *global production network* (GPN) emerged in international business literature at the end of the 90s to capture a major organisational innovation in global operations (Dicken, Kelly et al. 2001; Ernst and Kim 2002; Henderson, Dicken et al. 2002). The concept of GPN was put forward as an alternative to *global value chain* (GVC) to highlight the networked characteristics of production and its global geographical scope. As defined by Coe and Yeung et al. (2004), a GPN is “a globally organized nexus of interconnected functions and operations by firms and non-firm institutions through which goods and services are produced and distributed”. By this definition, one of the main characteristics of a GPN is that it involves multi-functions and operations including R&D or design. Thus, globalisation of innovation or international R&D management is assumed to be conducted in the same network structure of the GPNs. The broad definition of GPN provides a comprehensive framework for understanding the globalisation of world economic systems, but it does not add much value for understanding the distinction and relation between firms' globalisation of innovation and production.

Therefore, from a social network perspective, the paper defines a firm's GPN as a set of globally organised relationships within and among the focal firm and its firm and non-firm collaborators through which products and services are produced based on existing knowledge and technology. This definition captures the global characteristics of a firm's GPN, that is, the global spread of various actors engaged in production (both firms and non-firm organisations) (Coe, Hess et al. 2004) and the integration of internal and external networks as double networks (Zanfei 2007). This

definition strictly limits the network relations to only those related to manufacturing without generating new knowledge and technology. It distinguishes the networks to be used for applying existing knowledge and technology from those to be used for generating new ones.

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 (Patel and Pavitt 1998; Von Zedtwitz and Gassmann 2002; Criscuolo, Narula et al. 2005; Gammeltoft 2006; Gassler and Nones 2008; Van Beers, Berghäll et al. 2008; Dunning and Lundan 2009). The concept of international R&D organisation/alliance (Gassmann and Von Zedtwitz 1999; Oxley and Sampson 2004) differs from the concept of GIN in that it emphasises 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 the 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. Barnard and Chaminade (2011) define a GIN 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 global characteristics of a GIN, that is, the global dispersion of actors, the variety of actors engaged (both firms and non-firm organisations), and the high degree of functional integration. Nevertheless, it does not explicitly reflect the double-network (Zanfei 2007) characteristic of a firm’s GIN.

In this paper, from a social network perspective, a firm’s GIN is defined as a set of globally organised relationships within and among the focal firm and its firm and non-firm collaborators through which new knowledge and technology are generated and diffused. This definition emphasises the multi-actor (firm and non-firm organisations) and double-network (internal and external) characteristics of a firm’s GIN. It strictly limits the network relations to only those related to generating new knowledge and technology.

Our definitions of GIN and GPN stress the four main characteristics of a firm’s global network for innovation and production. First is the global dispersion of the network actors from local to national and then to international scope. Second is the diverse actor configuration of the networks, from firms to non-firm organisations,

such as universities, research institutes and government agencies. Third is the characteristic of being a double network by including both the internal network of the focal firm and the external ones. And last, but equally important, they are defined as ego-networks so that research based on such a definition can be used to explain how a firm that engages in global networks can affect its actions and outcomes in terms of innovation and production.

These definitions distinguish the network relations for the exploitation of existing knowledge and technology (GPN) from those exploring new ones (GIN). Therefore, it enables observation and analysis on the interaction, differences and commonalities between the firms' GINs and GPNs to generate management implication, particularly for firms to cope with the challenge of simultaneously managing their globalisation for innovation and their production.

The theoretical proposition of a firm's GIN and GPN

We expect a firm's GIN and GPN to present some differences. Innovation and production are two different activities in a firm's value creation process. This has been long discussed in the value chain research (see Kaplinsky and Morris 2001 for review) and is widely used in global value chain literature (Humphrey and Schmitz 2000; Gereffi, Humphrey et al. 2005). First, innovation refers more to the creation of new knowledge or new combinations of existing knowledge and relies more on the interaction between heterogeneous knowledge sources (Laursen and Salter 2006), whereas production relates more to exploiting existing knowledge and is, to a larger extent, based on the existing design in which a relatively smaller scope of actors is involved. We expect that higher variety in the network composition might be one of the characteristics of the GINs in contrast to that of the GPNs. Second, innovation entails more complex problem-solving, which bears high uncertainty, ambiguity and complexity, while production involves simpler problem-solving, which is more routinised, and consequently, more certain. Some researchers found that centralised networks limit the provision of innovation (Hennessey and Amabile 1988; Fleming and Koppelman 1996; Leenders, van Engelen et al. 2003); however, 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). Therefore, we expect that GPNs are more centralised than GINs.

We expect a firm's GIN and GPN to interact, as innovation and production are

two interrelated process. On one hand, the production infrastructure and process must be created or adjusted to meet the needs of producing new products or implementing a new process. On the other hand, innovation should plan for future production or solve a specific problem in the current production so that the condition of the current production infrastructure and process is taken into account. 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 et al. 2012). Empirical evidence also shows that some innovation always occurs in the production process and results in a certain interaction between the GINs and GPNs (Mariani 2002), or in other words, a co-location of innovation and production (Ekholm and Hakkala 2007; Ketokivi and Ali-Yrkkö 2009).

Furthermore, 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 a 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 the GINs and GPNs is to access different resources. The formation of the GPN is for efficiency (Ghoshal 1987) or market access (Ferdows 1997), while that of the GIN is for knowledge and competences (Brusoni, Prencipe et al. 2001; Dunning and Lundan 2009). But such a difference does not necessarily lead to a different pattern of ties of the two networks. On the contrary, the pattern of ties of the GIN and GPN may converge under certain conditions. First, when the market resources for production and knowledge resources for innovation agglomerate, the pattern of ties of the GIN and GPN aimed at these two types of resources may converge. Second, innovation and production are also interrelated processes mainly initiated and coordinated by the focal firm. Many of the activities are coordinated by the same actor and conducted at the same site. Thus, we have reason to expect that the GIN and GPN share a 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 of the same firm of this case study. Using social network analysis, we can 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 in the next section.

Methods

Selection of case firms

The selection of the firm was based on four criteria: global presence, innovation and production capabilities, size, and the market structure in which the firm operates. 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 firms are large companies headquartered in the same region of Sweden. Both firms have a strong and similar global presence as well as a strong reputation for innovation and production capabilities in terms of number of patents and global market share. Both firms operate in oligopoly markets in which a small number of sellers dominate.

Collection of data

The data sources of this paper include interviews, questionnaires, archives, websites, internal reports, internal documents and press news. In addition, 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-level and top management team members in the two case companies. Also, four 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 four ways; first, we selected highly knowledgeable informants². 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 to ensure that the informant did not mix up the relationships for innovation or production or any other activities. This was also helpful for informants to avoid being confused between what really happened and what should happen. Third, we granted anonymity to the informants, and fourth, we triangulated the information collected during the interview with archives, websites, internal reports, internal documents, press news and scientific publications about the case firms.

² Our key informant in AUTO is the former Vice President (VP) of Research who was later appointed the CEO of AUTO. He was also previously the manager of engineering of AUTO for five years and the VP of engineering of AUTO for 11 years. For the TELE case study, we had the VP of Research as our key informant. After the first interview, he was assigned as Head of Corporate Strategy of TELE. He was also previously the head of the largest business unit of TELE for many years. Both our informants not only have in-depth knowledge about the innovation activities of their company but also are familiar with the production activities of the firm. To some extent, this compensates for the absence of interviews with production managers.

Nevertheless, the limited number of interviews conducted in each of the case firms seriously limits the extent to which the observed patterns can be generalised to other companies; thus, this study can only be considered explorative.

The case firms' GINs and GPNs are weighted and undirected networks, and the provision of services and service innovations are excluded from this research to enable the comparison between networks and between firms.

We identified two groups of actors in the 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 according to the taxonomy of 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 a manufacturing company's 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 innovation and production system (Lundvall, Johnson et al. 2002). The differentiation between internal and external networks aims to better observe whether the core of the networks for innovation and production lay within the firm or outside of it.

We identified three different geographic levels of the GIN and GPN: local, national and international. The local level refers to the Swedish region where the case companies are headquartered. The national level refers to the rest of Sweden except the headquarters region, and the international level refers to the rest of the world except 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 represent 'local', 'national', and 'international' respectively.

Table 1. Names and abbreviations of internal and external actors of the GINs and GPNs

Internal Actors		External Actors	
R&D	R&D Department	CST	Customers
PRD	Production coordinator ³	SPL	Suppliers
HR	Human Resource Department	CPT	Competitors
MKT	Marketing Department	U&R	Universities and research institutes
FIN	Financial Department		
PCH/	Purchasing Department/	GOV	Government agencies
SOC	Sourcing Department		
SPD	Subsidiaries for production	L	Local
SRD	Subsidiaries for R&D	N	National
SMK	Subsidiaries for marketing	I	International

The relational data on the ties between actors was collected by asking 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 (see Table 2):

Table 2. The strength of the connections in Likert scale

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 the GIN and GPN

The analysis of the networks presented in this paper was conducted by social

³ 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.

network analysis (SNA) with the assistance of SNA software UCINET. The 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) or conduct different activities.

We analysed the composition of the case firms' GINs and GPNs, and we investigated the network structural attributes of the networks, including the actors' Freeman degree, network centralisation and pattern of ties. NetDraw with a principal components layout (Borgatti, Everett et al. 2002) was used to visualise the pattern of ties of the GINs and GPNs.

Main Findings

The GPN interacts with the GIN in both cases but such interaction shows case firm difference.

The GIN interacts with the GPN through the shared actors. Around 90% of the actors work for both the GIN and GPN in the two cases (see Figure 1 and Figure 2) although the shared actors are differently connected in the GIN and GPN respectively. In the case of TELE, a total of 26 out of 29 GIN actors also work for the GPN except the local competitor (LCPT), the international competitor (ICPT) and the international government (IGOV). In the case of AUTO a total of 21 out of 23 GIN actors also work for the GPN, except the national and international universities and research institutes (NU&R and IU&R). Shared membership implies that the knowledge the actor carries has a high propensity to be shared between both networks. Further, both case firms 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 firms: 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, the headquarters' R&D department (R&D), the local R&D subsidiaries (LSRD), the national R&D subsidiaries (NSRD) and the 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, therefore we 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, the headquarters’ marketing department (MKT), the national marketing subsidiary (NSMK), the international marketing subsidiaries (ISMK), the national customer (NCST) and the 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 the 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 an interviewee of AUTO.

The different contents of GIN-GPN interaction in the two firms brings up questions for further research.

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

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

The GINs have higher actor variety than the GPNs in both cases although the actor variety shows case firm difference

Both case companies' GINs have a greater variety of actors than their GPNs (see Figure 3 and Figure 4). TELE has three additional types of actors in the GIN than in the GPN, namely the local competitor (LCP), the international competitor (ICP) and the international government (IGOV). The connections with these actors are all have 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 (Ehrhardt 2004; Dittrich and Duysters 2007; Soh 2010) as well as the important role of government and competitors in the standard-setting alliance (Fontana 2008; Funk 2009). AUTO has two more types of actors in the GIN than in the GPN: 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 research studies which stress the important role universities and research institutes play as heterogeneous knowledge sources in innovation networks (e.g. Spencer 2003; Hemmert 2004; Chen and Kenney 2007).

Nevertheless, TELE's GIN and GPN both have a higher variety of actors than AUTO. TELE's GIN and GPN has 29 and 26 types of actors respectively while AUTO has 23 and 21.

Figure 3. TELE's GIN and GPN in circular layout

Figure 4. AUTO's GIN and GPN in circular layout

The GINs are more centralised than the GPNs in both cases, and the centralisation also shows case firm difference

Both case companies' GINs have higher network centralisation than their GPNs (see Table 3), 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 position power is concentrated in a small group of actors. Although centralisation facilitates coordination and integration (Provan and Milward 1995), it also limits the accessibility of information to peripheral actors in the network. The higher network centralisation of the GINs compared to the GPNs implies that the globalisation of innovation needs more integration and coordination among its actors than does the globalisation of production, which may result from the greater complexity, uncertainty and ambiguity of innovation. Two case firms' interviewees both confirmed their centrally controlled R&D system during the interviews.

Table 3. Network centralisation of the case firms' GINs and GPNs (%)

	GIN	GPN
TELE	44.09	30.44
AUTO	33.62	21.23

Noticeably, the GIN and GPN of TELE are more centralised than the GIN and GPN of AUTO respectively.

The GIN and GPN share same pattern of ties of the two cases respectively, but the pattern differs between the two cases.

Both case companies' GINs and GPNs have same pattern of ties. We mapped the two case firms' 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 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 falls in line with the fact that innovation and production are highly integrated value creation processes coordinated by the focal firm. The integration of innovation and production becomes more important when innovation is strongly related to customer or market-specific knowledge as mentioned by the interviewees in both companies. Under such a condition, market resources that attract the GPN and knowledge resources that attract the GIN agglomerate to the same location. Such agglomeration leads to the convergence of the pattern of ties of the GINs and GPNs.

In both case firms, their GIN and GPN have a similar pattern of ties; however, this such pattern is different between the two different firms in the two different industries. We found that the GIN and GPN of TELE are more globally organised, while those of AUTO are more locally organised.

Figure 5. TELE's GIN and GPN in principal component layout

Figure 6. AUTO's GIN and GPN in principal component layout

Discussion

The theoretical implication

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

for developing management theories in the context of globalisation.

The clear evidence of the differences in terms of network composition and network centralisation between the GINs and GPNs of the case firms suggests that the GIN and GPN have different structures and that it is inadequate to treat innovation as an add-on function of the GPN and assume that the innovation happens in the same structure of GPN. However, despite the differences in motivation and tasks undertaken in the GINs and GPNs, we see a large proportion of shared actors between the two networks and a convergence in the pattern of ties of the two networks. The shared actors in the networks and the shared pattern of ties of the GIN and GPN indicate the strong inherent connection between the innovation and production processes. It reflects the simultaneity and interdependence of innovation and production activities particularly when market resources for production and market-specific knowledge for innovation agglomerate to the same location. Given that innovation and production are different activities, and yet are repeated, simultaneous, and mutually antecedent processes with shared and different actors (Vermeulen and Kok 2013), it is theoretically more appropriate and clearer to consider the GIN and GPN as two different but interwoven layers of the same global value creation network of a firm.

The management implication

Management should be aware of the difference between the GIN and GPN when planning a company's strategic networks. First, the GINs are exposed to greater complexity and uncertainty on multiple levels (Håkansson and Ford 2002; de Rond and Marjanovic 2006; Möller and Rajala 2007) compared with the GPNs. Innovation calls for organisational flexibility and coordination (Liebeskind, Oliver et al. 1996; Santiago and Vakili 2005), while production requires more organisational stability and efficiency. The different emphases of innovation and production create tension in network decision-making, particularly when entering and exiting a product life cycle. Nevertheless, the effectiveness of releasing such tension by means of cooperative conflict management and comprehensive decision-making is affected by the degree of actor diversity and the network centralisation (Mihalache, Jansen et al. 2014). Thus, managing a firm's GIN and GPN requires different network management tactics.

Management must consider the interaction and coexistence of the GIN and GPN. First, when managing a firm's global network, management should be aware that the establishing or eliminating of a specific dyadic relation between two specific actors

may have a varying impact on innovation and production, 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 also have an impact on both innovation and production but to different extents and in different ways because it occupies a different position in the two networks. The change of the GPN may lead to the change of the GIN and vice versa. Second, management needs to pay attention to the overlap between the GIN and GPN, as in, where the interface is between global innovation and production and where the individual actors take double task of innovation and production.

The future research

In addition to the findings about GIN-GPN interaction, differences, and commonality, noticeable differences between the two cases are also found (see Table 3). In this paper, we suggest an industry-specific, knowledge base perspective to explore the cause of the differences. It has been argued that due to the different natures of the industry-specific knowledge bases (science-based versus engineering-based or analytic versus synthetic) (Asheim and Coenen 2005), firms in different industries are likely to organise their GIN differently (Asheim and Gertler 2005; Asheim and Coenen 2005; Moodysson, Coenen et al. 2008). It has been found that the industry-specific knowledge bases have a clear influence on the two case firms' GINs (Liu, Chaminade et al. 2013). Given that different forms of knowledge are considered one of the most important dynamics of globalisation of production (Dyer and Nobeoka 2002; Ernst and Kim 2002; Coe 2012), we have reason to expect that the knowledge base may have a similar influence on the firms' GPNs as well. The paper aims to apply the knowledge base perspective to explain the different findings between the two cases (see Table 4).

The industry-specific knowledge base perspective does not exclude the influence of firm-specific factors on the globalisation of innovation and production, such as a firm's strategy or culture (Kogut 1993; Kotabe and Murray 2004; Cesaroni, Di Minin et al. 2005; Hanson, Mataloni Jr et al. 2005; Dittrich and Duysters 2007; Mortara, Slacik et al. 2010; Mortara and Minshall 2011; Bader and Enkel 2014). In fact, further research combining the two perspectives may provide better understanding to firms' GINs and GPNs.

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

Findings	Explanations from knowledge base perspective
TELE's shared highly connected actors between its GIN and GPN are R&D-related actors while AUTO's are market-related actors	TELE's dominant knowledge base is more science- and R&D-based while that of AUTO is more market- and engineering-based.
TELE's GIN and GPN have higher actor variety than AUTO's	Knowledge created in TELE's industry is more complex and science-based. TELE's GIN needs more global coordination among more diverse actors, such as competitors and government agencies for standardisation, and its GPN needs more R&D-related actors for production compared with AUTO.
TELE's GIN and GPN are more centralised than AUTO's	Innovation in TELE's industry is more science-based and faces higher uncertainty, complexity, and ambiguity. Thus its GIN needs more coordination, integration, and centralised control. Its products are more standardised thus it can organise the GPN in a real global and centralised way. Innovation in AUTO's industry is more development and engineering rather than research. It is more problem-solving based on local market needs. Their products are less standardised but more customised. Thus AUTO's GIN and GPN are less centralised.
TELE's GIN and GPN are similarly organised in a global way and AUTO's are similarly organised in local way.	Knowledge created in TELE's industry is more science-based, standardized, codified and transferable and thus is appropriate and applicable worldwide. TELE can organise its GIN and GPN in a real global way. Knowledge created in AUTO's industry is more based on experiences, concrete know-how, craft and practical skills. Innovative solutions generated in one location may not be applicable to another location. Thus AUTO's GIN and GPN are more organised in a local way but under the control from the headquarters.

Conclusions

This paper is an explorative study about the interaction, differences, and commonalities between the GINs and GPNs of two firms. The findings are summarised in Table 5.

Table 5. Summary of the GIN-GPN interaction, differences, and commonalities of the cases

Interaction		
Finding	Network structural characteristics	Explanations
The GINs and GPNs interact	To both case firms, the GIN and GPN share most of the actors.	The interaction between the GIN and GPN reflects the interconnection between innovation and production processes in the value creation process.
Differences		
Findings	Network structural characteristics	Explanations
The GINs have higher actor variety than have GPNs	<p>The GINs have more types of actors than the GPNs.</p> <p>1) For TELE, government agencies and competitors of all geographical levels are involved in the GIN but not in GPN.</p> <p>2) For AUTO, international universities and research institutes are involved in the GIN but not in GPN.</p>	<p>1) In the ICT industry, collaborating with government agencies and competitors on standards-setting is more important for innovation than for production.</p> <p>2) In the automotive industry, knowledge sourcing from universities and research institutions is more important for innovation than for production.</p>
The GINs are more centralised than GPNs	Network centralisation of the GINs are higher than that of the GPNs	The GIN needs more integration and coordination, which is facilitated by network centralisation, than does the GPN thanks to the greater complexity, uncertainty and ambiguity of innovation.
Commonality		
Finding	Network structural characteristics	Explanations
The 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.

Based on our findings, we argue that it is inaccurate to consider the GIN and GPN as two separate networks or to consider that the GIN hides in the GPN. Instead, viewing the GIN and GPN as two different but interwoven layers of the global value creation network of a firm may provide better conceptual clarity for developing management theories in international business and for addressing the management challenge of simultaneously managing firms' globalisation for innovation and production. Furthermore, we also find differences when comparing the two case firms' GINs and GPNs. The paper suggests a knowledge base perspective and provides preliminary explanation for further research.

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

As with any exploratory analysis using novel, dedicated qualitative data, the paper has inevitable limitations. The first limitation is with the limited number of interviews. The second limitation is with the static nature of the data, which does not allow us to investigate whether the GINs evolve from GPNs, as the extant literature argues, or how the GINs and GPNs coevolve, which can be of great theoretical and practical importance.

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