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Three Essays on Network Embeddedness and International Business: Analysis of China's Aerospace Industry

par
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Résumé

Cette thèse explore les relations entre les configurations structurelles des réseaux inter-organisationnels et les stratégies d'internationalisation des entreprises dans le contexte du développement d'une industrie à forte intensité de connaissances dans une grande économie émergente. Adressant des contributions à l'acquisition des connaissances complexes d'une entreprise et à l'établissement de ses influences sociales, ce travail analyse les multiples dimensions de l'encastrement d'une entreprise dans les réseaux multiplex qui contribue à son avantage concurrentiel. Dans trois chapitres interdépendants, une série d'analyses empiriques évaluent l'impact des liens des affaires, la diversité des partenariats, et les chaînes de valeur mondiales sur l'encastrement des entreprises dans les réseaux. En utilisant la base des données de réseau collectées manuellement, qui composent des relations commerciales diverses parmi 920 entités économiques (les entreprises, les universités, les centres de recherche et de développement, les autorités gouvernementales), qui sont activement engagées dans le développement de l'industrie aérospatiale chinoise, cette thèse présente trois configurations des réseaux de production - le réseau multiplex national de production, le sous-réseau horizontal des partenaires collaboratifs, le sous-réseau vertical de la chaîne logistique. Après avoir calculé les mesures de centralité de tous les membres des réseaux et détecté leur affiliation aux communautés topologiques, cette thèse applique des méthodes quantitatives pour distinguer l'impact de plusieurs déterminants relationnels et géographiques sur l'encastrement dans les réseaux des entreprises diverses. Les conclusions principales de la thèse sont les suivantes: (1) comment l'établissement des relations verticales dans la chaîne logistique et des relations horizontales des partenaires collaboratifs coordonne la formation de communautés topologiques, et par conséquent, facilite l'acquisition des connaissances d'initiés par les entreprises étrangères; (2) la corrélation positive entre la diversité des partenariats et l'encastrement dans les réseaux pour les petites et moyennes entreprises (PME) malgré leur *liability of smallness*; (3) la forte domination des Fabricants d'équipement d'origine (FEOs) dans tous les stades de la chaîne de valeur, la contribution de la colocalisation dans des grappes industrielles à la position centrale des entreprises au noyau des réseaux, et l'interaction entre la *liability of* *foreignness* (LOF) et le développement économique régional, qui, par conséquence, a un effet sur l'encastrement structurelle et relationnelle d'une entreprise dans un réseau national de production. Cette thèse applique des approches interdisciplinaires qui combinent des théories et des techniques des affaires internationales, de géographie économique, d'innovation et d'entrepreneuriat. Ce travail caractérise les mécanismes de gouvernance dans des réseaux des affaires transfrontaliers et explique comment des antécédents divers affectent l'encastrement d'une entreprise dans des réseaux , qui est lié à ses avantages concurrentiels. Enfin, cette thèse offre les implications stratégiques pour les pratiques managériales et suggère des perspectives de recherche futures.

Mots clés : encastrement dans les réseaux, affaires internationales, industrie aérospatiale, chaînes de valeur mondiales, grappe industrielle, connaissances d'initiés, communauté topologique, petite et moyenne entreprise, innovation, entrepreneuriat

Méthodes de recherche : analyse des réseaux sociaux, méthode des moindres carrés ordinaire, régression logistique Probit, techniques de détection de communauté de la *Markov Cluster Algorithm* (MCL), analyse de centralité du réseau, analyse d'indice E-I des communautés, analyse d'indice de variation qualitative

Abstract

This thesis explores the relationships between the structural configurations of inter-organizational networks and the internationalization strategies of enterprises in the context of the developing knowledge-intensive industry situated in a large emerging economy. Addressing the contributions to complex knowledge acquisition and social influence establishment, this work specifies the multi-scopes of a firm's embeddedness in multiplex networks providing crucial competitive advantages. In three inter-related chapters, a series of empirical analyses assess the impact of network linkages, partnership diversity, and global value chain governance mechanisms on a firm's network embeddedness respectively. Based on the hand-collected network data of diverse business relationships among 920 economic entities (firms, universities, R&D centers, governmental authorities) that are actively engaged in the development of China's aerospace industry, this thesis presents configurations of the three production networks - multiplex national production network, horizontal collaboration sub-network, and vertical supply chain sub-network. After calculating the centrality indicators of all embedded network players and detecting their affiliation to topological communities, this thesis applies quantitative methods to distinguish the impact of several relational and geographic determinants of the network embeddedness of different types of firms (foreign-based firms, local SMEs, foreign subsidiaries etc.). Key findings of the thesis include: (1) how establishing vertical supplier chain relationships and horizontal collaborative partnerships coordinates topological community formation and enables foreign-based firms to acquire insider's knowledge; (2) the positive relevance of partnership diversity and the network embeddedness of small and medium-sized enterprises (SMEs) in spite of their liability of smallness; (3) the strong dominance of original equipment manufacturers (OEM) across the value chain stages, the contribution of co-location in industrial clusters to firms' proximity to the network core, and the interacting effect of liability of foreignness and regional economic development on a firm's structural and relational embeddedness in a national production network. This thesis applies an inter-disciplinary approach combining theories and techniques in international business, economic geography, innovation and entrepreneurship. It characterizes the governance mechanisms of cross-border business networks and explains how various antecedents affect a firm's network embeddedness related to its competitive advantages. Finally, this thesis outlines the strategic implications for managerial practices and suggests future research perspectives.

Keywords: network embeddedness, international business, aerospace, global value chains, industrial clusters, insidership, topological community, small and medium-sized enterprises, innovation, entrepreneurship

Research methods: Social Network Analysis**,** OLS multiple linear regression, Probit logistic regression, Markov Cluster Algorithm (MCL) community detection techniques, network centrality analysis, community E-I index analysis, Index of Qualitative Variation (IQV) analysis

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List of acronyms

APD	alliance portfolio diversity
AVIC	Aviation Industry Corporation of China
CASC	China Aerospace Science and Technology
CASIC	China Aerospace Science & Industry Corporation
CETC	China Electronics Technology Group Corporation
COMAC	Commercial Aircraft Corporation of China
CoPS	complex products and systems
FDI	foreign direct investment
GDP	gross domestic product
GVC	global value chain
IB	international business
IQV	Index of Qualitative Variation
JV	joint venture
LQ	location quotient
MCL	Markov Cluster Algorithm
MNE	multinational enterprise
MRO	maintenance, repair and operations
NBSC	National Bureau of Statistics of China
NECIDS	National Enterprise Credit Information Disclosure System
OEM	original equipment manufacturer
R&D	research & development
SAIC	State Administration for Industry and Commerce
SME	small and medium-sized enterprise
VIF	variance inflation factor

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I acknowledge that the earlier manuscripts of the thesis chapters have been presented in following conferences and workshops including:

- Academy of International Business Annual Meeting (2017 Dubai; 2018 Minneapolis; 2019 Copenhagen)
- Academy of International Business Canada Chapter Meeting (2018 Kingston)
- Canadian Council for SMEs and Entrepreneurship Conference (2017 Québec City)
- CIRANO-Sam M. Walton College of Business Workshop on Networks in Trade and Finance (2016 Fayetteville, 2017 Montréal)
- European International Business Academy (EIBA) Conference (2017 Milan)
- Global Conference on Economic Geography (GCEG) (2018 Cologne)
- Humangeographisches Kolloquium WiSe 2017/18, Friedrich-Schiller-Universität Jena (2017 Jena)
- Institute of Institutional and Innovation Economics (IINO) Workshop "Innovation in Emerging Economies" (2017 Berlin)
- International Business, Economic Geography and Innovation (iBEGIN) Conference (2016 Philadelphia; 2017 Venice)

- International Symposium on Multinational Business Management-Entrepreneurship, Organizational Change and Employment Management (2017 Nanjing)

- Munk School of Global Affaires Creating Digital Opportunity (CDO) Annual Partnership Conference (2017 Montréal)

I hereby thank the feedback and critiques from all conference chairs and discussants for deepening my intellectual insight and improving the quality of the papers.

Preface

This thesis got its start when I was completing the mandatory courses for Ph.D. candidacy. Having taken the courses "Global Economy, Creativity & Innovation" (Professor Patrick Cohendet, 2014 Fall), "Comparative Corporate Governance" (Professor Michael Carney, 2015 Winter) and "Applied Network Analysis" (Dr. Ekaterina Turkina, 2015 Fall), I was fascinated by now knowledge is created and transferred in the process of forming inter-organizational networks across geographic boundaries and institutional heterogeneity. During my preparation of the comprehensive exam, I reviewed a large sum of literature of international business, economic geography, corporate governance and organizational sociology. Regardless of their different research conventions, the frontier research of these subjects all calls for a better understanding of how inter-organizational networks are forms in the process of globalization and what the implications of a firm's network embeddedness in international business for managers and policymakers. Specifically, observing the rise of large emerging markets, where knowledge-intensive industry is becoming the vehicle of economic growth, and network formation plays a crucial role in the institutional transition, in the global business arena, I recognize the high potential of applying social network analysis in exploring the eco-system of business development in these economies as well as the new opportunities for various economic entities.

Tackling all these general research interests, in early 2016 I started this 3-year research project on the production networks of the Chinese aerospace industry. Adapting a deductive approach, I first collected the relational data and constructed the multiplex network configurations, then designed a series of empirical analyses to study:

- How foreign-based firms acquire insider's knowledge by leveraging different types of business relationships in the host country networks.
- What antecedents contribute to SMEs' embeddedness in the production networks.
- How the global value chain governance mechanisms coordinate production networks configurations.

These three inter-related themes thereafter compose the research questions of the chapters of my thesis.

In the past three years, I have toured around the world presenting the progress of my research. In various academic colloquia and workshops, I had the privileged to have the feedback and critiques of globally influential scholars including Professor Harald Bathelt (University of Toronto), Professor John Cantwell (Rutgers Business School, Newark and New Brunswick), Professor Jean-François Hennart (Tilburg University), Professor Ram Mudambi (Fox School of Business and Management, Temple University), Professor Julian Birkinshaw (London Business School). I am very grateful for their insightful comments to enhance the intellectual perspectives and overall quality of the manuscripts at different stages of working paper development.

Looking back at the starting point of my thesis, I am always amazed by the paths I have gone through crossing the river by feeling the stones. Throughout the voyage of endeavour, I have experienced the ups and downs as all scholars have experienced in crafting their research. Acknowledging the still existing limitations and imperfection in my research, I see this thesis as a milestone rather than the destination of this long journey. I cordially thank the generous support I have received from my supervisory committee members, academic advisors, friends and family since my arrival in Montréal in 2013. Though it is still hard to tell what the future brings, I would dedicate this thesis to my 20s and this city I've lived for 6 years for all the unanticipated memories since that snowy New Year's Day at the Pierre Elliott Trudeau International Airport.

Introduction

The growing interconnectivity and interdependence of economic entities (e.g. firms, universities, R&D centers, governmental authorities, communities) in cross-border business networks have become one of the most prominent characteristics of the economic globalization nowadays. Revolutionary technological innovation enables economic entities situated in dispersed geographic locations to exchange complex knowledge by establishing versatile business relationships with each other (Kogut, 2000; Bathelt *et al.*, 2004; Inkpen & Tsang, 2005).

International business researchers have paid increasing attention to the relevance between network configurations and a firm's competitiveness in the market. Given the hierarchy of power distribution in networks (Moody & White, 2003), reaching advantageous position in the business network facilitates firms to have (1) better access to strategic resources (Barney, 1991; Lavie, 2006) (2) higher capacity of organizational learning and innovation (Podolny & Page, 1998; Uzzi & Gillespie, 2002; Herstad *et al.*, 2014) (3) stronger influence on other economic actors' behavior (Gulati, 1998; Rugman & Verbeke, 2003a; Andersson *et al.*, 2007; Dhanaraj, 2007) (4) overcoming institutional voids by amending inter-firm relationships (Khanna & Palepu, 1997; Jansson, 2008). In this sense, understanding how inter-organizational networks are formed and coordinated contributes to our understanding of knowledge-driven growth for enterprises that conduct international business and the regions where they are located in.

Reviewing the large sum of literature on the subject, one can clearly identify the strong research potential and practical implication of applied network studies in international business (e.g. Holm *et al.*, 1996; Andersson & Forsgren, 2000; Dhanaraj, 2007; Johanson & Vahlne, 2009; Awate & Mudambi, 2017; Turkina & Van Assche, 2018), economic geography (e.g. Malmberg & Maskell, 1997; Ernst & Kim, 2002; Bathelt *et al.*, 2004; Glückler, 2007; Coe *et al.*, 2008; Ter Wal & Boschma, 2009a; Bathelt & Li, 2013; Turkina *et al.*, 2016), innovation and entrepreneurship (Aldrich & Zimmer, 1986; Hoang & Antoncic, 2003; Coviello, 2006; Sorenson *et al.*, 2006; Phelps *et al.*, 2012). Whereas most of the research of the fields mentioned above concentrates on the conceptual synthesis of the strategic implication of network configurations on embedded firm's performance and competitiveness, empirical data-driven analyses on the determinants of network governance mechanisms, specifically in the context of developing economies, still remain scarce.

This thesis explores how international business networks are constructed and coordinated, how embedded players interact with each other to achieve multiple strategic goals in the network configurating processes. To tackle these subjects, I will conduct three inter-related studies in this thesis on the following topics:

- How foreign-based firms obtain insidership by leveraging different types of business relationships in host country networks. On the ground of knowledge generation and transfer patterns across topological communities, this study evaluates how establishing cross-border horizontal collaborative relationships and vertical arm's length supply chain relationships contributes to foreign-based firms' efforts in to acquire insider's knowledge in the host country.

- What antecedents contribute to local SMEs' embeddedness in the production networks. This study indentifies of strategic goals of outgoing SMEs in embeding in production networks, then assesses how firm size, age and partner diversity affect the goal achievement.

- How the global value chain governance mechanisms coordinate production networks configurations. This study detects how value chain stages, industrial cluster formation and miscellaneous geographic factors affect a firm's proximity to the network core and its number of direct contacts in international business.

The three chapters of this thesis all emphasize the strong practical implications of network embeddedness for firms, especially in the context of knowledge-intensive industries in emerging economies. Furthermore, they underline the contributions of geographic location, value chain coordination and diversification of partnership strategies to a firm's network embeddedness.

The empirical analysis of this study is based on multiplex production network configurations of China's aerospace industry. The selection of the context is based on the following criteria:

- The complexity of knowledge exchanges and business relationships across geographic boundaries in the aerospace industry.

The aeronautical product manufacturing process reflects the hierarchical integration of a wide range of inter-related value-added sectors and knowledge exchange activities in the global production networks. Major categories of aeronautical products, such as passenger aircraft, aircraft carriers and engines, helicopters, avionics equipment, flight simulator, belong to the high cost, complex products and systems (CoPS). These products consist of a large number of tailored-made and engineering intensive components, devices and sub-systems, which require a high degree of novel knowledge and technology. The complex manufacturing process of aeronautical products relies on world-wide coordination of business activities and cooperation among stakeholders, including OEMs, multiple-tier suppliers, support service providers, airlines companies, R&D centers, universities, and policymakers (Niosi & Zhegu, 2005). The configurations of the aerospace production networks are characterized by complex knowledge exchange, diversity in business relationships and global geographic scope. Hence, the industrial setting fits in the general purpose of the thesis well.

- The emerging market power of Chinese enterprises in the global competition of the aerospace industry.

The emergence of the Chinese aerospace industry distinctly reflects new opportunities arising in the global aerospace industry. Characterized by world leading economic growth, constant attractiveness to FDI, large population with increasing income, strong governmental support, China appears to be world's second largest civil aviation market with robust growth rate (Cliff *et al.*, 2011). On the demand side, increasing travel frequency by air in China expedites the establishment of new air routes, delivery of new aircraft and construction of new airports. It is estimated that the current value of Chinese civil aviation market is 950 billion US dollar and the total number of aircraft fleet in 2034 will reach 7210, which triples that number in 2014 (See Table 0.1).

Table 0.1: Chinese Civil Aviation Statistics (2006-2014)

	2006	**2008**	**2010**	**2012**	**2014**
Number of Passengers Dispatched by Civil Aviation (Million Passenbers)	159.678	192.511	267.691	319.361	391.949
Domestic Routes	145.53	177.32	248.377	296.002	360.399
International Routes	14.15	15.19	19.3143	23.3581	31.5498
Regional Routes (HMT)	5.36	5	6.7237	8.3368	10.0524
Passenger-Distance Dispatched by Civil Aviation (Passenger Kilometre)	2370.66	2882.8	4039	5025.74	6334.19
Domestic Routes	184.675	230.553	328.006	403.376	501.739
International Routes	52.391	57.727	75.893	99.198	131.68
Regional Routes (HMT)	7.581	7.182	9.818	12.388	14.966
Number of Civil Aviation Routes (Line)	1336	1532	1880	2457	3142
Domestic Routes	1068	1235	1578	2076	2652
International Routes	268	297	302	381	490
Regional Routes (HMT)	43	49	85	99	114
Number of Civil Aviation Airports (Unit)	142	152	175	180	200
Number of Civil Aircraft (Unit)	1614	1961	2405	3589	4168

*HMT: Hong Kong, Macau, Taiwan

Sources: National Bureau of Statistics of China

On the supply side, with strong support from the government, domestic aerospace firms aim to “catch-up” with competitors originated from advanced economies. Recognized as one of the “strategic emerging industries” by the Chinese government, the aerospace industry serves as a national economic pillar and forerunner of economic growth of the country. Chinese central government provides special funds and enacts preferential policies for domestic firms specialized in the aerospace industry. In 2008, the remerger of AVIC I and AVIC II as the new Aviation Industry Corporation of China (AVIC), as well as the foundation of The Commercial Aircraft Corporation of China (COMAC) signaled the country’s ambition to utilize the national power to challenge the existing order of the global aerospace market. On the other hand, the Chinese government incrementally reforms the institutions and eradicates market entry barriers for foreign MNEs to solve the long-existing problem of inefficiency and low competence. Encouraged by the preferential industrial policies, an increasing number of foreign MNEs enter the Chinese aerospace market in recent years and embed themselves in the local networks via forming diverse business relationships local partners. For instance, the development of China’s first narrow-body twinjet airliner- C919 Model engaged close technological collaboration between COMAC and global giants such as SAFRAN, GE Aviation, UTC Aerospace Systems, Bombardier. In 2017, the first flight testing of C919 aircraft was successfully launched and soon attracted the interests of buyers (by the end of 2018, COMAC has received in total of 815 orders from 28 customers). The global expansion of production networks of China’s aerospace industry underlines the dynamisms of changing the landscape of the global competition.

- The important role of network embeddedness in business development in a large emerging economy.

The rise of emerging economies brings up new perspectives to understand the network evolution in international business. Characterized by on-going economic liberation and institutional reform, emerging economies provide immense market potential and local intelligence yet to be fully integrated into the global market (Hoskisson et al., 2000). Globally present MNEs “transmit capital, knowledge, ideas and value systems across borders” (Meyer, 2004) that incorporate emerging economies in the global market and enhance the competitiveness of local firms through network linkages (Wright et al., 2005). On the other hand, institutional voids and the consequential liability of foreignness require cautious planning of internationalization strategy in entering emerging economies (Zaheer, 1995; Khanna & Palepu, 1997). Conflicts of interest between MNEs and local parties often lead to high transaction costs and discriminatory market barriers for MNEs in the progress of their market entry (Hoskisson et al., 2000; Nachum, 2010). The stickiness of local-context specific relational knowledge requires high absorptive capacity (Cohen & Levinthal, 1990) and frequency interactions with local partners based on trust and long-term commitment (Reagans & McEvily, 2003). All these opportunities and challenges in the progress of internationalization entail the high relevance in network-based business development strategies in the emerging economies that are not sufficiently paid attention to in conventional IB research based on advanced economies (Wright *et al.*, 2005; Cuervo-Cazurra, 2012; Meyer & Peng, 2016).

The empirical analysis of this study is based on multiplex production networks of China's aerospace industry. I construct a hand-collected dataset that captures the egocentric networks of 140 large commercial aviation companies in China that are included in the *Civil Aviation Industrial Yearbook 2014* as egos as well as their first-degree direct contacts as alters. Then, I approach to their first-degree formal business contacts at home and abroad including strategic alliances, joint-ventures and R&D programs, tentative cooperation and supplier-buyer agreement. All these business relationships are categorized into two types of linkages in the networks (Giroud & Scott-Kennel, 2009; Turkina & Van Assche, 2018):

(1) Horizontal Linkages: the collaborative alliances in the form of co-production, co-management and technological sharing activities based on the common knowledge base and mutual trust.

(2) Vertical Linkages: the arm's length supply chain relationships with suppliers, subcontractors, distributors and buyers in the sequential input-output flows.

In addition, I collected data on the attributes of the embedded economic entities. Firms and other organizations whose major business establishments are registered in the national administrative system for industry and commerce in 31 provincial administrative regions in mainland China (excluding Hong Kong, Macau, Taiwan) are identified as local-based economic entities, *vice versa*, those registered beyond the national boundaries as identified as foreign business units. For local-based economic entities, I used information provided by the State Administration for Industry and Commerce's (SAIC) National Enterprise Credit Information Disclosure System (NECIDS) to identify its official name in Chinese, address of registration, type of incorporation and ownership, year of foundation and registration, major business specialization and registered capital. For foreign-based ones, I mainly obtain data based on the information disclosure on their web portals and publicly available financial reports. In addition, secondary data such as business news on aerospace industry and market research reports are also important references to determine the existence of linkages.

Finally, I incorporated all connected economic entities into two sub-networks- horizontal collaborative network (Horizontal Network) and vertical supplier-buyer network (Vertical Network) - by the archetypes of linkages. Then I overlapped the layout of both sub-networks among the same group of economic entities to a multiplex production network of the Chinese aerospace industry (Multiplex Network). Based on the structural layout of these networks, I applied a series of network analysis techniques to depict their overall structural features and identify the positions of individual players in the framework. Then I conducted regression analyses to study how organizational and geographic attributes affect the embeddedness of individual economic entities in the network configurations of these networks. By the end of each chapter, I discuss the practical implications of the research findings and potential future research directions.

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Chapter 1
Foreign-based Firms and Host Country Networks: Analysis of China's Aerospace Industry

Abstract

A growing IB literature has studied how multinational subsidiaries integrate into host country networks, yet little is known how foreign-based firms, which are not located in the host country, embed themselves in these same networks. Based on the relationship between cross-border knowledge transfer and network community formation, we argue that geographic boundary affects foreign-based firms' effort in insidership acquisition via diverse types of business relationships in a host country. Using hand-collected network data for China's aerospace industry, we find that foreign-based firms primarily use "vertical" buyer-supplier linkages to integrate into host country communities. This differs from local firms which disproportionately use "horizontal" partnership linkages to embed themselves in communities.

1.1 Introduction

There is growing consensus among international business scholars that embeddedness in the local networks matters for a foreign firm's competitiveness in a host country. The acquisition of insidership - the knowledge about the new opportunities via social exchanges with central actors in business networks- affects a foreign firm's performance in host countries (Johanson & Vahlne, 2009; Holm *et al.*, 2015; Cano-Kollmann *et al.*, 2016). For individual foreign firms, insidership acquisition extends the channel to absorb strategic resources and local-context specific knowledge, as well as stimulate future collaboration potential in opportunity development (Cantwell & Mudambi, 2011). By absorbing and transferring local business know-how in the network architectures, foreign firms can enhance their innovation capability and market performance (Andersson *et al.*, 2002; Capaldo, 2007; Phelps *et al.*, 2012).

In regard to the insidership acquisition process in local business networks in the host countries, most IB studies have focused on the roles of foreign-owned subsidiaries that have set up in the host country in this process (e.g. Andersson *et al.*, 2007; Dhanaraj, 2007; Cantwell & Mudambi, 2011;

Meyer *et al.*, 2011; Rugman *et al.*, 2011; Asakawa *et al.*, 2018). Their arguments attribute to the presumption of their "dual embeddedness" in both the intra-firm network with their headquarter and other subsidiaries and the inter-organizational network with co-located firms in the host countries (Figueiredo, 2011; Ciabuschi *et al.*, 2014; Schotter *et al.*, 2017). In the host country context, the tacit and sticky local knowledge is bounded to specific territories and requires frequent face-to-face communication between managers of co-located firms and other stakeholders (Nonaka & Takeuchi, 1995; Cantwell & Santangelo, 1999; Maskell & Malmberg, 1999; Asheim & Isaksen, 2002; Mudambi & Swift, 2011). By establishing subsidiaries, headquarters located outside the host country can benefit of local tacit knowledge spillover absorption through feedback pipelines across geographic boundaries. (Jaffe *et al.*, 1993; Bathelt *et al.*, 2004; Mudambi, 2011; Schotter & Beamish, 2011). Consequently, the range of direct local contacts as well as the social influence on the other network members, that is, the local network positions subsequently contribute to its organizational capacity and local competitiveness (Monaghan *et al.*, 2014).

Nonetheless, these studies do not fully consider *foreign-based firms*- the corporate entities that are neither physically located in the host country nor predominately owned by a business group of the host country- as independent entities of local business networks in the host countries. Generally considered to be market outsiders, foreign-based firms are urged to establish local subsidiaries and exercise their business mandates in the host countries (e.g.Tan & Meyer, 2011; Vahlne *et al.*, 2012; Schweizer, 2013). However, there are a number of reasons why this assumption may not match real practices. First of all, due to high resource commitment and uncertainty-incurred market risk, establishing subsidiaries might not be the first choice of new market entry (Hill *et al.*, 1990; Brouthers, 2002; Grover & Malhotra, 2003; Meyer *et al.*, 2009). Increasing number of foreign-based firms form joint-ventures or adapt other non-equity modes (e.g. outsourcing and offshoring, joint R&D partnership, licencing) to learn from external partners to become insiders at much lower risk level. That means, without having a local presence, foreign-based firms can still develop strong business relationships with a broad range of local partners. For example, they may establish vertical supply chain relationships to local buyers and/or outsource manufacturing and services to the local subcontractors to discover new demand and develop market knowledge as local competitiveness (Camuffo *et al.*, 2006; Mudambi & Tallman, 2010; Cao & Zhang, 2011). Besides, they can form collaborative alliances with highly competent local partners to extend new knowledge horizons in the progress of technological innovation (Tamer Cavusgil *et al.*, 2003; Grant & Baden - Fuller, 2004; Simonin, 2004). Establishing subsidiaries may contribute to insidership acquisition of foreign-based firm, but it is not a necessary condition. At the same time, foreign-based firms can become insiders by forming diverse business relationships with local partners in addition to establishing subsidiaries.

This study explores the mechanisms of insidership acquisition and how foreign-based firms can leverage different types of business relationships to access local knowledge in the host country network to become insiders. We first propose an extended concept of *host country network* that not only includes the linkages between firms located in the host country, which include local firms, foreign subsidiaries and other locally present organizations, but also incorporates foreign-based firms that are located outside the territorial boundary but have linkages with firms located in the host country. The individual firms and other organizations that conduct business activities in the host country (e.g. manufacturing operations, new product research and development (R&D), inbound-and-outbound logistics, marketing and sales, specialized services) are thereafter referred to as the *nodes* of the network. Then, the formal inter-organizational business relationships (e.g. supplier-buyer agreements, manufacturing and service outsourcing, joint-venture and/or R&D partnerships) are characterized as the *linkages*. According to the diverse forms of business relationships, all network linkages are categorized into two archetypes - horizontal collaborative alliances (*horizontal linkages*) and vertical arm's length supply chain relationships (*vertical linkages*). Then, we focus on how foreign-based firms are gathered within internally densely connected and externally exclusive communities in the host country networks.

To study foreign-based firms' integration in the host country network, we applied community structure detection techniques to analyze how nodes are connected and gathered in network subgroups. Based on the graph topology of network layout, we partition the host country network into several inter-connected *topological communities*. Within each topological community, nodes are more densely connected with each other than with nodes outside of the community (Fortunato, 2010; Ding, 2011). We will use this approach to verify to what extent foreign-based firms form topological communities with local firms and which type of linkages (horizontal versus vertical) they use to become insiders in the host country networks.

This study analyzes the network structure of the international business networks of the Chinese aerospace industry. This contextual setting takes the international manufacturing and knowledge exchanges across geographic boundaries, as well as the dynamism of the Chinese aerospace industry into consideration. The production of aeronautical products integrates tailored-made and engineering-intensive components, devices and sub-systems, accordingly, the manufacturing processes involve intensive knowledge exchange in technological innovation and manifold business relationships across the globe. Recognizing the aerospace industry as a strategic industry, Chinese government incrementally adjust its industrial policies in the aerospace sector and lessen the entry barriers for foreign-based firms. In light of the fact that the MNEs "transmit capital, knowledge, ideas and value systems across borders" (Meyer, 2004: 259), strengthening the international connections towards foreign-based firm cant enhance the competitiveness of local firms and regional innovation system through knowledge spillovers in networks and incrementally incorporate disperse regions in the global market (Meyer, 2004; Wright *et al.*, 2005; Scalera *et al.*, 2015). To explore and exploit the large market potential, foreign-based firms also have a strong motive to integrate into the Chinese aerospace business network and build up linkages with local partners. As a result, the increasing connections that direct to the foreign-based firms and the fast-changing dynamics of domestic business networks have become a "new normal" in the Chinese aerospace industry. Studying the Chinese aerospace business networks helps us to understand the general motives, patterns and consequences of foreign-based firms' presence in the host country networks.

The organization of this study is as follows. We first review the literature on the relationship between network embeddedness and insidership as means to acquire competitive advantages in the host country networks. Then we zoom in to the structural components of the network, that is, topological community and discuss the nature of their formation and the relationship to the network embeddedness of individual firms. Next, we develop our hypotheses on the impact of geographic factors on different typology of business relationships within and across topological communities. Based on the analysis of the Chinese aerospace business networks, we apply several sets of empirical tests to examine if our hypotheses hold. As a conclusion, we summarize how foreign-based firms leverage their cross-border horizontal and vertical linkages to embed themselves in local communities to obtain the insidership as their internationalization strategy.

1.2 Literature Review

1.2.1 Insidership, Network Structure, and Topological Communities

The insidership acquisition is a collaborative organizational learning process embedded in networks, which involves the social exchange among firms of diverse specializations and the establishment of relationships (Hakansson & Johanson, 1992; Johanson & Vahlne, 2009; Holm *et al.*, 2015). Perceived as knowledge processors in the networks, individual firms combine their intrinsic strategic assets as knowledge base with the external architectural frames of pipelines in the knowledge exchange dynamics (Kusunoki *et al.*, 1998; Amin & Cohendet, 2004; Bathelt *et al.*, 2004). Representing the collective knowledge acquired to achieve the productive objectives, the knowledge base a firm grounds in its business conduct represent the cognitive boundary of organizational learning and affects the pattern of inter-organizational collaboration (Saviotti, 2004; Quatraro, 2010; Krafft *et al.*, 2011). On this basis, Buckley *et al.* (2009) identified two types of inter-organizational knowledge transfers in establishing strategic business relationships: (1) complementary knowledge: similar specialized knowledge shared by firms in the forms of collaborative partnerships; (2) supplementary knowledge: dissimilar specialized knowledge obtained from business partners via backward and forward linkages. Over different stages of opportunity development, firms incrementally explore (including recognition and experimentation) new horizons of knowledge base by learning and exchanging supplementary knowledge, and also exploit (including refinement and extension) the depth of the existing knowledge base by sharing complementary knowledge (March, 1991; Alvarez *et al.*, 2013; Mainela *et al.*, 2014).

The inter-organizational learning in insidership acquisition is embedded in networks they form via establishing diverse business relationships. How knowledge is created and transferred is, thereafter, embodied in the structural layout of the network (Cowan & Jonard, 2004). Gulati (1998) referred to the impact of network structure on the organizational behavior and market performance of individual nodes as network embeddedness consisting of two dimensions: (1) relational embeddedness: network-related advantages generated by of learning and the exchange of information in close dyadic relationships. (2) structural embeddedness: competitive advantage generated by influence over the whole network through direct and indirect connections in the network configuration layout. Well-connected firms with high network embeddedness are more capable of taking control of resources and information flows and influencing the behavior of the others. Thereafter, they are more likely to become network insiders than less well-connected counterparts (Gulati, 1999; Teece, 2007; Monaghan *et al.*, 2014). Shaping the network embeddedness of individual firms on the ground of different knowledge bases and capacities, the configuration of inter-organizational business networks follows certain social rules (Ter Wal & Boschma, 2009b).

These rules include (1) homophily and assortativity: firms of similar social background and knowledge base are likely to establish mutual connections with each other (McPherson *et al.*, 2001; Kossinets & Watts, 2009; Rivera *et al.*, 2010); (2) triadic closure: through the mitigation of a common broker, two indirectly connected firms are likely to establish a weak tie between each other over time (Burt, 1992; Kossinets & Watts, 2006; Opsahl, 2013); and (3) preferential attachment: firms that already have a large number of social contacts are likely to have more relationships with new partners (Barabási & Albert, 1999; Newman, 2001; Vázquez, 2003). The first two rules are based on the assimilation of common knowledge base, social status and relationships, which are strengthened by mutual trust and long-term commitment. While the preferential attachment rule is the result of different levels of absorptive capability and social hierarchy.

As a consequence, the knowledge-based configuration mechanisms contribute to the scale-free "small world" structual features of business networks (Watts & Strogatz, 1998; Uzzi & Spiro, 2005). Disperse linkages bridge a large amount of nodes in a deceralized network framework. However, the inter-organizational linakges are not evenly distributed. On the one hand, a large quantity of linkages can gather among a few nodes and contribute to the formation of internally densely connected subnetwork communities. On the other hand, a small fraction of highly capable "boundary spanners" (e.g. Williams, 2002; Mudambi, 2011; Schotter *et al.*, 2017) channel these communities and contribute to the overall connectivity of the large networks. Since the identification of these subnetwork communities is based on graphical topology of network hierarchy and applies community detection techniques (e.g. Bonacich, 1972; Clauset *et al.*, 2004; Newman & Girvan, 2004; Van Dongen, 2008; Fortunato, 2010), we define these internally densely connected and externally sparsely channelled sub-network communities as *topological communites*.

Representing the gathering tendency of business relationships, the structural composition of topological communities implies how firms acquire insidership embedded in business networks. Sharing complementary knowledge and exploiting the depth of common knowledge base enhanced by mutual trust and long-term commitment, nodes embedded within the same topological communities are more likely to have intensive multilateral business collaborations with each other and generate insidership. In contrast, due to the high resource commtiment and market risk, the cross-community linkages are more likely to be directed to a few boundary spanners of high absorptive capacity (Cohen & Levinthal, 1990). The boundary spanners lead new knowledge explorationy and the supplementary knowledge exchanges across different knowledge bases. In addition, they may also embed themselves in the topological community at the interface of sequential production stages via forward and backward linkages in production flows across geographic boundaries (Schotter *et al.*, 2017).

In sum, establishing boundary spanning linkages across topological communities based on absorptive capacity and market power initiate the process of opportunity discovery, while extending and deepening direct connections to other members within the same topological community based on mutual trust and commitment ultimately finalize the process turning a firm from outsider to insiders. Figure 1.1 exhibits the generic layout of topological communities. In the next section, we will continue how geographic boundary affect the configuration of topological communities and the insidership acquisition process.

Figure 1.1 here

1.2.2 Foreign-based Firms in the Host Country Networks

In numerous IB studies, foreign-based firms are treated as outsider in the host country networks. Due to geographic distance and environmental differences between host and home countries, foreign-based often encounter the challenge of liability of foreignness (Johanson & Wiedersheim -

Paul, 1975; Hymer, 1976; Zaheer, 1995). The spatial distance between the host and home countries increases communication and transportation costs. Consequently, it reduces the effectiveness of cross-border knowledge transfer (Zaheer, 1995). Differences in cognitive perception, organizational structure, cultural norms and institutional all set hurdles for foreign-based firms to understand the local-context specific knowledge in the host countries (Polanyi, 1966; Gertler, 2003; Dhanaraj *et al.*, 2004; Boschma, 2005). Liability of foreignness of foreign-based firms is reflected in missing connections with local suppliers, subcontractors, research partners and policymaker. It leads to the lack of essential local market knowledge and constraints new opportunity development (Brouthers *et al.*, 2016). The relationship-/network-specific disadvantages and difficulties a foreign-based firm encounter in opportunities discovery and creation in new market entry are, thereafter, defined as as "liability of outsidership" (Johanson & Vahlne, 2009).

Though highly relevant, liability of foreignness and liability of outsidership have different theoretical grounds. The former characterizes country-specific competitive disadvantages related to the geographic distance and institutional differences, while the latter addresses the lack of knowledge due to limited access of contacts regardless of geographic location. Though co-location related knowledge spillover indeed contribute to the learning process of subsidiaries, to reach spatial proximity does not serve as a sufficient condition for autonomous interactions in the networks or lead to the acquisition of insidership as consequence (McKelvey *et al.*, 2003; Moodysson & Jonsson, 2007; Moodysson, 2008). Latest research in international business and economic geography even suggests that geographic distance is not a good predictor to explain network configuration. Boschma (2005) claims that the spillover effect of co-location only takes spatial distance into account, but disregards industry related factors including the cognitive, organizational, social, and institutional differences between home and host regions. Mariotti *et al.* (2010) argue that although geographic proximity provides the potential for co-located economic entities to interact with each other, it hardly guarantees actual interaction and the subsequent knowledge spillover in between. Moreover, through geography-determined foreign/local division is still regarded as the threshold in market entry, the conceptualization and deterministic role of geographic distance in internationalization are under question, putting geographic factors to a weak indicator to explain the interactions in the networks (Turkina *et al.*, 2016; Beugelsdijk *et al.*, 2018; Turkina & Van Assche, 2018). As Johanson and Vahlne (2009) remarked, though "foreignness complicates the process to become an insider", the process of opportunity development and social exchanges in networks can turn a foreign-base firms from an outsider to an insider.

The relational proximity within topological community provides an alternative perspective to explain the insidership acquisition. Johanson and Vahlne (2009) attribute reciprocal learning in enhancing business relationships with local firms based on mutual trust and long-term commitment as the solution to shift outsidership to insidership in the host country networks. In this sense, the insidership acquisition predominantly takes place within the dense inter-organizational connections within the topological communities. In addition, though lacking local insights at first place in new market entry, many foreign-based firms are competent in leveraging strategic organizational resources within and beyond the border of the host country to overcome liability of outsidership (Tsai, 2001; Schleimer & Pedersen, 2014; Cano-Kollmann *et al.*, 2016; Kano, 2017). Foreign-based firms with high capacity to understand knowledge of different natures are more likely to form tight and sustainable alliances with trustworthy local partners as their conduits of insidership (Reuer & Lahiri, 2013; Amann *et al.*, 2014; Peterson & Søndergaard, 2014). By establishing cross-border linkages with already existing local topological communities sharing complementary knowledge bases, foreign based firms can also become deeply embedded in the same community and serve as boundary spanners to optimize the efficiency of local knowledge diffusion (Rychen & Zimmermann, 2008; Lorenzen & Mudambi, 2013; Morrison *et al.*, 2013).

1.2.3 Linkage Diversity and Topological Communities

Our next step is to assess the effectiveness of insidership acquisition via different types of business relationships. In this research, we concentrate on the formal business networks based on contractual relationships in the production processes and knowledge exchanges (Parker, 2008; Li *et al.*, 2010). The knowledge exchanges in forward-and-backward linkages as well as the positive spillover externalities and trust-based knowledge sharing thanks are the two centripetal forces of network agglomeration (Fujita *et al.*, 2001). These two knowledge-based mechanisms of network formation are entailed in the diversity of business relationships that can be attributed to two categories: (1) horizontal linkages: business relationships that connect firms of similar profiles and competencies. They are collaborative alliances in the form of co-production, co-management and technological sharing activities based on the complementary knowledge base and mutual trust (Spencer, 2008; Giroud & Scott-Kennel, 2009; Buckley, 2011; Turkina *et al.*, 2016); (2) vertical linkages: business linkages in sequential input-output flows. They represent arm's length supplier-buyer relationships based on the supplementary knowledge base (Giuliani *et al.*, 2005; Giroud & Scott-Kennel, 2009; Perri *et al.*, 2013).

Relating to the mechanisms of topological community formation, we can further infer that, as firms of similar profiles tend to establish mutual connections in an internally densely interconnected community on the homophilic knowledge basis, horizontal linkages are more likely to assemble within the same topological community (Kossinets & Watts, 2009; Li, 2014; Turkina *et al.*, 2016). In contrast, vertical linkages are established between firms with divergent specialization and cognitive distance over the backward-and-forward production streams (Fujita *et al.*, 2001; Boschma, 2005). Depending on the market structure, firms on the edges of vertical linkages often have a different degree of connectedness in the network. Some economic members are more capable of accessing broad knowledge pool embodied in different topological communities than the others. In the sense of insidership acquisition, learning supplementary knowledge from their suppliers and buyers, firms establish vertical linkages to discover new demand and market opportunities (Cox, 2001; Lonsdale, 2001; Ireland & Webb, 2007). While, sharing complementary knowledge based on mutual trust and reciprocity, firms become interconnected in specialized production modules and finalize the insidership acquisition at the opportunity exploitation stage (Muthusamy & White, 2005; Dunning & Lundan, 2008; Spencer, 2008). Given the topological community formation mechanisms, we predict that, generally, the internal connectivity within topological communities are coordinated by horizontal linkages, while the intra-community pipelines are more likely to be channelled by vertical linkages.

1.3 Hypotheses

In the literature review, we underline two preconditions of the hypotheses: (1) Generally, the internal connectivity within topological communities is mostly coordinated by horizontal linkages, while cross-community pipelines are more likely to be vertical linkages. (2) Liability of foreignness may affect the effectiveness of insidership acquisition but does not prevent foreign-based firms to become insiders in the host country networks. To assess how these two factors interact to affect insidership acquisition, we propose following hypotheses.

In terms of horizontal linkages, liability of foreignness reduces the effectiveness of knowledge spillover and sets friction on the cognitive proximity between foreign-based firms and local partners of equivalent profiles. The transaction costs in market entry and market risk when local rivals take free-ride from knowledge sharing deteriorate the competitiveness of foreign-based firms in the host country (Smarzynska Javorcik, 2004; Spencer, 2008; Perri *et al.*, 2013). The long-term selection of horizontal partners implies that foreign-based firms are more likely to concentrate their network resources in the host country on strengthening the relationships with a limited number of competent and trustworthy horizontal partners rather than evenly distributing them with local firms specialized in the same sector. Given all these constraining conditions, we anticipate a lower likelihood that cross-border horizontal linkages will direct foreign-based firms to another member in the same topological community to acquire insidership.

Hypothesis 1: Cross-border horizontal linkages between foreign-based firms and local-based firms are not as likely as local horizontal linkages to appear within the same topological community.

On the other hand, though establishing vertical linkages are generally more likely to facilitate new opportunity discovery and extend the range of knowledge base, foreign-based firms can leverage their market power and global experience in exchange for local insider's knowledge in the host countries (Almeida, 1996; Amin & Cohendet, 2004; Phene & Almeida, 2008). Entering the host countries as "external stars", foreign-based firms extend the depth of local knowledge endowment and optimize the efficiency of local knowledge diffusion (Rychen & Zimmermann, 2008; Lorenzen & Mudambi, 2013; Morrison *et al.*, 2013). They absorb locally entrenched relational knowledge and diffusing globally circulated technical knowledge in the international production networks (Easterby-Smith *et al.*, 2008; Asmussen, 2009; Vahlne *et al.*, 2012; Verbeke & Asmussen, 2016). This process extends their knowledge breadth and contributes to the domestic-international network interaction (Scalera *et al.*, 2018). Conversely, many local firms, especially those from emerging economies, that seek global expansion, have a strong motive to establish alliances with incoming foreign-based firms without leaving their home to "catch up" (Yiu *et al.*, 2007; Yiu, 2011). This provides the possibility wherein foreign-based firms can acquire insidership by forming cross-border collaborations with external partners originated from the host country. Therefore, the cross-border vertical linkages in the host market facilitate the supplementary knowledge interdependence between foreign-based firms and their local suppliers/buyers (Murray *et al.*, 2005). Meanwhile, given that local-based firms are likely to gather linkages within the same topological community, a foreign-based firm can leverage its heterogeneous new knowledge base over vertical supplier-buyer relationships with multiple local-based firms in the same topological communities, thus integrates itself in the respective topological community.

From the perspective of competitive dynamics, foreign-based firms can use their local suppliers and buyers as the medium to get into indirect touch with potential alliance partners and crowd out less competent local competitors that aim to pave the same path in the short run (De Backer & Sleuwaegen, 2003). On the premise that local firms are highly likely to gather within the same topological community sharing complementary knowledge based on the local context, foreign-based firms can bring in supplementary knowledge via cross-border vertical linkages and plug into these horizontally integrated local topological communities, especially in the case of many world's leading MNEs with global influence (Turkina *et al.*, 2016). Having a supreme absorptive capacity to comprehend and transfer complex knowledge, they usually overwhelm the power of local suppliers and buyers in the host countries and become local insiders by vertical integration in local networks.

In practice, IB scholars have observed how foreign-based firms utilize arm's length supply chain relationships in embedding in the host country networks to acquire insidership. In the international business networks in North America and Asia-Pacific region, Japanese multinational enterprises incorporate their foreign subcontractors and affiliates in densely connected *kereitsu* business groups through backward vertical linkages (Belderbos *et al.*, 2001; Belderbos & Heijltjes, 2005). In the Swedish automobile market, American automobile manufacturers managed to build up linkages to local auto parts suppliers and created densely connected international communities as local hub coordinators with strong bargaining power (McKelvey *et al.*, 2003). In Mexican and Polish aerospace clusters, the dominating force of local production module formation has been shifted from horizontal partnerships within local industrial clusters toward cross-border collaboration with foreign OEMs in the form of vertical linkages (Romero, 2011; Turkina *et al.*, 2016). In all, although vertical linkages are less likely to coordinate connections within the same topological community than horizontal linkages, foreign-based firms are more likely to tap into the local communities by vertical linkages.

Hypothesis 2: Cross-border vertical linkages between foreign-based firms and local-based firms are more likely to appear within the same topological community than local vertical linkages.

1.4 Research Design

1.4.1 Data Collection

Our network data consists of the universe of economic entities embedded in the international network of the Chinese aerospace industry on the base year 2016. To construct our network, we identified active economic entities embedded in the Chinese aerospace business networks as observing organizations and collected their corporate information as attributes. We adapted a selection method based on the first-degree ego networks of the most influential local aerospace firms. As a starting point, 140 local commercial aviation enterprises with annual income above 20 million Yuan (approximately 3 million US dollar) included in *Civil Aviation Industrial Yearbook 2014* are selected as focal firms. In a second step, we collected data on the first-degree formal business contacts of these focal nodes (including firms, universities, research institutes, governmental authorities) that establish collaborative alliances, joint-venture and R&D projects, supplier-buyer agreement and third-party outsourcing deals as their dyadic partners. In a third step, we collected geographic and industrial information of each economic entity as network attributes. We define firms registered outside the 31 provincial administrative regions in mainland China (excluding Hong Kong, Macau, Taiwan) as foreign-based firms, while those registered firms registered in mainland China recorded in the national administrative system for industry and commerce (NASIC) as local firms. As the selection of economic entities is set on establishment level, an MNE's headquarters and affiliates located abroad are labelled as foreign-based firm. Meanwhile, MNE subsidiaries and joint ventures located in China are regarded as independent local-based firms due to their local proximity to other players in the host country and international distance that demand mandates from headquarters in the home countries (Cantwell & Mudambi, 2005; Giroud & Scott-Kennel, 2009). For foreign-based firms, we access their corporate information including location, type of incorporate, business specialization, and year of market entry in China from their web portals, publicly available financial report and third-party dataset (Orbis corporate dataset provided by Bureau van Dijk in this study). For local firms, we refer to the same corporate information from National Enterprise Credit Information Disclosure System (NECIDS), except that we replace the year of market entry with the year of foundation.

As the next step, we searched for information on the inter-organizational collaborations between the observing organizations based on publicly available information till the base year (2016). In our network dataset, if two organizations have established formal inter-organizational partnership, this pair of organizations are recognized as dyadic partners connected by one linkage in between. Then, we joined these linkages with the dyadic partners and constructed in a multiplex host country network. Based on the nature of the partnership, we divided the linkages into two categories- horizontal linkages and vertical linkages. Since two organizations can establish both types of linkages, in practice, we mark this pair of dyadic partners as "double embedded" and include this linkage in both horizontal and vertical subnetworks.

Finally, to reduce the noise in the network dataset, we conducted the following data cleaning process. We converted the weighted network to a dichotomized network to concentrate on the structural features of the international network. We removed the isolated nodes that are not connected to the main network component, so that all embedded nodes are directly or indirectly interconnected with each other. As a result, we construct a giant international network that consists of 877 nodes connected by in total 2516 mutual linkages.

1.4.2 Methodology

Given the construct of the international network, we started the process of community detection by applying Markov Cluster Algorithm (MCL) (Van Dongen, 2000), which determines the topological partition of communities by the hierarchical order of topological communities based on the stochastic bootstrapping procedure of random walks. The boundaries of topological communities are distinguished by the difference in agglomeration and modularization tendency while the possibility of cross-community overlapping is excluded. (Borgatti *et al.*, 2002; Enright *et al.*, 2002; Karrer *et al.*, 2008; Van Dongen, 2008; Fortunato, 2010).

The hypotheses we propose concentrate on determining what types of linkages are more likely to connect members within the same topological community. More specifically, we will test the moderation effect of cross-border activities between foreign-based firms and their local partners on the general horizontal community-coordinating and vertical community-spanning effect. We introduce the Probit logistic regression model to test the propensity a dyadic linkage bundle two nodes within the same topological community and select the binary variables INTRA_COMMUNITY as the dependent variable. The probability a linkage connects two nodes within the same topological community is noted as P(INTRA_COMMUNITY). The positive coefficient indicates a higher likelihood the corresponding independent variable contribute to the formation of intra-community linkages, while a negative coefficient would indicate the higher likelihood of connecting communities. Since we only compare two groups of linkages, namely, (1) the cross-border linkages between foreign-based firms with local partners and (2) local linkages between two firms located in the host country, we remove linkages that are not directly linkages to a Chinese firm. After this data cleaning process, 2165 pairs of international and local linkages that connect in total 547 firms remain in the dataset.

The independent variables are:

(1) CROSS_BORDER: if the linkage is a cross-border linkage between a foreign-based firm and a local firm. The local partners also include MNEs' subsidiaries and joint-ventures with external local partners.

(2) HORIZONTAL: if the linkage is in the form of horizontal collaboration including joint-venture, joint-R&D program, and collaborative strategic alliances.

(3) VERTICAL: if the linkage is in the form of arm's length supplier-buyer relationships.

In the Probit Models, interaction terms will be added multiplying CROSS_BORDER by HORIZONTAL/ VERTICAL to evaluate the cross-border moderation effect on community coordination.

To control the exogenous geographic and industrial factors, we also include following control variables:

(1) CO-LOCATION: if the dyadic partners a local linkage connect are located within the same provincial region.

(2) LOCAL_DEVELOPMENT: if at least one of the dyadic partners a linkage connect is located in a provincial region with GDP per capita over 10,000 USD (2016).

(3) MNE_SUBSIDIARY: if the linkage connects a foreign-based firm abroad and an MNE subsidiary in China.

(4) BOTH: if the linkage appears to be both horizontally and vertically integrated.

(5) LARGE_LOCAL: if the linkages direct to one of the 140 ego firms above designated size or five large local aerospace business groups (AVIC, CASIC, CASC, COMAC, CETC).

(6) HEADQUARTER: if at least one of the dyadic partners a linkage connect is the headquarter of a firm

(7) OEM: if at least one of the dyadic partners a linkage connect is an original equipment manufacturer of aircraft or engine.

(8) SERVICE: if at least one of the dyadic partner s a linkage connect is specialized in supplementary service sectors that are not included in the primary manufacturing processes.

(9) R&D: if at least one of the dyadic partners a linkage connect is specialized in high-tech-related research and development sectors.

(10) LONG_TERM: if the linkage exists for more than five years. In our case, the linkages should be established before 2011.

As the establishment of horizontal and vertical linkages have a strong negative linear correlation with each other but not exclusive, we test our hypotheses in two separate models:

Horizontal Model:

$P_{INTRA\_COMMUNITY} = \beta_0+\beta_1$ HORIZONTAL+ β_3CROSS_BORDER+ β_4 HORIZONTAL × CROSS_BORDER +λcontrols

Vertical Model:

$P_{INTRA\_COMMUNITY} = \beta_0+ \beta_2$ VERTICAL + β_3CROSS_BORDER+ β_5 VERTICAL× CROSS_BORDER +λcontrols

1.5 Empirical Analysis and Results

1.5.1 Composition of Topological Communities

According to the results of MCL community detection, we detect that there are in total 26 non-overlapping topological communities (See Figure 1.2). Among them, there are 5 large topological communities agglomerate more than 70 economic entities and 7 medium-sized ones with more than 10 nodes (See Table 1.1). In total 706 economic entities (nodes) are embedded in the five largest topological communities, where the majority of foreign-based firms in our sample set are placed (N=299, p=80.6%).

Table 1.1 here

Figure 1.2 here

If we take a closer look at the core players with the most linkages in each of these giant communities (See Table 1.2), we observe that each community is mostly coordinated by firms specialized in highly knowledge-intensive subsectors at the end of the aerospace value chain (e.g. aircraft assembly, engine manufacturing, avionics), which require large-scale inter-sectorial collocation and knowledge exchange. Apart from Community 3 which is predominately coordinated by local aircraft assembly and avionics firms, all other four large communities contain foreign-based firms with a large number of cross-border linkages. Specifically, we find that large global aircraft OEMs, namely Airbus, Boeing and Bombardier gather within the same community (Community 4). They are more closely connected to airlines rather than their local suppliers in the same topological communities. While their Chinese counterpart COMAC is more proximate to their downstream suppliers from both home and abroad in the same topological community (Community 2). In addition, we find that among these well-connected nodes in each topological community, the local ones tend to specialize in the same sectors, while their foreign partners in the same topological community are more likely to be specialized in a forward or backward sector in the production process (e.g. Community 2 and Community 4). This observation hints the presumption of topological community formation and the hypotheses regarding the embeddedness of foreign-based firms. In the next section, we will apply a more rigorously empirical analysis in this regard.

Table 1.2 here

1.5.2 Probit Logistic Regression of Intra- and Inter-Community Linkages

Table 1.3 presents the descriptive statistics and correlations of the independent and control variables. We observe that most pairs of independent and control variables do not have a strong tendency of linear correlation with Person's r-value below 30% benchmark. Hence the impact of multicollinearity on Probit regression is expected to be low. As predicted, the pair between horizontal and vertical linkages have a significant negative linear correlation with each other (r=-0.897, p=0.000). Given that only a small portion of pairs (N=123, p=4.89%) of linkages are both horizontally and vertically embedded, we conclude that the horizontal and vertical linkages in our sample have strong exclusiveness and we do not include variables horizontal linkage and vertical linkage within the same logistic regression model.

Table 1.3 here

Table 1.4 exhibits the logistic regression models on the cross-border moderation effect on intra-community linkage formation. We develop seven parallel Probit logistic regression models that evaluate the main effect of CROSS_BORDER on P(INTRA_COMMUNITY), and its moderation effect on horizontal and vertical linkages. The proposed logistical regression models are globally significant with Likelihood Ratio χ^2 ranging from 99.110 to 173.360 (N=2165, p<0.001)

Table 1.4 here

There is strong evidence to support the precondition of topological community formation. The general patterns of topological community formation of horizontal coordination and vertical cross-community spanning holds. Horizontal linkages are more likely to gather players in topological communities (column 2: β_2=0.488, p=0.000; column 4: β_2= 0.505, p=0.000; column 6: β_2= 0.631, p=0.000), while vertical linkages are more likely to channel sparsely distributed topological communities as cross-community pipelines (column 3: β_2=-0.488, p=0.000; column 4: β_2=- 0.505, p=0.000; column 7: β_2= -0.722, p=0.000). The conclusions are consistent and all statistically significant.

Secondly, we reconfirm the relevance of liability of foreignness and ousidership in topological communities. In both horizontal and vertical models. We find that, generally, cross-border linkages are less likely to connect firm within the same topological communities (column 3: β_2= -0.147, p=0.019; column 4: β_2=-0.054 , p= 0.478, column 6: β_2=-0.147, p=0.019; column 7: β_2= -0.452, p=0.000). The conclusions are consistent, while only the coefficient in column 6 is not statistically significant. Hence, we argue that its moderation effect on horizontal linkages offset the statistical significance of the main effect of CROSS_BORDER.

To evaluate the cross-border moderation effects of horizontal and vertical linkages, we compare the results of the interaction term. We find strong support for Hypothesis 1 (column 6: β_3=-0.260, p=0.031) indicating that cross-border linkages are less likely to be horizontal when connecting nodes in the same topological community. At the same time, we also find strong support for Hypothesis 2 (column 7: β_5=0.443, p=0.000) that cross-border linkages are more likely to be vertical within topological communities. Figure 1.3 further illustrates how cross-border linkages moderate the likelihood horizontal and vertical linkages are allocated within the same topological community. It turns out that overall cross-border linkages have a lower degree of propensity to be allocated within the same topological communities than local linkages. However, the slopes of the solid lines representing cross-border linkages are both flatter than the dashed lines representing local linkages. This result indicates that foreign-based firms are more likely to use cross-border horizontal linkages as pipelines to reach heterogeneous topological communities, while use the vertical linkages to strengthen its embeddedness in topological communities.

Figure 1.3 here

Regarding the control variables, we find that linkages directed to corporate headquarters and service sectors are more likely to contribute to intra-community linkage formation. In contrast, embeddedness in both horizontal and vertical network, direction to large local aerospace firms and direction to R&D sector have higher propensity to contribute to inter-community linkages.

1.5.3 Robustness Test

To test the robustness of the Probit model, we divide all observed linkages by the time dimension and detect if the general conclusions we reach so far apply over time. In this case, we drop the binary dummy LONG_TERM from the original Probit Model that tests the moderation effect of cross-border linkages on the allocation of horizontal and vertical linkages within/across topological linkages. Accordingly, we construct three sets of observations that consist of newly established linkages (Short-term) and long-term linkages (Long-term), then compare them with the whole sample (Full). In Table 1.5, we find that the general community coordinating effect of horizontal linkages and community spanning effect of vertical linkages apply in all listed robustness test models. In general, cross-border horizontal linkages are less likely to be allocated within the same topological community, while the statistical significance of this moderation effect is not evident among long-term horizontal linkages. On the other hand, we find that the cross-border moderation effect applies to both short-term and long-term vertical linkages.

Table 1.5 here

1.6 Conclusions and Discussions

This paper discusses the effect of host country network embeddedness on foreign-based firm's insidership in new business opportunity development embedded in international business networks. Firms start discovering new opportunities via establishing linkages with partners of different specialized knowledge bases exchanging supplementary knowledge, then deepen their understanding of knowledge in opportunity exploitation by exchanging complementary based on long-term trust and commitment (Buckley *et al.*, 2009; Alvarez *et al.*, 2013; Mainela *et al.*, 2014). Embodied in diverse forms of inter-organizational relationships, the knowledge exchanges and sharing facilitates a firm's effort in acquiring insidership and contribute to the formation of large-scale business networks (Johanson & Vahlne, 2009).

The configuration of a host country network involves both foreign-based firms and their local partners. Based on the graphic topological criteria, the embedded nodes this large-scale network can be grouped into internally densely connected and externally exclusive topological communities. The intra-community connectivity is predominantly orchestrated by collaborative partnership (horizontal linkages) sharing complementary knowledge in opportunity exploitation. While the inter-community pipelines, which are mostly in the form of arm's length supply chain relationships (vertical linkages), represent the supplementary knowledge exchanges among firms of different knowledge in new opportunity exploration (Alvarez & Barney, 2007; Buckley *et al.*, 2009; Turkina

& Van Assche, 2018). Meanwhile, the cross-border geographic factor alters the effectiveness of this general "horizontal coordinating versus vertical spanning" pattern. For foreign-based firms, there is a trade-off between their international expertise in technological knowledge and market knowledge and unfamiliarity with local context-specific relational knowledge. Overall, the foreign-local division of nodes in the host country networks represents the impact of geographicaly bounded context in international business (Zaheer, 1995). Liability of foreignness largely hinders the insidership acquisition and reduces the effectiveness of horizontal linkages in connecting foreign-based firms to partners within the same topological community. In this sense, establishing wholly owned subsidiaries or partially owner joint ventures are the means for foreign-based firms to position their local presence to absorb local knowledge spillover (Almeida & Phene, 2004; Rugman *et al.*, 2011; Asakawa *et al.*, 2017). On the other hand, foreign-based firms can be well embedded in the host country networks by establishing cross-border linkages with external partners in addition to direct mandating their local subsidiaries (Lorenzen & Mudambi, 2013; Cano-Kollmann *et al.*, 2016; Kano, 2017).

Integrating the literature mentioned above, our paper brings new insights on how foreign-based firms can acquire insidership in the host country networks by analyzing the effectiveness of horizontal and vertical linkages. Though topological communities are predominated connected by horizontal linkages, foreign-based firms are not as likely to acquire insidership in host country networks by using these linkages. The results of our study indicate that, by bringing in heterogeneous knowledge inflow and leveraging the existing local infrastructure of horizontally integrated topological communities, foreign-based firms are more likely to acquire insidership embedded in topological communities by establishing cross-border vertical linkages orchestrated by supply chain mechanisms. Depending on their strategic goals and capacities in the host country, foreign-based firms can use vertical linkages to acquire insider's knowledge in topological communities as the first step and horizontal linkages to strengthen their advantages between topological communities based on different knowledge bases.

Due to the complexity of international business networks, we acknowledge that this research has its limitations and many relevant questions remain open. First, though we have made effort in interpreting the managerial implications of topological community detection from the perspective of knowledge sharing and exchanges across different knowledge bases in the process of internship acquisition, more refined evidence needs to be provided to confirm this process indeed takes place within and between topological communities detected by the network analysis techniques. Secondly, in this research, we only analyze the inter-firm linkages in the international networks, while the other important types of cross-border linkages including firm-university and firm-government collaborations are filtered out. We suggest further research could explore and exploit these topics from network perspectives. Thirdly, we generalized the relationships between foreign-based firms with their local subsidiaries and external partners as "cross-border linkages", while given the heterogeneous organizational natures. As next step, we should evaluate the impact separately. Also, we do not include the linkages between foreign-based firms outside the host country in our discussion. As an extension, we suggest discussing how foreign-based firm could obtain "insidership" from other well embedded foreign-base firms without directly engaging in partnerships with local firms. Finally, we only discuss the roles of incoming foreign-based firms while do not dig deep enough on how out-going local firms alter the network configuration at the same time. In future research, we suggest synthesizing our findings with recent research on the roles of outgoing firms in the home country networks (e.g. Yiu *et al.*, 2007; Asmussen *et al.*, 2009; Guler & Guillen, 2010; Iurkov & Benito, 2017) to capture a comprehensive view on the motive antecedents, behavior patterns and social impact of cross-border business activities on the evolution of international business networks.

Tables

Table 1.1: Statistical Summary of Topological Communities

Number of nodes: 877
Number of linkages: 2516
Density: 0.006

Number of intra-community linkages: 1268 (51.0%)
Number of inter-community linkages: 1248 (49.0%)

Community	Size (N)	Foreign-based firms		Number of Linkages		Intra-community density	Scale
		No.	Percentage	Intra-community	Inter-community		
1	344	146	42.4%	404	564	0.007	Large (N≥70)
2	106	56	52.8%	106	278	0.019	
3	94	21	22.3%	94	231	0.022	
4	92	53	57.6%	464	577	0.111	
5	70	23	32.9%	58	181	0.024	
6	33	18	54.5%	36	81	0.068	Medium (10≤N<70)
7	17	11	64.7%	17	42	0.125	
8	17	10	58.8%	14	52	0.103	
9	15	10	66.7%	16	124	0.152	
10	13	6	46.2%	12	28	0.154	
11	12	3	25.0%	8	20	0.121	
12	10	2	20.0%	9	72	0.200	
13	8	0	0.0%	0	68	0.000	Small (N<10)
14	8	0	0.0%	7	1	0.250	
15	5	2	40.0%	4	4	0.400	
16	5	3	60.0%	4	26	0.400	
17	4	1	25.0%	3	1	0.500	
18	4	3	75.0%	2	87	0.333	
19	3	1	33.3%	2	12	0.667	
20	3	0	0.0%	1	19	0.333	
21	3	0	0.0%	2	1	0.667	
22	3	1	33.3%	2	2	0.667	
23	2	0	0.0%	1	3	1.000	
24	2	0	0.0%	0	12	0.000	
25	2	0	0.0%	1	1	1.000	
26	2	1	50.0%	1	9	1.000	

Table 1.2: Nodes with Most Linkages in 5 Giant Topological Communities

Rank	**Community 1**		**Community 2**		**Community 3**		**Community 4**		**Community 5**	
(size)	344		106		94		92		70	
	Firm	Sector	Firm	Sector	Firm	Sector	Firm	Sector	Firm	Sector
1	BIAM	Aircraft material	COMAC	Aircraft assembly	AVIC Chengdu	Aircraft assembly	***Boeing***	Aircraft assembly	AVIC Shaanxi	Aircraft assembly
2	AVIC ACAE	Engine manufacturing	***Honeywell International***	Engine manufacturing	Baocheng	Avionics	***Airbus***	Aircraft assembly	AVIC LAMC	Aircraft component
3	***Rockwell Collins***	Avionics	***GE Aircraft Engines***	Engine manufacturing	AVIC Hongdu	Aircraft assembly	***Bombardier***	Aircraft assembly	***Topcast***	International Trade
4	***ESI***	Avionics	AVIC Harbin	Aircraft assembly	AVIC ALI	Avionics	Air China	Airlines	***Nordam***	Aircraft component
5	***SNECMA***	Aircraft engine	AVIC Shenyang	Aircraft assembly	Yunma	Aircraft assembly	China Eastern	Airlines	Dongan Engine	Engine manufacturing

Note: foreign-based firms are highlighted as bold italic text.

Table 1.3: Pearson correlation coefficients of independent variables and control variables

	Variables	N	s.d.	(1)	(2)	(3)	(4)	(5)
(1)	CROSS_BORDER	974	0.498					
(2)	HORIZONTAL	771	0.479	0.107 ***				
(3)	VERTICAL	1517	0.458	-0.060 ***	-0.879 ***			
(4)	CO-LOCATION	162	0.263	-0.257 ***	0.104 ***	-0.094 ***		
(5)	LOCAL_DEVELOPMENT	1160	0.499	0.257 ***	0.069 ***	-0.054 **	-0.028	
(6)	MNE_SUBSIDIARY	96	0.206	0.238 ***	-0.057 ***	0.077 ***	-0.061 ***	0.138 ***
(7)	BOTH	123	0.232	0.103 ***	0.330 ***	0.160 ***	0.029	0.036 *
(8)	LARGE_LOCAL	1125	0.500	0.191 ***	0.173 ***	-0.122 ***	0.091 ***	0.304 ***
(9)	HEADQUARTER	850	0.488	-0.140 ***	-0.059 ***	0.040 *	-0.056 ***	-0.098 ***
(10)	OEM	61	0.166	0.065 ***	0.101 ***	-0.029	-0.006	-0.049 **
(11)	SERVICE	433	0.400	-0.067 ***	0.014	-0.057 ***	0.112 ***	0.213 ***
(12)	R&D	1606	0.438	0.130 ***	0.029	-0.005	0.039 **	-0.003
(13)	LONG_TERM	1466	0.468	0.072 ***	0.031	-0.026	0.031	-0.021

(cont)

	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(7)	0.034						
(8)	0.113 ***	0.116 ***					
(9)	-0.173 ***	-0.042 **	-0.285 ***				
(10)	-0.023	0.151 ***	0.102 ***	-0.040 **			
(11)	-0.085 ***	-0.083 ***	-0.111 ***	-0.116 ***	-0.085 ***		
(12)	-0.083 ***	0.049 **	0.293 ***	-0.267 ***	0.101 ***	0.087 ***	
(13)	0.014	0.012	0.064 ***	-0.019	-0.014	-0.038 *	-0.060 ***

Note: *if p < 0.10, ** if p < 0.05; *** if p < 0.01

Table 1.4: Cross-border Moderation Effect on Intra-Community Linkage Formation

	Benchmark	Horizontal Models			Vertical Models		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
HORIZONTAL		0.488 (0.063) ***	0.505 (0.063) ***	0.631 (0.086) ***			
VERTICAL					-0.488 (0.063) ***	-0.505 (0.063) ***	-0.722 (0.090) ***
CROSS_BORDER			-0.147 (0.063) **	-0.054 (0.077)		-0.147 (0.063) **	-0.452 (0.108) ***
CROSS_BORDER*HORIZONTAL				-0.260 (0.121) **			
CROSS_BORDER*VERTICAL							0.443 (0.126) ***
CO-LOCATION	0.223 (0.110) **	0.164 (0.110)	0.093 (0.114)	0.062 (0.115)	0.164 (0.110)	0.093 (0.114)	0.057 (0.116)
LOCAL_DEVELOPMENT	0.072 (0.061)	0.067 (0.062)	0.100 (0.063)	0.083 (0.064)	0.067 (0.062)	0.100 (0.063)	0.075 (0.064)
MNE_SUBSIDIARY	-0.099 (0.140)	-0.003 (0.140)	0.064 (0.143)	0.041 (0.144)	-0.003 (0.140)	0.064 (0.143)	0.018 (0.143)
BOTH	-0.178 (0.121)	-0.493 (0.128) ***	-0.480 (0.129) ***	-0.458 (0.131) ***	-0.004 (0.124)	0.025 (0.125)	-0.009 (0.124)
LARGE_LOCAL	-0.285 (0.065) ***	-0.360 (0.066) ***	-0.356 (0.066) ***	-0.356 (0.066) ***	-0.360 (0.066) ***	-0.356 (0.066) ***	-0.356 (0.066) ***
HEADQUARTER	0.207 (0.061) ***	0.222 (0.062) ***	0.215 (0.062) ***	0.218 (0.062) ***	0.222 (0.062) ***	0.215 (0.062) ***	0.218 (0.062) ***
OEM	-0.224 (0.177)	-0.293 (0.183)	-0.274 (0.184)	-0.253 (0.184)	-0.293 (0.183)	-0.274 (0.184)	-0.265 (0.182)
SERVICE	0.261 (0.075) ***	0.238 (0.076) ***	0.226 (0.076) ***	0.216 (0.076) ***	0.238 (0.076) ***	0.226 (0.076) ***	0.201 (0.077) ***
R&D	-0.192 (0.069) ***	-0.174 (0.069) **	-0.151 (0.069) **	-0.150 (0.069) **	-0.174 (0.069) **	-0.151 (0.069) **	-0.153 (0.070) **
LONG_TERM	0.068 (0.059)	0.059 (0.059)	0.071 (0.059)	0.074 (0.060)	0.059 (0.059)	0.071 (0.059)	0.072 (0.060)

CONS	0.062 (0.087)	-0.057 (0.089)	-0.035 (0.090)	-0.063 (0.091)	0.432 (0.098) ***	0.471 (0.100) ***	0.654 (0.115) ***
N	2165	2165	2165	2165	2165	2165	2165
LR chi2	99.110	158.660	164.220	167.630	158.660	164.220	173.360
$p>\chi2$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.036	0.056	0.058	0.059	0.056	0.058	0.062

Note: *if $p < 0.10$, ** if $p < 0.05$; *** if $p < 0.01$; Standard errors in parentheses.

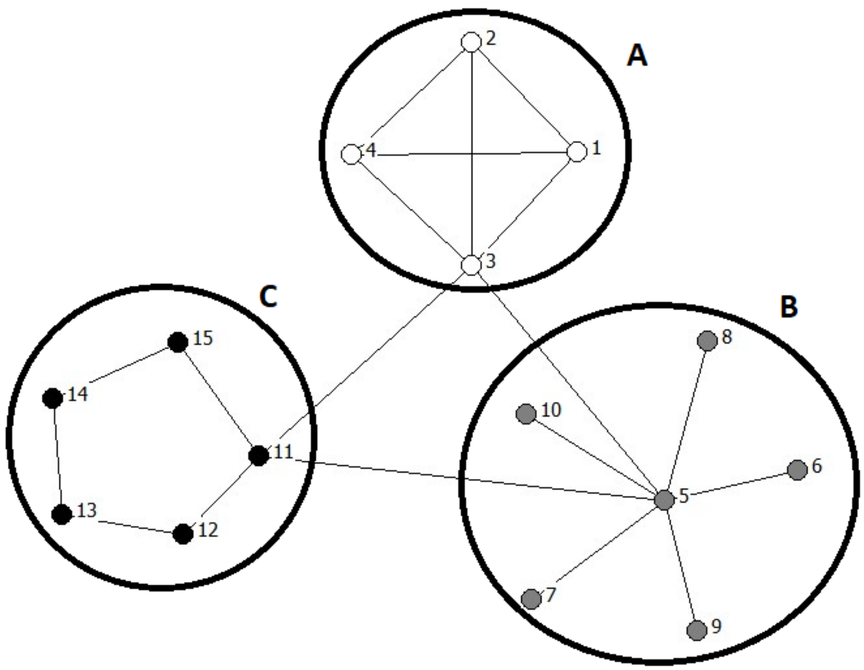
Table 1.5: Robustness Test on Cross-border Moderation Effect

Variables	Horizontal Models									Vertical Models								
	Full			Short-Term Linkages			Long-Term Linkages			Full			Short-Term Linkages			Long-Term Linkages		
HORIZONTAL	0.631	(0.086)	***	0.765	(0.150)	***	0.569	(0.108)	***									
VERTICAL										-0.723	(0.090)	***	-0.814	(0.154)	***	-0.655	(0.113)	***
CROSS_BORDER	-0.048	(0.076)		0.087	(0.141)		-0.172	(0.092)		-0.445	(0.108)	***	-0.379	(0.197)	*	-0.497	(0.132)	***
CROSS_BORDER*HORIZONTAL	-0.257	(0.120)	**	-0.374	(0.223)	*	-0.205	(0.147)										
CROSS_BORDER*VERTICAL										0.442	(0.126)	***	0.481	(0.231)	**	0.370	(0.153)	**
CO-LOCATION	0.069	(0.115)		0.108	(0.221)		0.031	(0.136)		0.063	(0.116)		0.096	(0.222)		0.029	(0.136)	
LOCAL_DEVELOPMENT	0.078	(0.064)		0.012	(0.124)		0.156	(0.076)	**	0.070	(0.064)		0.009	(0.124)		0.146	(0.076)	*
MNE_SUBSIDIARY	0.038	(0.144)		-0.393	(0.283)		0.177	(0.167)		0.015	(0.144)		-0.399	(0.283)		0.157	(0.167)	
BOTH	-0.458	(0.131)	***	-1.172	(0.269)	***	-0.212	(0.159)		-0.008	(0.124)		-0.619	(0.257)	**	0.202	(0.150)	
LARGE_LOCAL	-0.350	(0.065)	***	-0.185	(0.125)		-0.423	(0.079)	***	-0.351	(0.066)	***	-0.186	(0.125)		-0.422	(0.079)	***
HEADQUARTER	0.217	(0.062)	***	0.146	(0.107)		0.263	(0.077)	***	0.217	(0.062)	***	0.141	(0.107)		0.265	(0.077)	***
OEM	-0.259	(0.184)		-0.566	(0.313)	**	-0.091	(0.230)		-0.270	(0.182)		-0.560	(0.314)		-0.110	(0.228)	
SERVICE	0.214	(0.076)	***	0.349	(0.133)	***	0.119	(0.095)		0.200	(0.077)	***	0.342	(0.133)	***	0.105	(0.095)	
R&D	-0.158	(0.069)	**	-0.485	(0.136)	***	0.017	(0.083)		-0.161	(0.069)	**	-0.483	(0.136)	***	0.011	(0.083)	
CONS	-0.010	(0.080)		0.132	(0.150)		-0.067	(0.099)		0.707	(0.108)	***	0.945	(0.180)	***	0.581	(0.136)	***
N	2165			699			1466			2165			699			1466		
LR chi2	-1412.412			-436.977			-959.639			-1408.527			-436.230			-957.660		
p>χ2	0.000			0.000			0.000			0.000			0.000			0.000		
Pseudo R2	0.059			0.097			0.056			0.061			0.099			0.058		

Note: *if $p < 0.10$, ** if $p < 0.05$; *** if $p < 0.01$; Standard errors in parentheses.

Figures

Figure 1.1: Generic Conceptual Model of Topological Communities

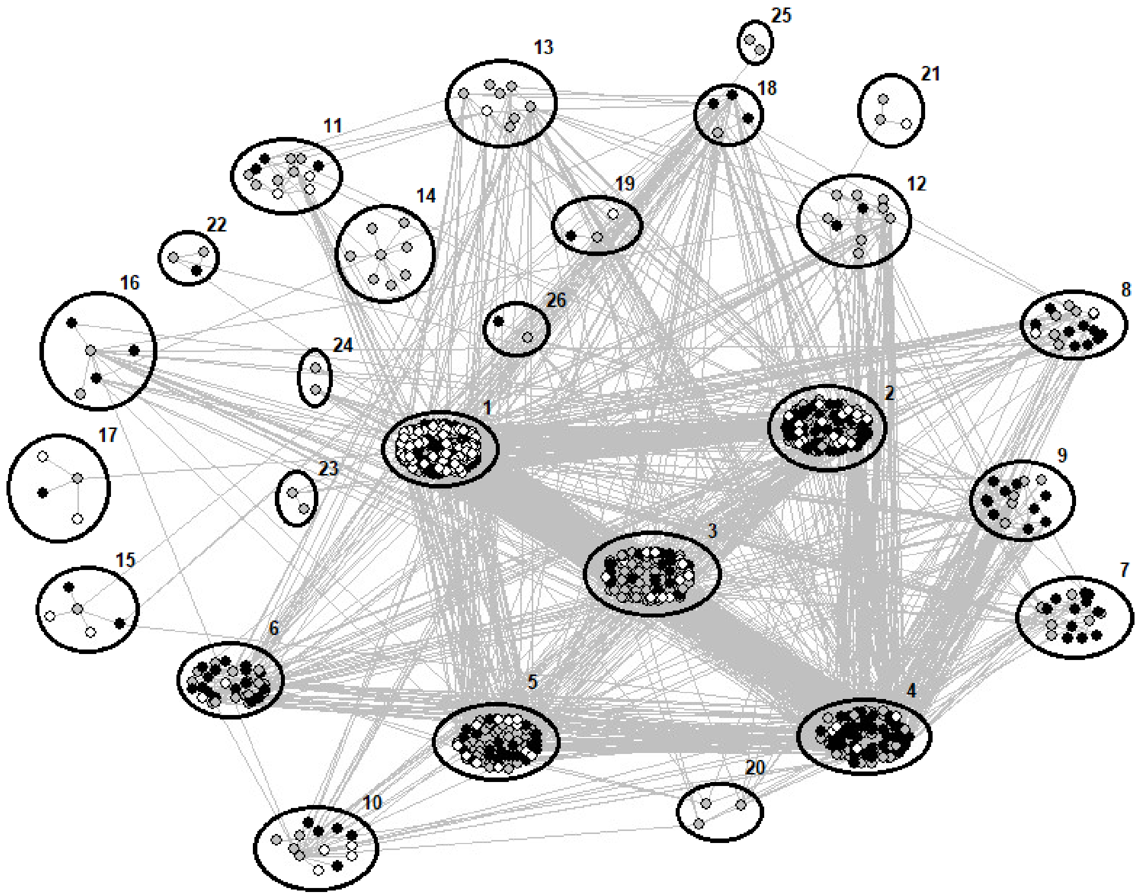


Note: Different colors represent a node's affiliation to exclusive topological communities

Figure1.1 presents a generic model of topological communities based on the betweenness of each node over the path of connection other nodes. In this network consisting of 15 nodes and 19 linkages, three topological communities with distinguishing characteristics are detected according to Girvan-Newman modularity algorithm (Girvan & Newman, 2002), Community A is a "clique-shaped" community, where each node is directly connected with two other neighbouring nodes. Community B is a "star-shaped" community all linkages are directed to a key player, that is, Node 5. Community C is a "circle-shaped" community as the overall layout of the community structure appears to be a cycle, and each member equally has two directly connected neighboring contacts. Overall, the topological structure of Community A and C are decentralized as within communities; each member has equal powers in the network. In contrast, Community B is a centralized community coordinated by the key player, and the interconnectivity of the whole community is dependent on its brokerage. Hence, the topological structure of this community is more hierarchical, and the key members have stronger power over the others. Zoom in to individual members, we also observe that these topological communities are connected through three linkages that are directed to the community spanners, namely Node 3, Node 5, and Node 11. The mutual connection between these nodes channels the inter-community connectivity of their respecitve topological community, thereby maintain the overall connectivity of the whole network and reduce the average path length across members assigned in different topological communities. The existance of inter-community pipelines also alter the power distribution of embedded members. In Community A and C, other members must go through community spanners Node 3 and Node 11 respectively to get in touch with members from other communities. The equilibrium of equally distributed power, therefore, breaks down, and the brokerage role enables stronger hierarchical advantages of community spanners over other members. In Community B, the key player Node 5 keeps the gateway of knowledge in-and-outflows toward this community. The cross-community boundary spanning role further strengthen the key player's authority over the other members in the same community.

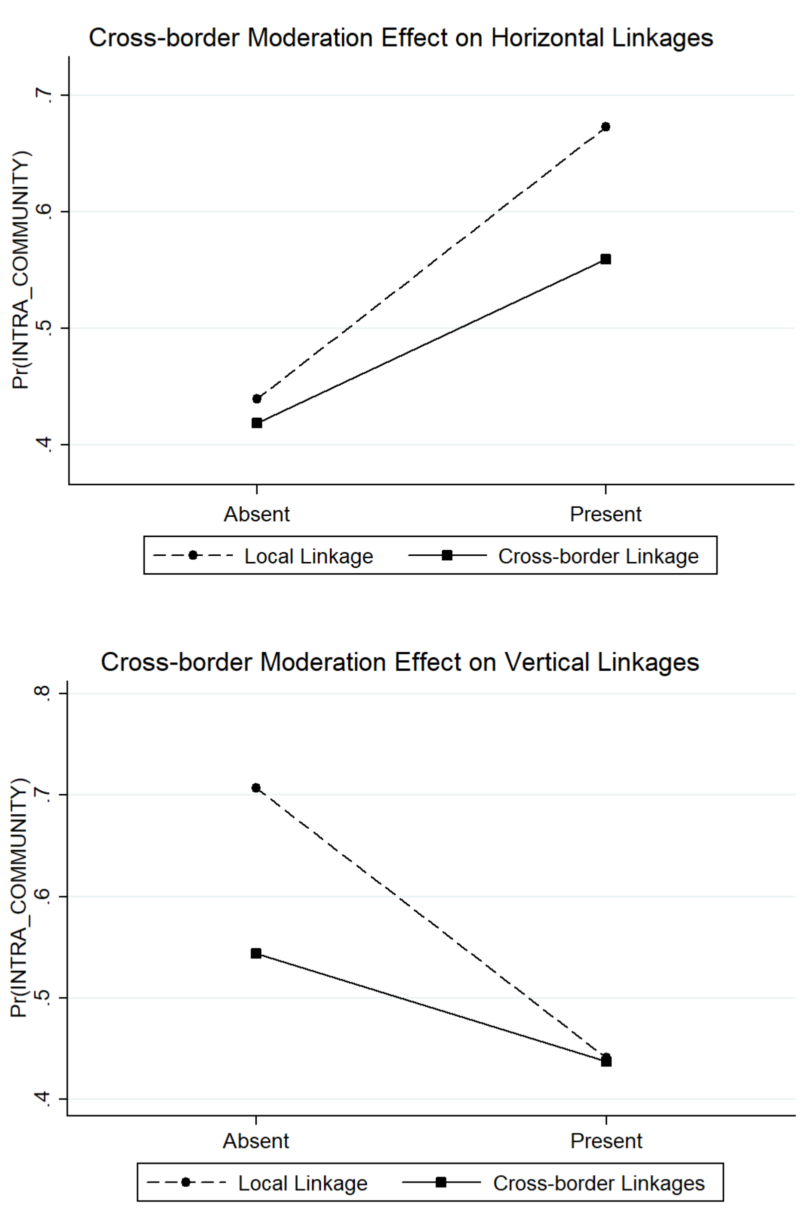
Figure 1.2: Partition of Chinese Aerospace Network by Markov Clustering Algorithm

(Display layout: grouped by Markov topological communities)



Note: Black nodes represent foreign-based firms, grey nodes represent local-based firms, white nodes represent other organizations.

Figure 1.3: Cross-border Moderation Effect on Horizontal and Vertical Linkages



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Chapter 2
Antecedents of SME Embeddedness in Inter-Organizational Networks: Evidence from China's Aerospace Industry

Abstract

It is widely acknowledged that a small and medium-sized enterprise's (SME's) embeddedness in an inter-organizational network affects its performance, yet little is known which factors drive an SME's network position. In this paper, we develop several theoretical hypotheses relating an SME's size, age and partner diversity to its position in an inter-organizational network. Then, we test the hypotheses by conducting multiple regression analysis on a hand-collected dataset of inter-organizational linkages in China's aerospace industry. We find empirical support that size and egocentric diversity of direct partners are positively related to an SME's centrality in the inter-organizational network. In contrast, we do not find evidence that an SME's age is positively related to its network centrality. Finally, we discuss the implications of our findings for SME strategy.

2.1 Introduction

Globalization has profoundly changed the way how goods and services are produced. Thanks to reduced communication barriers and transportation costs, firms have long abandoned the practice of producing goods and services in a single country. Through outsourcing and offshoring, they have sliced up their supply chains and dispersed their production activities across multiple countries, leading to what are known as global value chains (Gereffi et al., 2005; Sturgeon et al., 2008). A large number of manufacturers apply integrated production systems that pull inputs from all over the world. In other words, today's manufacturing firms – big or small – tap into global production networks to get things done (Ernst & Kim, 2002).

A vast literature has analyzed the roles that large lead firms play in the formation and evolution of global production networks. Gereffi (1999) and Gereffi et al. (2005) studied the orchestrating position that lead firms such as global buyers, and vertically integrated multinational enterprises (MNEs) play in the governance of these networks. They pointed out that dominant players not only exert influence over their partners through explicit coordination but also through reputation and leadership in their respective industries. Similarly, Dhanaraj and Parkhe (2006) suggested that orchestrating lead firms coordinate fragmented production modules that are spread out over the globe by ensuring knowledge mobility, managing innovation appropriability and fostering network stability. Building on these arguments, Kano (2017) conceptualized a global value chain as an asymmetrical low density/high centrality network with a large orchestrating firm at its center and numerous smaller peripheral companies attached to it.

Nevertheless, less attention is paid to the positions of SMEs in global production networks. A commonly held image is that SMEs are a relatively homogenous group of peripheral players in global value chains which simply heed to the incentive schemes provided by large lead firms (Christopherson & Clark, 2007). This vision, however, rests on theoretically misguided and empirically weak underpinnings. While many SMEs are peripheral players, they by no means can all be fit in this category. Among SMEs, there are some that are significantly better positioned in the network than others, linking to a larger quantity of business partners, building more important connections, and setting up links to more diverse partners (Eagle et al., 2010; Thorgren et al., 2016; Zahra et al., 2000). Indeed, Schoonjans et al. (2013) pointed out that while there is a growing recognition that externalized networks are a crucial intangible asset that contributes to an SME’s growth, our understanding how SMEs acquire benefits from formal business-to-business network connections remains poorly understood.

This paper aims to at least partially fill this gap in the literature by analyzing which type of SMEs are more likely to take on a central position in an inter-organizational network. Does it depend on their size? Is it related to their age? And does it depend on the diversity of the partners to which it is connected? Answering these questions is important since it allows us to get a better insight into the types of SMEs that have extensive access to resources from their network partners and strong bargaining power over their network partners.

We study the relation between SME antecedents (size, age and partner diversity) and their centrality in an inter-organizational network in the context of China's aerospace sector. China's aerospace industry – which consists of both lead firms and SMEs – heavily relies on formal inter-firm collaboration to make their products and is therefore particularly relevant for our purposes. Chinese aerospace firms form inter-firm partnerships to pool knowledge and resources and to benefit from economies of scale. At the same time, they subcontract significant portions of their supply chain to external firms. In this paper, we thus take advantage of a large dataset that we have hand-collected on formal linkages between a network of aerospace establishments in China to conduct our empirical analysis.

Our paper is organized as follows. In Section 2.2, we build on the literature of inter-organizational networks and SMEs to develop three hypotheses that link an SME's size, age, and egocentric diversity of direct partners to its network position. In section 2.3, we discuss the procedures we have used to collect our network data in China's aerospace industry. Section 2.4 presents our econometric model specification. Section 2.5 presents the results of our analysis. Section 2.6 and 2.7 conclude and discuss directions for future research.

2.2 Background

2.2.1 Network Embeddedness, Resources and Performance

In this section, we rely on concepts and insights from the study of inter-organizational networks to investigate how a firm's embeddedness in the network affects its ability to access resources and knowledge from other organizations that contribute to economic returns.

Strategy scholars have paid growing attention to social network analysis when studying the performance implications of a firm's inter-organizational relations. Building on ideas developed in the analysis of inter-personal networks, researchers have proposed that firms can be considered as nodes embedded in webs of inter-organizational relations, and have investigated the antecedents and consequences of their embeddedness in these networks (e.g. Gulati, 2007). Several scholars have emphasized the structural properties of networks (e.g. Burt, 1992), while others have focused on the characteristics of inter-organizational ties (e.g. Granovetter, 1985).

Most relevant to our study, however, a third set of studies have depicted inter-organizational relations as conduits of network resources that shape firm performance. Network resources are the tangible and intangible assets that reside outside of a firm's organizational boundaries but that can potentially be accessed through inter-organizational connections to other companies (Gulati & Gargiulo, 1999; Lavie, 2006). A firm's network resources critically depend on its embeddedness in the network, as there exists a hierarchical order in the network which affects the transmission of knowledge and resources. Firms or other actors which are embedded in different network positions, therefore, have access to different network resources.

The key measure to capture a firm's embeddedness in an inter-organizational network is its network centrality. A high level of network centrality signifies that an actor has a prominent position which allows it to gain access to resources and information flows and influence the behavior of other players. In contrast, a low level of network centrality signifies a player's peripheral position in the network and the consequential disadvantages in resource acquisition, information access as well as social influence (Freeman, 1978; Wasserman & Faust., 1994). There are four measures of centrality that are particularly important in the literature:

Degree centrality: It counts the number of direct connections that an actor has with other actors (Nieminen, 1974). An actor with high degree centrality is in direct contact with many actors, and is thus considered to have access to a wide variety of knowledge and resources that is unavailable internally (Ring & Van de Ven, 1992; Dyer & Singh, 1998; Tsai, 2001). This measure is favored by many empirical studies since it only requires information about an actor's direct number of relations. Nonetheless, degree centrality ignores the impact of indirect ties and the whole network structure (Freeman, 1978; Burt, 1987; Reagans & Zuckerman, 2008). A peripheral player with high degree centrality does not necessarily have high controlling power and social influence in comparison to a player that has a small number of direct linkages with key network partners.

Betweenness centrality: It measures how frequent an actor appears between other pairs of nodes' shortest path. This measurement implies an actor's capacity to broker linkages between parties that lack other connections, as it serves as the medium broker over "structural holes"(Burt, 1992). An actor with a high degree of betweenness centrality has stronger control over the flows as a broker in the whole network and holds higher bargaining power over other actors in the network.

Closeness centrality: It represents how close an actor is to all other actors in the same network (Okamoto *et al.*, 2008). In this study, we calculate the multiplicative inverse of the sums of steps of all geodesics ("nearness") as a measurement for closeness centrality. An actor with high closeness centrality is considered more reachable and efficient in communication with its direct and indirect partners, since fewer steps reduce the decay of information diffusion and diminish the transaction costs incurred during the transfer of resources.

Eigenvector centrality: It represents an actor's access to other well-connected actors in terms of neighbourhood degree and whole network reachability. Calculation of eigenvector centrality is based on the number of an actor's direct contacts, and each of these alter player's structural central position in the whole network. It signifies an actor's power in the network and is often linked to a firm's social status (Bonacich, 1987; Bonacich & Lloyd, 2001). An actor that is more eigenvector central is considered to have higher network resources since it can more easily access key knowledge and resources from elsewhere in the network through both its direct and indirect ties (Stuart *et al.*, 1999; Podolny, 2001; Soh *et al.*, 2004). In contrast, if an actor has a low eigenvector centrality, it can only tap into limited knowledge and resources from the network through its portfolio of linkages.

From our discussion above, each centrality measure captures a distinctive strategic characteristic of a "node" in the network. That is, while they all capture a firm's embeddedness in the network, they all focus on a different way they are embedded. Meghanathan (2015) indeed conducted a comparative correlation analysis between these centrality measures and found that there exists a strong correlation between degree centrality, closeness centrality and eigenvector centrality. However, betweenness centrality is generally poorly correlated with the other centrality measures and especially with eigenvector centrality. In this regard, we will treat "network centrality" as a comprehensive concept that encompasses the various network centrality measures in our hypothesis development, while treating them as separate dependent variables in our empirical analysis.

2.2.2 SMEs and Inter-organizational Networks

While most studies on inter-firm networks have focused on activities of large firms such as multinational enterprises (MNE) (Rugman & Verbeke, 2004; Goerzen & Beamish, 2005; Hagedoorn, 2006; Feldman & Zoller, 2012), one can argue that SMEs are the type of firms that benefit most from the opportunities related to creating network connections. On the one hand, in their effort to overcome their inherent resource scarcities (Mackinnon *et al.*, 2004; Cooke *et al.*, 2005; Meijaard *et al.*, 2005), SMEs rely more heavily than large firms on network resources outside their organizational boundary (Keeble *et al.*, 1998; Zahra *et al.*, 2000; Audretsch *et al.*, 2005; Mitra, 2012; Narula, 2014). Their survival and performance therefore crucially depend on their capability to identify and connect to competent partners that provide them with complementary assets and resources (Almeida & Kogut, 1997; Hite & Hesterly, 2001).

On the other hand, their resource scarcity also imposes major constraints on SMEs' capability to absorb external knowledge and establish social influence over other organizations. Consequently, SMEs are often placed in a peripheral position in the network and are less likely to build linkages to well-connected lead firms. Therefore, it is necessary for SMEs to thoroughly understand the power of networks and the firm-level factors that affect their ability to integrate into them.

Many entrepreneurship studies on SME networks have highlighted the importance of inter-personal networks among entrepreneurs (Knight, 2000; Vecchio, 2003; Cooke *et al.*, 2005; Thomason *et al.*, 2013). However, few studies have studied the configuration of an SME's network of inter-organizational linkages. Miller and Friesen (1983) claimed that in a "simple firm" where power is centrally controlled at the top, the informal relationships among individual entrepreneurs are crucial for resources acquisition and capacity enhancement. When SMEs grow up to be larger “planning bureaucracies”, however, organizational-level market strategies, organic structures and environment challenges increasingly affect the organizational behavior of SMEs and shape their path of development (Miller, 1983, 2011). The impact of entrepreneurs’ indigenous individual capacity on SMEs’ performance is thus moderated by exogenous organizational constraints that are embodied in inter-organizational networks (Lumpkin & Dess, 1996; Lumpkin & Dess, 2001). Brass et al. (2004) indeed suggest that the formation of inter-organizational networks is determined by a firm’s motive to acquire network resources, learning capacity, mutual trust on its partners as well as social norms and status. In addition, they also argued that a firm’s position in an inter-organizational network has a strong impact on its organizational behavior, outcomes of innovation activities. In line with these findings, we suggest extending the scope of SME networks from personal level to organizational level and identify the antecedents that affect SMEs’ embeddedness in inter-organizational networks.

2.2.3 Hypothesis Development

Taking the importance of an SME’s network embeddedness for its performance as a starting point, we in this section evaluate which firm-level characteristics are most likely related to an SME’s centrality in an inter-firm network. Numerous studies identify size, age, and partnership diversity as key factors contributing to a firm’s centrality in generic network models (Bonacich *et al.*, 1998; Everett & Borgatti, 1999; Owen-Smith & Powell, 2004; Bell, 2005; Eagle *et al.*, 2010; Leydesdorff & Rafols, 2011). Nonetheless, to our knowledge, none of these studies have empirically investigated these relations for SMEs specifically. In this study, we aim to bridge this gap by studying the relation between an SME’s firm characteristics and its embeddedness in China’s aerospace network.

Size

A first factor that should influence an SME’s centrality in the network is its size. Firm size is often measured by “sales, total assets, net assets, equity and employment” and is used to capture a firm’s access to financial funding, human capital and knowledge inflows as strategic resources (Smyth *et al.*, 1975). Small firms are generally considered to be at a disadvantage compared to large firms. Their inferior size is often considered as a signal that they have weak social status and bargaining power in the network (Galaskiewicz *et al.*, 1985). That is, they lack the ability to develop linkages with key players in the network and are often dependent on financial and technological support from their partners. This pushes smaller firms into the periphery of the network, only able to link with other peripheral players that provide marginal network resources. (Christopherson & Clark, 2007; Laforet, 2011).

One should expect that this hierarchical order in terms of various sizes also exists among SMEs (Levy & Powell, 2004). Supported by more physical assets and social resources acquired through the inter-organizational network, large SMEs are more likely to be closer to the network core than small SMEs. The higher social status and prestige of large firms allows them to link to more central firms in the networks (Rogers, 2004; Freeman *et al.*, 2006), while smaller SMEs tend to stick to a small number of partners sharing a homogenized culture and a "resist against change" in partnership selection (Minguzzi & Passaro, 2001; Kan & Tsai, 2006).

In this sense, we anticipate firm size to be strongly correlated to an SME's centrality in the network. This leads to our first hypothesis:

Hypothesis 1: An SME's size is positively related to its network centrality in an inter-organizational network.

Age

A second factor that is expected to influence an SME's network centrality is its age.

There are a number of reasons why young SMEs are more likely to have a low degree of centrality in the network. First, young firms are more likely to be exposed to a "liability of newness" than old SMEs (Stinchcombe, 1965; Aldrich & Zimmer, 1986), which can be expected to push them in the periphery of the inter-organizational networks. Since linkage formation requires long-term commitment and trust based on repeated interaction over time (Uzzi, 1997), from a relational perspective, younger SMEs are less likely to have a large number of direct linkages, which is signaled by low degree centrality.

Second, from a structural perspective, it is hard for young SMEs to build a relation with well-connected network players since social status is an important driver of network centrality (Bitektine, 2011). Young SMEs with limited social status are less likely to establish efficient communication channels and legitimacy to influence their partners and competitors, leading to low closeness centrality and betweenness centrality. Unless they can directly establish strong ties with centrally positioned firms through informal mechanisms at entry stage or have a high capacity to frequently interact with other firms, less experienced young SMEs tend to be positioned at the periphery in inter-organizational networks (Capaldo, 2007), and are less likely to be proximate to lead firms, which is signaled by low eigenvector centrality. In general, both in inter-personal and inter-organizational networks, actors that enter a network at a later stage (or in other words, younger actors) have lower network centrality (Jackson, 2008). Therefore, we should expect the following hypothesis to hold:

Hypothesis 2: An SME's age is positively related to its network centrality in an inter-organizational network.

Egocentric diversity of direct partners

Getting connected is the first step for SMEs to extend beyond their organizational boundary and compensate for their lack of capacity and/or inexperience. In inter-organizational networks, SMEs collaborate with diversified partners including suppliers, customers, third parties, science partners and venture finance partners (Miller, 2011). A subsequent strategic concern is how to establish and manage complex connections in inter-organizational networks.

The first-order neighbourhood of a focal firm and its interconnected direct partners is defined as its egocentric network whereas the diversity of its composition is conceptualized as its egocentric diversity (Marsden, 2002). In inter-organizational networks, firms' egocentric diversity is mainly reflected in (1) tie strength (Granovetter, 1973), (2) partner diversity (Goerzen & Beamish, 2005) and (3) tie multiplexity (Shipilov, 2012; Shipilov *et al.*, 2014; Shipilov & Li, 2014).

In this study, we specifically focus on egocentric diversity of a firm's direct partners, or alliance portfolio diversity (APD) (de Leeuw *et al.*, 2014), based on the categorization of organizational governance structure. The impact of the egocentric diversity of a firm's direct partners to its performance has been profoundly discussed in recent entrepreneurship studies (Inkpen & Tsang, 2005; Phelps, 2010; Duysters *et al.*, 2012; de Leeuw *et al.*, 2014). Nonetheless, as Chen and Tan (2009) suggested, while relational diversity plays an evident role in entrepreneurship, empirical research on the channels through which egocentric network diversity affect a firm's network position is limited.

Several studies have addressed the diversity-performance mechanisms attributing to the strategic goals embodied in network embeddedness. It is argued that egocentric diversity of partners enable a firm to establish efficient configuration to reduce redundancy in information exchange (Baum *et al.*, 2000) and provides "broadened resource and learning benefits" (Jiang *et al.*, 2010). In addition, since the process of establishing an egocentric network with assorted types of partners engages long-term negotiation and competition among various market players, a firm that is capable of establishing a highly diversified alliance portfolio often leverages stronger bargaining power over its partners (Bae & Gargiulo, 2004; Lavie, 2007). For SMEs, diversity of egocentric network not only contributes to their competitiveness in terms of resource acquisition and knowledge absorption but also builds up its reputation and social status endorsed by market leaders through weak ties (Burt, 1992; Lechner & Dowling, 2003; Capaldo, 2007). In this sense, an SME with a high degree of egocentric diversity of partners is more likely to be linked to lead firms. This leads to our final hypothesis:

Hypothesis 3: The egocentric diversity of an SME's direct partners is positively related to its network centrality.

2.3 Network data

2.3.1 China's Aerospace Industry

To test our hypotheses, we take advantage of a dataset that we have hand-collected on formal linkages between a network of aerospace establishments in China. We focus on China's aerospace sector for the following reasons:

On the demand side, in the past few decades, China's aerospace industry has maintained above-average growth driven by global economic growth and technological innovation. Increasing frequency of passenger and air cargo traffic, establishment of new air routes and supportive infrastructures, and diversification of aerospace services have boosted market demand and have created new market niches for SMEs to enter.

On the supply side, the complexity of products, manufacturing processes, and relationships among business units in China's aerospace industry have strongly affected the formation of production networks. Demand for tailor-made products and services require high degree of specialized technological input and coordinated knowledge exchange and partnership between firms, universities, research institutes and government. SMEs benefit from competitive advantages facilitated by the specialized technological competence of entrepreneurs embedded in a wide range of networks. Additionally, the flexibility of organizational configuration and partnership selection of SMEs contribute to the dynamisms of the aerospace networks.

Although Original Equipment Manufacturers (OEMs) such as Airbus, Boeing, GE Aviation, Honeywell Aerospace and COMAC still hold the dominant power coordinating the production processes, the Chinese government has incrementally reduced the entry barriers of SMEs in the market and implemented regulatory incentives to encourage the engagement of private venture capital flowing into the market.

In sum, studying China's aerospace production network captures the complex and dynamic inter-organizational configuration between SMEs and their partners. It reflects the trend of integration of emerging economies in the global production networks and emphasizes on how heterogeneous players including SMEs interact in the progress.

2.3.2 Data Collection

The inter-organizational network consists of two basic elements – organizational players (nodes) and dyadic linkages (ties). In our sample, the nodes include SMEs as focal research subjects as well as their dyadic partners which include large domestic firms, foreign firms, universities, research institutes, and governmental institutions.

We use a three-step procedure to collect our network data on formal linkages between aerospace establishments. In a first step, we compiled a list of 140 large commercial aviation enterprises from the Civil Aviation Industrial Yearbook 2014 and identified them as anchor firms. In a second step, we identified their first-degree formal business linkages both at home and abroad. These linkages include strategic alliance, joint ventures, R&D partnerships, buyer-supplier relations and letters of intent for cooperation. When identifying anchor firm partners, we not only included incorporated firms, but also non-incorporated institutions such as governmental institutions, research institutes, universities and vocational colleges. At the end of this process, we ended up with a list of 920 business units in China which were connected to 5098 non-redundant ties.

In a third step, we collected data on the attributes of the network players (firms and other organizations). For Chinese business units, we used information from the State Administration for Industry and Commerce's (SAIC) National Enterprise Credit Information Disclosure System (NECIDS) to identify an entity's official name in Chinese, address of registration, type of incorporation and ownership, year of foundation and registration, major business specialization and registered capital. For foreign units, we mainly obtain data based on the information disclosure on their web portals and publicly available financial reports. In addition, secondary data such as business news on aerospace industry and market research reports are also important reference to determine the existence of linkages.

Based on the information available, we categorize these 920 units into five types: (1) domestic SMEs; (2) domestic large firms; (3) foreign firms; (4) university and research institutes; (5) governmental institutions.

A few words of explanation are needed on how we distinguished SMEs from large firms. In the literature, firm size is often associated with "sales, total assets, net assets, equity and employment" (Smyth et al., 1975). However, due to the particularities of China's reporting system (Qu et al., 2013; Wang et al., 2008), a large portion of sampled firms in our dataset do not provide publicly available information measuring firm size. We have therefore decided to use registered capital as an alternative proxy. Registered capital is the limited liability of capital contributions from all shareholders on account. According to the Corporate Law of People's Republic of China (2013), firms legally registered in China must report registered capital annually to the public in NECIDS. A minimum amount of registered capital is requested to when a firm is established and registered in NECIDS depending on the governance structure and industry (minimum 20%, for limited liability firm). Shareholders are obliged to contribute their proportion over designated periods before new shares are issued. SMEs are highly dependent on debt-related financing, whereas registered capital is relevant to their scale of available assets and implies their financial sustainability to resist market risks and capability to pay off debts (Acs & Isberg, 1991; Huang & Ouyang, 2002). In the empirical analysis, we use registered capital to signify an SME's financial resources and risk resistance, which are highly related to their firm size. In this study, we define SMEs as domestic firms with registered capital less than 1000 million RMB (approximately 150 million US dollars). Those firms with registered capital greater than this threshold are considered large domestic firms.

The descriptive statistics in Table 2.1 illustrate that the number of domestic business units are significantly larger than their foreign counterparts. Domestic SMEs represent more than 30 percent of the total number of business units.

Table 2.1: Proportion of Business Units by Region and Type

	Number	Percentage
By region		
Domestic	543	59.02%
Foreign	377	40.98%
By type		
Domestic SMEs	299	32.50%
Large domestic firms	97	10.54%
Foreign firms	335	36.41%
Universities and research institutes	132	14.35%
Governmental institutions	57	6.20%
Total	920	100.00%

Next, we follow Turkina et al. (2016) and Turkina and Van Assche (2018) by distinguishing between two linkage types based on the motive and status of dyadic relations among business units. Strategic alliances, joint venture, joint R&D projects and tentative cooperation are categorized as horizontal linkages, while arm's length supplier-buyer relationships are characterized as vertical linkages. These linkages and nodes are joined as two separate production sub-networks, namely, horizontal partnership sub-network and vertical supply chain sub-network. Both sub-networks follow different patterns of new linkage formation and involve heterogeneous power distribution dynamics over time (Turkina et al., 2016). Our data collection exercise allows us to create two sub-networks (horizontal and vertical) which when overlapped onto each other generates a large multiplex network that combines all types of linkages and a double-embedded network that only counts for linkages that appear in both networks.

Table 2.2: Network Statistics of China's Aerospace Production Networks

	Multiplex Network	Horizontal Sub-Network	Vertical Sub-Network	Double embedded Network
Number of nodes	920	663	593	336
Number of ties	5098	2206	3158	266
Density	0.006	0.003	0.004	0.000
Centralization	0.285	0.100	0.220	0.035
Average degree	5.541	2.398	3.433	0.289
Average distance	3.689	4.542	3.292	4.506
Transitivity	0.081	0.107	0.036	0.012

As shown in Table 2.2, both the horizontal and vertical sub-network consist of sparsely distributed nodes that appear to be exceedingly concentrated to major components, while peripheral nodes are bridged to the center within a short geodesic path. Such phenomenon is conceptualized as "small world", which is characterized by high cliquishness and short path length (Milgram, 1967; Watts & Strogatz, 1998). Then again, if we compare the differences between both sub-networks, the horizontal sub-network includes a larger number of nodes than the vertical sub-network, but due to the lower quantity of horizontal linkages, the density of the horizontal sub-network is lower than that of the vertical sub-network. On average, ego nodes in the vertical sub-network has more direct partners and may reach indirect partners in fewer steps than those in the horizontal sub-network. Nonetheless, it appears that in the horizontal sub-network, there are more "bridges" than in the vertical sub-network, hence the level of transitivity of the horizontal sub-network is higher than for the vertical sub-network.

From the network statistics of the union set (Multiplex Network) and intersection set (Double-embedded Network), it turns out that only one third of the business units has both types of linkages, leading to a low density and connectivity of the double embedded network. At the same time, the complementary effect of horizontal and vertical linkages contributes to the overall density, concentration and ego nodes' connectivity to their direct and indirect partners. Due to the large number of structural holes, it turns out that the transitivity of the united multiplex network is lower than that of horizontal sub-network, but higher than that of the vertical sub-network.

2.4 Methods

To empirically study the relation between an SME's antecedents (size, age and partner diversity) and its centrality in the inter-organizational network, we follow a large literature by estimating a multiple linear regression model of the following form:

$$Centrality_i = \alpha + \beta_1 Size_i + \beta_2 Age_i + \beta_3 Iqv_i + \mathbf{C}_i\gamma + \varepsilon_i.$$

$Centrality_i$ is the dependent variable that measures an SME i's centrality in the network. The regression includes three key independent variables: $Size_i$ captures an SMEs' registered capital, Age_i accounts for the number of years since the SME has been set up, the Index of Qualitative Variation Iqv_i (Blau *et al.*, 1982) represents an SME's egocentric diversity of direct partners, and ε_i is the error term. In each regression, we also include a vector of control variables $C_i\gamma$ to capture the effect of geographic and industrial heterogeneity. Note that our regression analysis allows us to pick up a correlation and that we cannot make an inference on causality in either direction from these regressions.

2.4.1 Dependent Variables

Multifaceted network centrality serves as a comprehensive measure of a firm's network embeddedness. Based on the discussion on network embeddedness and centrality measures, we use four measures of centrality in our regression analysis:

Degree centrality (C_d): Degree centrality sums up the total number of focal firm's direct partners with dyadic ties. It measures the width of resources and information flows from direct partners and represents the range of ego unit's direct neighbourhood.

Betweenness centrality (C_b): Betweenness centrality quantifies the number of times an ego acts as a bridge along the shortest path between two other nodes. It measures the brokerage power of the ego over the resources and information flows and represents the bargaining power over other partners and competitors in the network.

Closeness centrality (C_c): Closeness centrality measures ego units' communication reachability and efficiency. In this study, we calculate nominalized Freeman Closeness centrality (Freeman, 1978) as follows:

$$C_{C^{(i)}} = \frac{\left[\sum_{j=1}^{n} d(i,j)\right]^{-1}}{N-1},$$

where d(i,j) denotes the geodesic path length of ego i to reach alter j, and N represents the total number of nodes connected in the same network. A high degree of closeness centrality represents high reachability of the ego units to its direct and indirect partners.

Eigenvector centrality (C_e): Unlike the previous centrality measures that can be directly counted from the display, the eigenvector centrality of an ego unit is computed based on the eigenvalue derived from adjacency matrix rearrangement (Katz, 1953; Bonacich, 1987). It takes both the configuration of the entire network as well as the number of direct linkages an actor possesses. If we denote the eigenvector centrality of node *i* is x_i and the vector of eigenvector centrality $\mathbf{x} = (x_1, x_2 \ldots)$. The adjacent matrix for given network **A**, where the binary element A_{ij} represents if there is a connection between node *i* and neighbouring node *j*. A constant eigenvalue λ meets the criteria that

$$\mathbf{A} \cdot \mathbf{x} = \lambda \mathbf{x}$$

And the relative score of x_i is the eigenvector centrality of node *i*, so that

$$C_{e(i)} = x_i = \frac{1}{\lambda} \sum_{j=1}^{n} A_{ij} x_j$$

High eigenvector centrality represents an ego's proximity to well-connected firms that have high influence in the whole network.

2.4.2 Independent Variables

Size: As we have explained above, we measure firm size using an SMEs' registered capital in NECIDS System.

Age: We calculate the age of domestic SMEs based on the information registered in NECIDS on the base year 2016. For firms that have experienced significant corporate restructuring, we have recorded the founding year of their main business division as the year of foundation.

Egocentric diversity of direct partners: Based on the five-way categorization of business units, the diversity of a domestic SME's direct partners is measured by the Index of Qualitative Variation (IQV) (Blau *et al.*, 1982):

$$IQV_r = \frac{1 - \sum_{i=1}^{n} p_i^2}{1 - \frac{1}{n}}$$

where p_i represents the proportion of each type of alter-partners' presence, and n represents the total number of categories: domestic SME, large domestic firms, foreign firms, universities and research institutes, governmental institutions.

2.4.3 Control Variables

To control the impact of heterogeneous ties across geographic regions, business sectors and governance structure in an SME's egocentric network, in the regression models, we also include the following tie diversity measures as control variables: the number of direct cross-national connections, linkages to non-incorporated organizations (universities, research institutes, and governmental institutions), linkages to non-manufacturing units and number of horizontal linkages.

Foreign linkages: Number of an SMEs foreign partners (firms, universities, research institutes, and governmental institutions).

Non-incorporated linkages: Number of an SME's non-incorporated partners (domestic and foreign universities, research institutes, and governmental institutions).

Non-manufacturing linkages: Based on the dichotomy of business activities in Porter's generic value chain model (Porter, 1985), we labelled business units that are not specialized in the manufacturing sector as "non-manufacturing connection" and count an SMEs total number of direct connections to such units.

Horizontal linkages: Based on the observation of the whole network property, we can observe the leverage effect on network efficiency of horizontal linkages. Since in comparison to arm's length supply chain linkages, establishment of horizontal linkages requires a higher frequency of repetitive contacts and degree of mutual trust, we count an SME's total number of horizontal linkages as a measure of their long-term orientation.

2.5 Results

Table 2.3 presents some descriptive statistics. Apart from the combinations number of horizontal linkages and linkage diversity (r= 0.50; p=0.000) and the pair of the prior and non-incorporated connections (r=0.35; p=0.000), the linear correlation coefficients of all other pairs of independent variables are either insignificant or remain at a low level (<0.30). When we calculate the mean variance inflation factor (VIF) of these independent variables based on regression models, it turns out that the mean *VIF* value remains at a relatively low level (mean *VIF*= 1.29). This suggests there is no evidence of multicollinearity.

Table 2.3: Correlations, Means and Standard Deviations of Independent Variables

		Mean	**S.D.**	**1**		**2**		**3**		**4**	**5**		**6**	
1	**Size**	2.04	2.53											
2	**Age**	22.42	18.79	0.28	***									
3	**Egocentric diversity of direct partners**	0.33	0.33	0.20	***	0.12	**							
4	**Foreign linkages**	2.85	7.83	0.13	**	0.05		0.02						
5	**Non-incorporated linkages**	0.89	2.51	0.01		0.05		0.38	***	0.02				
6	**Non-manufacturing linkages**	0.26	0.44	0.02		-0.18	***	0.20	***	-0.05	0.22	***		
7	**Horizontal linkages**	2.11	2.96	0.20	***	0.28	***	0.50	***	0.06	0.35	***	-0.12	**

Note: Significance level: *<0.1; **<0.05; ***<0.01

Next, we present the results of our multiple regression analysis in Table 2.4. Models 1 to 4 use degree centrality, betweenness centrality, closeness centrality and eigenvector centrality as dependent variables respectively. Our results suggest there is some evidence that an SME's size is positively related to its centrality in the network. The results in Model 1 suggest that SMEs with a higher level of registered capital have higher degree centrality (Model 1: β= 0.2276; p=0.002). Moreover, the results in Model 4 suggest that larger SMEs also have a higher degree of eigenvector centrality, suggesting that they are more proximal to well-connected units than those with lower level of registered capital (Model 4: β= 0.0010, p=0.004). We find no evidence, however, that larger SMEs have higher betweenness or closeness centrality. These results thus provide partial evidence for our Hypothesis 1.

We do not find evidence for Hypothesis 2. In terms of age, only Model 4 finds a significant relation between age and SMEs' eigenvector centrality, but the relation is negative which is contrary to the Hypothesis 2. The absolute value of the coefficient in Model 4 is nonetheless extremely small (Model 4: β= -0.0001; p=0.004). As for the other three models, the relation between age and centrality is insignificant.

Finally, we find consistent evidence that a SME's egocentric diversity of direct partners is positively and significantly related to its centrality. An SME with high degree of diversification of direct partners tend to have wider range of direct ties, high brokerage power and efficiency in resource and information transmission, and they are better connected to the most well-connected players in the network (Model 1: β=2.7613, p=0.000; Model 2: β= 831.3707, p=0.021; Model 3: β=0.0436, p=0.000; Model4: β=0.0097, p=0.000). Hypothesis 3 is therefore robustly supported for all four measures of network centrality.

Focusing on the control variables, we find that the relation between tie diversity and network centrality is not as consistent as for egocentric diversity of direct partners. Unexpectedly, connections to foreign units only have a marginally significant relation with an SME's closeness centrality, and it turns out to be negative (Model 3: β=-0.0008, p=0.044). In contrast, the positive relation between linkages to non-incorporated units such as universities, research institutes, and governmental institutions and network centrality are evident in improving the width or direct linkages, brokerage and bargaining power as well as partnership with well-connected players. Nevertheless, their contribution to global communication reachability and efficiency of SMEs are not significant (Model 1: β=1.1249, p=0.000; Model 2: β=86.405, p=0.046; Model 4: β=0.004, p=0.000). Specialization in non-manufacturing sectors only significantly contributes to the number of direct partners, while its influence on SMEs' connection to indirect partners is not evident (Model 1: β=0.9594, p=0.029). Finally, SMEs that establish long-term oriented horizontal linkages, such as strategic partnership, joint-venture and joint R&D programs with direct partners are better positioned in complex business network in all four aspects of network embeddedness (Model 1: β=0.8216, p=0.000; Model 2: β= 457.4075, p=0.000; Model 3: β=0.0028, p=0.0034; Model4: β=0.001, p=0.019). These results are in line with our arguments on the important of mutual trust in knowledge transfer.

Table 2.4: Multiple Regression Models on Centrality Measures

Dependent Variable	(1) C_d: Degree Centrality		(2) C_b: Betweenness Centrality		(3) C_c: Closeness Centrality		(4) C_e: Eigenvector Centrality	
Size	0.2276 (0.0739)	***	16.2281 (40.4329)		0.0017 (0.0013)		0.0010 (0.0003)	***
Age	-0.0088 (0.0101)		-1.4554 (5.5207)		-0.0002 (0.0002)		-0.0001 (0.0000)	***
Egocentric diversity of direct partners	2.7613 (0.6524)	***	831.3707 (356.9468)	*	0.0436 (0.0115)	***	0.0097 (0.0027)	***
Foreign linkages	-0.0105 (0.0225)		0.1310 (12.2989)		-0.0008 (0.0004)	**	-0.0001 (0.0001)	
Non-incorporated linkages	1.1249 (0.0788)	***	86.4048 (43.0890)	*	0.0022 (0.0014)		0.0035 (0.0003)	***
Non-manufacturing linkages	0.9594 (0.4375)	**	-104.7804 (239.3556)		0.0056 (0.0077)		0.0029 (0.0018)	
Horizontal linkages	0.8216 (0.0746)	***	457.4075 (40.8393)	***	0.0028 (0.0013)	**	0.0007 (0.0003)	**
Constant	0.5380 (0.3374)		-151.9292 (184.6198)		0.2231 (0.0059)	***	0.0043 (0.0014)	***
N	299		299		299		299	
F-value	118.60	***	40.990	***	9.200	***	41.340	***
R-squared	0.7405		0.497		0.181		0.499	
Root MSE	3.0048		1644.100		0.053		0.013	

Note: Significance level: *<0.1; **<0.05; ***<0.01

2.6 Discussion

In this study, we have conducted social network analysis to test how size, age and egocentric diversity of direct partners are related to an SME's embeddedness in inter-organizational networks. The empirical results turn out to be divergent compared to our hypotheses that these three antecedents unilaterally and coherently contribute to an SME's embeddedness in inter-organizational networks.

First, the empirical result that an SME's size is positively related to its degree and eigenvector centrality confirms our Hypothesis 1 that smaller firms are constrained to extend the range of direct dyadic partners (degree centrality) and may have more difficulties linking to well-connected lead firms in the network (eigenvector centrality). However, we do not find evidence that firm size positively contributes to an SME's brokerage bargaining power (betweenness centrality) and communication reachability and efficiency (closeness centrality). This may be due to the fact that, apart from resources and capacity that are embodied in firm size, an SME's specialized business sectors and governance structure also play an important role determining if it is necessary for the focal SME to serve as brokers bridging the structural holes between other firms and to optimize the path to reach all other players in addition to the most strategically important partners (Pitt *et al.*, 2006; Kirkels & Duysters, 2010). In our sample, we observe SMEs specialized in support services such as Maintenance, Repair and Operations (MRO), IT consulting, logistics and financial services are more likely to have higher betweenness centrality and closeness centrality than SMEs specialized in manufacturing of equivalent size. A similar phenomenon appears that SMEs which participate in joint ventures are more likely to bridge diverse organizational players than state-owned or domestic private SMEs regardless of size. Therefore, for further study, we suggest studying how heterogeneity in business sectors and governance structure mitigate the effect of firm size on SMEs' betweenness centrality and closeness centrality.

Second, contrary to Hypothesis 2, we do not find strong evidence suggesting that an SME's age is positively related to the various centrality measures. Specifically, no relation was found between age and the three measures degree centrality, betweenness centrality and closeness centrality. Only a very small negative relation was found between age and eigenvector centrality. There are a number of factors which could explain this counterintuitive result. First, an SME's age may not capture well the degree of experience that its managers have. An experienced manager or entrepreneur that sets up a new SME may have a rich portfolio of inter-personal contacts that allows the young firm to rapidly embed itself into the network. Particularly in the Chinese context where "Guanxi" plays a crucial role in business development, (Bian & Ang, 1997; Lovett *et al.*, 1999; Yang, 2009), an SME's network centrality may be particularly driven by the experience of the managers rather than by the firm's age. In addition, while it has been documented that young SMEs encounter a liability of newness, they may also benefit from a "learning advantage of newness" (Posen & Chen, 2013). In comparison to incumbent SMEs, entrant SMEs may more proactively adapt to new trends and more efficiently building up linkages with lead firms. There is indeed growing evidence that younger firms can avoid "lock-in" in less well-connected cliques isolated from the network core that older firms may be trapped in (Autio *et al.*, 2000; Visser & Boschma, 2004; Sydow *et al.*, 2009). Finally, many young SMEs may be spinoffs of large lead firms, with whom these SMEs have the innate advantage of forming close relationship in the inter-organizational networks as part of the orchestration mechanism of large lead firms' headquarters (Mudambi, 2008; Schotter & Beamish, 2011).

Third, the we find strong evidence that egocentric diversity of direct partners is positively related with all four centrality measures. Diversification is often emphasized as a rudimentary strategy to enhance a firm's financial performance and technological capacity. Researchers have in the past used different approaches to measure diversity including variation of productions, multi-ethnicity of employees, multiple business sectors firms are specialized, or the complex board structure in corporate governance (Hitt *et al.*, 1997; Thomas, 2004; Freund *et al.*, 2007). In this study, we specify the two types of organizational diversity that we expect to affect an SME's network embeddedness. The consistent positive impact of egocentric diversity of direct partners on all centrality measures implies that SMEs' partnership selection strategies should expand from only focusing on large domestic firms or multinationals to get in contact with non-incorporated organizations such as universities, research institutes and governmental institutions. As for tie diversity, the impact of industrial, organizational and geographic factors varies depending on the strategic orientations of network activities. Connecting to foreign business units downgrades the reachability and efficiency of SMEs' communication. In contrast, connections to non-incorporated units, such as universities, research institutes and governmental institutions can expand SMEs' neighbouring range of direct partners, brokerage and bargaining power and proximity to well-connected market leaders. Finally, the impact of industrial heterogeneity is marginal, as SMEs specialized in non-manufacturing sectors hold the advantage of more direct partners, but do not necessarily have effective reach to indirect partners and influencing power in the whole network.

2.7 Conclusion

This study has identified several antecedents of SMEs' embeddedness in inter-organizational networks and has tested their relation to multiple network centrality measures. We have first emphasised the importance of inter-organizational network embeddedness for SMEs in terms of acquiring network resources and enhancing capabilities. Next, we have introduced multiple network centrality measures which capture the relational and structural aspects of an SME's embeddedness in inter-organizational networks. Finally, we have applied social network analysis method to identify how age, size and egocentric diversity of direct partners affect an SME's network embeddedness. We found that an SME's size is positively related to its range of direct partners as well as to its proximity to well-connected lead firms. Further investigation needs to be conducted to identify if other factors (such as business sector and governance structure) mitigate the effect of size on SMEs' brokerage bargaining power and communication reachability and efficiency. Concerning age, we did not find empirical support that younger SMEs are less central than older SMEs and have discussed potential reasons why this is not the case. Finally, the consistent positive relation between egocentric diversity of direct partner and firm centrality highlights the importance of interaction with miscellaneous organizational players as direct contacts. It is suggested that SMEs should diversify their partnership with heterogeneous types of organizations to achieve assorted strategic goals in inter-organizational networks.

For further research, we suggest studying the degree to which different aspects of network embeddedness contribute to strategic resources acquisition, capacity enhancement, and behavioral influence over other partners. In addition, the scope of research can be extended to multinational and cross-industry level. We suggest further exploring how cross-national and cross-sector ties contribute to an SME's competitiveness. Additionally, longitudinal studies on the shift of linkages among diverse partners over time could also help to understand the dynamics inter-organizational network evolution and how the changing network contributes to an SME's competitiveness. Finally, we would suggest studying how heterogeneous cultural backgrounds and informal inter-personal linkages (e.g. "Guanxi" in Chinese context) are linked to inter-organizational networks and how they affect an SME's performance and capacity.

Figure 2.1: Multiplex Network of China's Aerospace Industry by Diversity

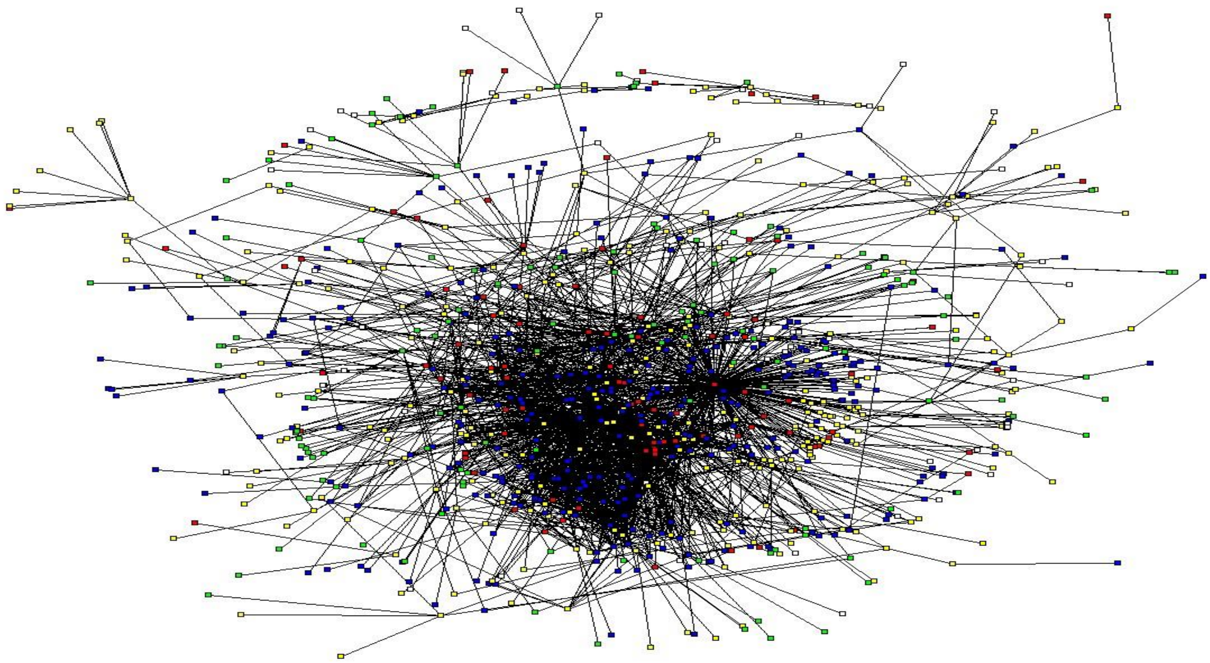


Figure 2.2: Horizontal Sub-Network of China's Aerospace Industry by Diversity

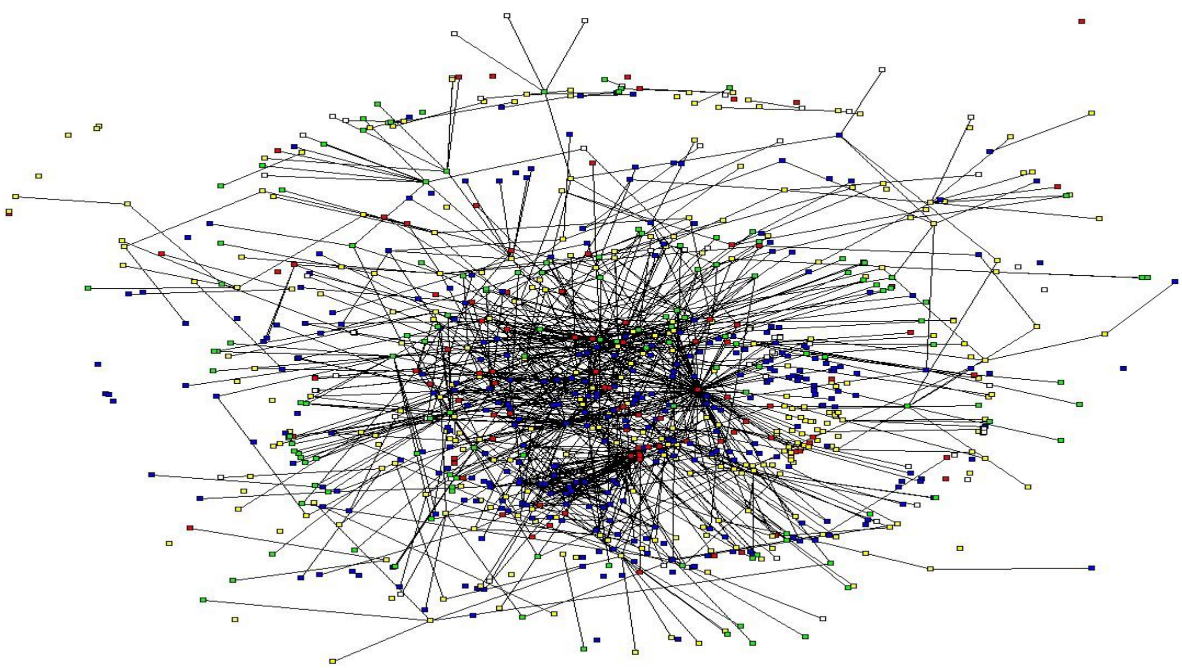


Figure 2.3: Vertical Sub-Network of China's Aerospace Industry by Diversity

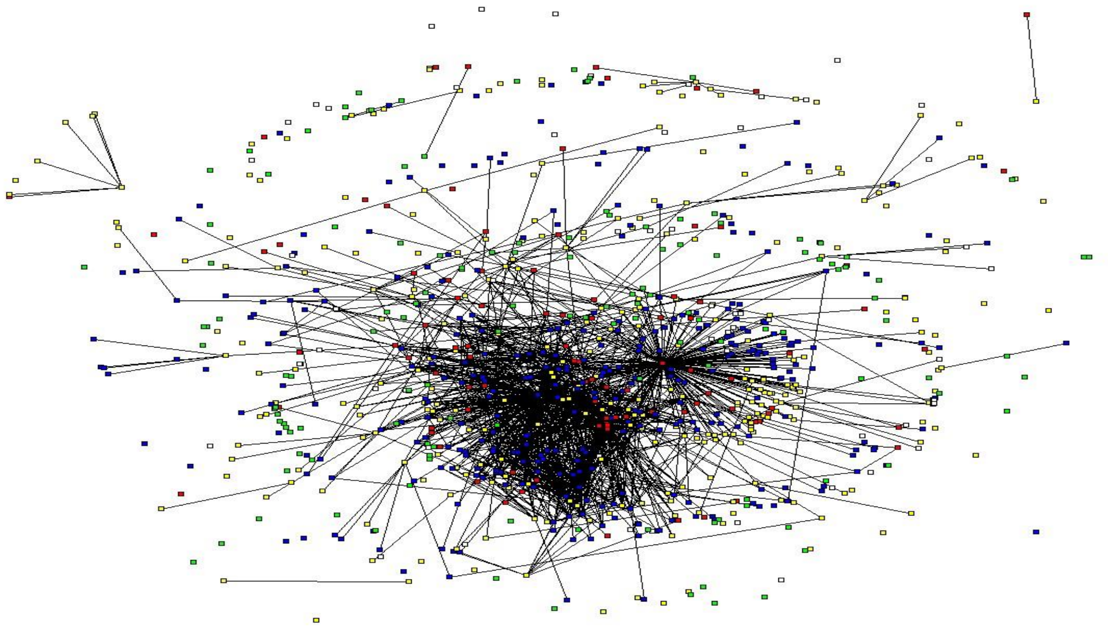
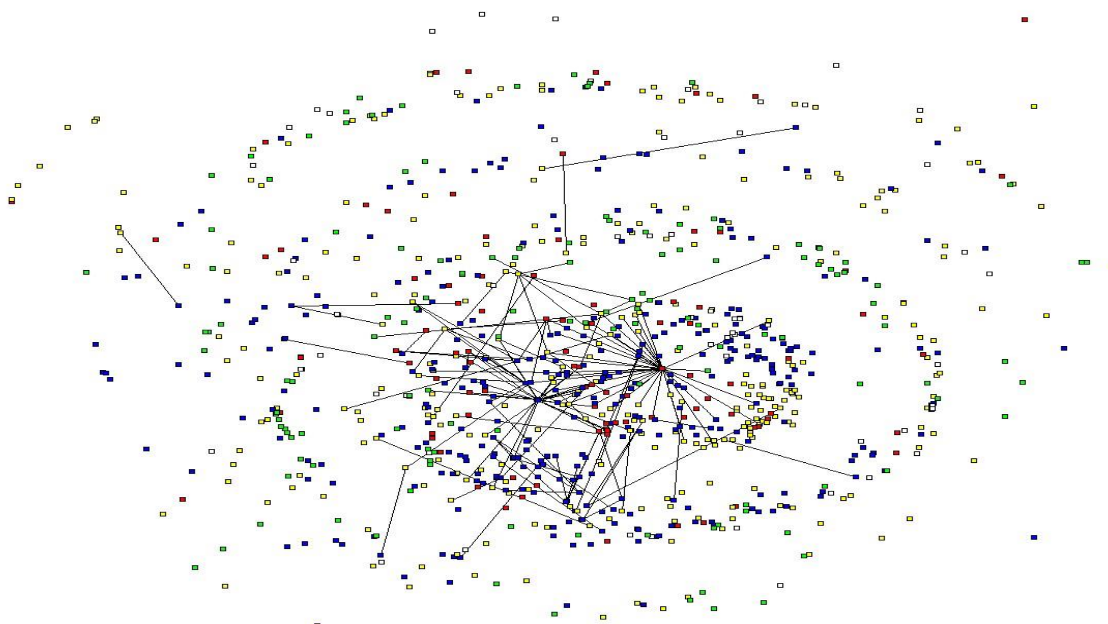


Figure 2.4: Double Embedded Network of China's Aerospace Industry by Diversity



Note: The colors of vertices represent different types of business units: (1) Domestic SMEs (yellow); (2) Domestic large firms (red); (3) Foreign firms (blue); (4) University and research institutes (green) (5) Governmental institutions (white).

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Chapter 3
Global Value Chains and National Production Networks: Analysis of China's Aerospace Industry

Abstract

This study explores how the value chain positioning and industrial clusters contribute to a firm's position in a national production network in terms of its proximity to the network core and range of social relationships. Integrating the theories of the global value chains, industrial clusters and social networks, we analyze the configurations of national production networks and determinants of a firm's network embeddedness. Based on the analysis on the Chinese aerospace industry, we fine that OEMs dominate the production phases in the network hierarchy. At the same time, location in industrial clusters contributes to a firm's proximately to the network core mainly by vertical integration. In addition, geographic boundaries and local economic development have diverse effects on a firm's network embeddedness in both structural and relational terms.

3.1 Introduction

The growing interconnectivity among firms located in geographically disperse locations has become a prominent feature of globalized production nowadays. Conducting interrelated business activities, firms establish business relationships with diverse partners across geographic boundaries and contribute to the formation and evolution of production networks overtime (Ernst & Kim, 2002; Henderson *et al.*, 2002; Castells, 2011). This process accompanies knowledge creation, absorption and transfers taking place in various locations (Amin & Cohendet, 2004; Bathelt *et al.*, 2004). Based on their different knowledge base, specialized expertise and absorptive capability, firms at different stages of the global value chains choose various forms of business relationships getting in contact with each other (Lane & Lubatkin, 1998; Myers & Cheung, 2008; Capone & Lazzeretti, 2018). Consequently, the patterns and intensity of inter-firm relationships lead to the construction of a hierarchical order where embedded firms are allocated in different positions in the production networks (Ernst & Kim, 2002; Lazzeretti & Capone, 2016; Broekel & Mueller, 2018). The governance mechanisms of the global value chains provide a heuristic framework for understanding how production networks are constructed and coordinated. Integrating the input-output streams of value-adding business activities on the global scale, the global value chain model underlines the inter-organizational coordination mechanisms that connect modularized production activities carried on by firms established in disperse locations (Porter, 1985; Humphrey & Schmitz, 2000; Gereffi *et al.*, 2005; Mudambi, 2008; Sturgeon *et al.*, 2008; Turkina *et al.*, 2016). Subsequently, the entire nexus infrastructure that incorporates formal inter-organizational relationships together with all economic entities these relationships connect construct the production networks (Ernst & Kim, 2002; Coe *et al.*, 2004; Yeung, 2009).

A great number of prior studies has highlighted the strong strategic implication of production network configuration on the competitive advantages of firms globally (e.g. Dyer & Singh, 1998; Foss, 1999; Andersson *et al.*, 2002; Coviello, 2006; Cantwell, 2013). They attribute a wide range of connections and a dominant position in the network hierarchy as important sources of competitive advantages. Nonetheless, many of these studies focus on either the worldwide geographic interconnections between countries and regions on the global scale (Ernst, 2002; Henderson *et al.*, 2002; Coe *et al.*, 2004; Yeung, 2009; Neilson *et al.*, 2014), or the organizational coordination mechanisms of the intra-firm network between headquarters and its subsidiaries in different host countries (Andersson *et al.*, 2002, 2007; Dhanaraj, 2007; Meyer *et al.*, 2011; Rugman *et al.*, 2011). Few studies have combined both geographic and organizational coordination within the same explanatory framework to address the strong relevance of the global value chains and production networks. Moreover, regardless of the existing literature on the concept of the global production networks, empirical studies on the configurations of the production networks in a national market context are still insufficient.

This study explores how the value chain governance, industrial cluster agglomeration and geographic location affect a firm's position in the national production network of a knowledge-intensive industry. In this framework, firms benefit from a wide range of direct contacts in absorbing knowledge inflows and closeness to the network core in establishing its influence in the national market. These network-related advantages are affected by a firm's positioning in the value chain stream and its geographic location. To verify the hypotheses, we constructed a set of network configurations of the Chinese aerospace industry including a multiplex national production network, a horizontal collaborative partnership network and a vertical supplier-buyer relationship network. All these production networks consist of multinational economic entities (firms, universities and R&D centers, governmental authorities) connected by diverse business relationships. By conducting empirical network analysis, we will identify at what value chain stage firms are most likely to take advantageous network positions. Then we estimate how industrial cluster agglomeration, geographic boundaries and economic development affect the results. Based on the findings from the empirical analysis, we propose several directions for future research.

3.2 Literature Review and Hypotheses

3.2.1 Network Position as Competitive Advantages

In an open economy, the national production networks integrate economie entities that operate business activites and establish direct connections with each other. These processes involve social exchanges in business relationships among firms of diverse specializations across geographic boundaries (Hakansson & Johanson, 1992; Ernst & Kim, 2002; Yeung, 2009). Individual firms are perceived as knowledge processors that combine their intrinsic strategic assets as knowledge base with the embedded architectural frames that channel them to external knowledge sources hold by other counterparts in the knowledge exchange dynamics (Kusunoki *et al.*, 1998; Amin & Cohendet, 2004). A firm with high absorptive capacity - the capability to evaluate, assimilate and apply new knowledge acquired- often has better access to retrieve different knowledge bases, recognizes the value of new knowledge and applies it to commercial ends orchestrating knowledge flows over the network structure (Cohen & Levinthal, 1990; Boschma & Lambooy, 1999; Tsai, 2001; Fabrizio, 2009; Cantwell & Mudambi, 2011).

In the framework of production networks, how firms related to each other is defined as their network position (Burt, 1976). Reflecting a firm's role in the industrial structure and relational dynamics, a firm's position in the production network has a strong impact on its market performance and overall competitiveness (Gulati *et al.*, 2000; Uzzi & Gillespie, 2002; Broekel & Hartog, 2013). These advantages include better access to strategic assets (Dunning, 1988; Barney, 1991; Dunning, 2001; Lavie, 2006; Peppard & Rylander, 2006; Sturgeon *et al.*, 2008), high leverage power in knowledge diffusion and innovation process over partners and competitors (Stuart & Sorenson, 2003; Arregle *et al.*, 2009; Hennart, 2009; Cantwell *et al.*, 2010; Santangelo & Meyer, 2011; Shi *et al.*, 2014; Lazzeretti & Capone, 2016), as well as prestigious social status and influence in the whole production ecosystem (Uzzi, 1997; Gulati & Gargiulo, 1999; Podolny, 2001; Inkpen & Tsang, 2005). Based on the different degree of network-based competitive advantages firms acquire, the governance of production networks follows a hierarchical order wherein power is unevenly distributed (Cook & Emerson, 1978; Lavie, 2006; Broekel & Mueller, 2018). Well-connected network players with higher organizational capability occupy the advantageous network positions at the core, *vice versa*, less well-connected ones with lower organizational capability are driven to the disadvantageous network position in the periphery (Capaldo, 2007; Ter Wal & Boschma, 2011; Lipparini *et al.*, 2014).

A firm's network position comprises of two layers, that is, the firm's its relative importance in the whole web of exchange relationships and the sum of contacts it has direct connections with (Johanson & Mattsson, 1992). In consistence with the two layers of network positions, Gulati (1998) specified that there are two dimensions of network embeddedness that generate competitive advantages: those generated by the influence over the whole network through direct and indirect connections in the network configuration layout, and the competitive advantages generated by of learning and the exchange of information in close dyads. He defined the former types of network-related competitive advantages as a firm's structural embeddedness and the latter as its relational embeddedness. A firm with a high degree of structural embeddedness takes a preferential position as a bridging broker over the structural holes and has stronger bargaining power over counterparts that are dependent on its control over knowledge flows (Burt, 1992; Rowley *et al.*, 2000; Moran, 2005). A firm with a high degree of relational embeddedness has a wide range of direct access to resources and knowledge that constantly improve the quality of its social relationships under uncertainty (Uzzi & Lancaster, 2003; Carson *et al.*, 2006; Meuleman *et al.*, 2010). To assess the degree of a firm's structural and relational embeddedness in a network framework, researchers in social networks have developed a series of centrality measures (e.g. Nieminen, 1974; Freeman, 1978; Bonacich, 1987). High network centrality generally indicates the competitive advantages a firm obtains from taking a preferable network position in quantitative terms (Wang *et al.*, 2018). In the empirical analysis, we will compare different centrality measures as comprehensive indicators of network positions.

3.2.2 Value Chain Stages and Network Positions

The global value chains characterize the interrelationship of value-adding activities and business sectors on a global scale. Their governance mechanisms consist of inter-organizational coordination between different stages and cross-border connections between regions where specialized firms are located. The segregation of production activities at sequential stages of value chain undertaken by specialized firms is defined as modularization (Ernst & Kamrad, 2000). Based on the knowledge and relational complexity of business activities, the amount and degree of interdependence of firms in each specialized modules vary (Fleming & Sorenson, 2001). As the cost and difficulty in knowledge exchanges increases, firms specializing in high knowledge complex modules must have high organizational capability to access and proceed complex knowledge context (Sorenson *et al.*, 2006). A firm's allocation in modules represents the technological and organizational knowledge base a firm obtains from and shares with counterparts (Lee & Yang, 2000). In this sense, firms specialized in high knowledge complex modules are more likely to be better positioned in the production networks.

The modularization process in the value chain is embodied in the sequential stages in the value chain. A generic value chain model of a given industry consists of primary business activities that engage physical creation and transfer of products (e.g. manufacturing operations, distribution and sales), as well as support activities that that coordinate and sustain primary activities (e.g technological Research & Development, procurement and logistics, human resources, management administration and other specialized services) (Porter, 1985). Facilitated by the coordination of support service providers, the primary manufacturing process combines the value-adding stages including multiple-tier suppliers, Original Equipment Manufacturers (OEMs), distributers and end buyers. Among firms specialized in all stages of the value chain, we argue that the OEMs act as the orchestrators of the value chains and have higher network centrality than other firms. They carry out the majority manufacturing and assembly activities and play the dominant role in controlling and coordinating the input-output flows between suppliers, distributers and buyers (Sturgeon, 2001; Quesada *et al.*, 2006; McDermott *et al.*, 2013). At the same time, to optimize the cost structure and utilize trans-local resources and knowledge, they outsource value-adding activities to third-parties and extend the range of their business networks in the decentralization process (Williams *et al.*, 2002; Bales *et al.*, 2004). In terms of knowledge exchange, OEMs outsource specified knowledge and serve as "flagships" that facilitate the technological capability upgrading of multiple-tier suppliers, especially to independent local suppliers through informal mechanisms (Fan *et al.*, 2000). Dealing with complex relationships and knowledge exchanges, OEMs have a broader range of social contacts and serve as pivotal coordinators monitoring the manufacturing operations and market sales. Hence, we propose:

Hypothesis 1: OEMs are more centrally positioned than other firms in the national production networks.

3.2.3 Industrial Clusters and Network Positions

The worldwide extension of the global value chains characterizes the geographic scope of cross-border business activities. In addition to the generic inflow-output stages, the global value chains model also emphasizes the geographic divisions across specialized regions of different levels of economic development (Gereffi & Fernandez-Stark, 2016). The modularization of the global value chain highlights the tendency of spatial agglomeration of specialized production positions industrial clusters, namely "geographic concentration of inter-connected companies" (Porter, 2000). As a starting point, heterogeneity in resource endowments, infrastructure facilities and industrial policies drive firms of diverse specializations and capabilities to launch their establishments and operations in locations where they can achieve competitive advantages and forms industrial clusters subsequently (Barney, 1991; Markusen, 1996; Porter, 1998). Within industrial clusters, co-located firms share public goods to reduce production costs, generate local context-specific tacit knowledge through frequent face-to-face communication between decision makers and benefit from the positive externality of knowledge spillover effect (Nonaka & Takeuchi, 1995; Cantwell & Santangelo, 1999; Maskell & Malmberg, 1999; Asheim & Isaksen, 2002; Mudambi & Swift, 2011).The spatial proximity between these co-located firms contributes to positive externality of knowledge spillovers, in turn, benefits all the players attached to the same milieu and leads to regional specialization in the industrial clusters (Jaffe *et al.*, 1993; Malmberg & Maskell, 1997; Porter, 2000; Giuliani & Bell, 2005).

Meanwhile, coordinated by sequential order of the value chain stages, modularized business activities taking place in geographically disperse industrial clusters become interconnected in the production networks (Ricci, 1999; Arndt & Kierzkowski, 2001; Coe *et al.*, 2004). In this process, globally presented multinational enterprises (MNEs) accelerate the formation of industrial clusters by taking the lead of local knowledge generation and sharing and coordinate the relationships within the clusters where their headquarters are located in. (Rugman & Verbeke, 2003b). They also act as the boundary spanners across industrial clusters through cross-border connections with subsidiaries and external partners (Carlsson & Mudambi, 2003; Marrone *et al.*, 2007; Mudambi, 2008). Facilitated by their with superior technological competence and absorptive capacity, MNEs take the role codifying and diffusing locally entrenched tacit knowledge across clusters (Nonaka & Takeuchi, 1995; Easterby-Smith *et al.*, 2008; Asmussen, 2009). Thanks to the orchestration of MNEs, the “local buzz” generated by the interactions of co-located firms within specialized industrial clusters become interconnected in the networks through the “global pipelines” that leverage by the boundary spanners (Bathelt *et al.*, 2004). The development of clusters through the knowledge sharing among co-located firms and the increasing global linkages of highly competent cluster gatekeepers calls for further exploration of multi-layer trans-local networks of cluster beyond a separate understanding of the local and the global spheres (Bathelt & Li, 2013; Broekel & Mueller, 2018; Gong & Hassink, 2018). Compared with firms located outside industrial clusters, firms located in the industrial clusters have a better chance to benefit from the orchesteration of influential MNEs, thus extend their range of direct contacts and reach the nework core.

Therefore we propose:

Hypothesis 2: Firms located in industrial clusters are more centrally positioned in the national production networks.

3.2.4 Geographic Boundaries and Network Positions

In the national production networks, the geographic division between foreign and local markets affects the position of firms of different national origins. In general terms, geographic distance and environmental differences between different national markets lead to "liability of foreignness" (Hymer, 1976; Zaheer, 1995). To differentiate the geographic location from the ownership structure, we define firms located outside the territorial boundary designated national market as foreign-based firms. When entering the local market, foreign-based firms often lack social connections with local partners and have insider's insight on local-context specific knowledge. Moreover, the information asymmetry, bounded rationality of decision-makers, and the tendency of opportunism of business partners all result in high transaction costs and market risk in the cross-border business activities (Williamson, 1975; Grover & Malhotra, 2003). Johanson and Wiedersheim-Paul (1975) define the factors preventing or disturbing information flows between different national market as "psychic distance", which reflect the impact of geographic origin on a firm's familiarity with a foreign market. The psychical geographic distance adds the costs of logistics and communication and offsets the economic gains from cross-border business. Moreover, the local social context and institutional settings further impose restrictive strings on the network embeddedness of foreign-based firms in the market they enter (Kogut & Singh, 1988; Kostova & Zaheer, 1999; Xu & Shenkar, 2002; Salomon & Wu, 2012). The formal and informal institutional constraints are embodied in the difference of cognitive perception, organizational structure, cultural norms and institutional regimes. Subsequently, they affect the order of cross-border collaborations and innovation output in the national production networks (Boschma, 2005; Balland *et al.*, 2015; Capone & Lazzeretti, 2018). Additionally, "home bias" still broadly exists in cross-border business activities. Local firms are more likely to establish business relationships with each other than with foreign-based counterparts in the national production networks (Wolf, 2000; Hillberry & Hummels, 2003; Ke *et al.*, 2010). Unfamiliarity with local knowledge due to lack of sufficient partnership with trustworthy and long-term committed local partners leads to the relationship-/network-specific disadvantages, namely liability of outsidership (Johanson & Vahlne, 2009; Brouthers *et al.*, 2016). Compared with local firms, foreign-based firms are less likely to take a core position in the national production network they enter.

Hypothesis 3: Foreign-based firms are less centrally positioned in a national production network than the local-based ones.

3.2.5 Economic Development and Network Positions

Another scope to observe the geographic determinants of national production network configurations is the regional economic development. On the global scale, firms specializing in high knowledge complex sectors are highly likely to agglomerate in economically developed regions. These regions are more bundant in production factors, which include highly skilled human capital, well-developed infrastructure facilities, highly efficient administrative regimes, and stringent and transparent intellectual property rights production (Archibugi & Michie, 1997; Porter, 1998; Humphrey & Schmitz, 2002). These factors attract the agglomeration and interactions of firms specialized in high value-adding business. Subsequently, the geographic distribution of value-adding activities shapes a “smile curve” where high value-added knowledge-intensive activities are concentrated in a few economically developed regions, while low value-added resources- and labor-intensive activites are broadly spread across developing world (Iammarino & McCann, 2006; Mudambi, 2008). In turn, countries and regions of versatile industrial structure and the relative competitive advantages in high value-added sectors have higher economic growth potential and occupy the core of the production networks (Hidalgo & Hausmann, 2009). These regional advantages also contribute to the connectivity of the local firms. The better global connectivity in economically developed regions facilitates local firms’ effort in establishing partnerships and knowledge absorption across geographic boundaries, thus deepen their embeddedness in the production networks(Yeung, 2009). Moreover, as spatially sticky complex knowledge tends to be generated in a few economically advanced regions, firms located in these regions have better chance to access sophisticated knowledge from local interactions, and obtain stronger bargaining power over firms located in less developed regions that also aim to acquire such knowledge (Balland & Rigby, 2017). We further propose:

Hypothesis 4: Firms from economically developed regions are more centrally located in national production networks than the other firms.

3.3 Data Collection

To test the hypotheses, we construct a series of production network configurations of the Chinese aerospace industry and conduct the analysis of the effects of organizational and geographic determinants on an individual firm's network position. This contextual selection is based on the representativeness of high knowledge complexity and global coordination mechanisms of the aerospace value chains, as well as the emerging power of Chinese aerospace firms that aim to establish global competitiveness through extending its national production networks.

Over the last decade, the aerospace industry maintains above-average growth driven by global economic growth and rudimental technological innovation, in spite of recent short-term market shocks, including financial crisis, oil price fluctuation and new security threats (Boeing, 2015). On the demand side, increasing individual income level and air travel frequency, especially in emerging economies, create new market niches. On the supply side, technological innovation, lower oil price and deregulation lowers market entry thresholds with a considerable profit margin as well as accelerate replacement cycle of aircrafts and related-equipment. The complex aerospace production processes reflect the hierarchical integration of a wide range of inter-related value adding sectors and knowledge exchange activities spread all over the world. Major categories of aeronautical products (e.g. passenger aircraft, aircraft carriers and engines, helicopters, avionics equipment, flight simulator) belong to the high cost, complex products and systems (CoPS) that consist of a large number of tailored-made and engineering intensive components, devices and sub-systems. It requires intensive and diversified R&D and requires world-wide coordination and cooperation strongly influenced by government support (Niosi & Zhegu, 2005). The complexity of products, manufacturing process, knowledge exchange and relationships among various business units all strongly interaction between production network formation and global value chains. We believe, studying the cross-border value chain and production networks of aerospace industry fits the purpose of this study well.

Although the global aerospace industry is still largely dominated by developed countries in North America and Western Europe, emerging economies such as China, Russia and Brazil have settled their roots in the industry and launched a considerable challenge to their western competitors. Characterized by world leading economic growth, rising middle class with increasing income, increasing market openness to FDI, and strong policy support from the government, China appears to be world's second largest civil aviation market with robust growth rate (Cliff *et al.*, 2011). At the same time, China's aerospace industry is undergoing economic liberation and reform provide both opportunities to explore and exploit the market as well as challenges such as institutional voids and market uncertainty for foreign-based firms entering the market (Khanna & Palepu, 1997; Arnold & Quelch, 1998). Studying Chinese aerospace industry helps to understand how various geographic, organizational and institutional factors alter the evolution of complex production networks in the market and forecasts the developing trend of high-end manufacturing industries in emerging economies.

The data collection process of this study is based on a reverse selection process of leading firms' dyadic partners in China's aerospace industry. We first refer to the 140 commercial aviation enterprises above designated size included in *Civil Aviation Industrial Yearbook 2014*, that is, enterprises specialized in the aerospace industry with annual income over 20 million yuan (approximately 3 million US dollar) since 2011 (National Bureau of Statistics of China, NBSC), as focal nodes (egos). Then, we approach to their first-degree formal business contacts at home and abroad including strategic alliances, joint-ventures and R&D programs, tentative cooperation and supplier-buyer agreement as their alter nodes. In addition to firms, these contacts also include non-incorporated institutions such as R&D centers, universities, vocational colleges, and governmental authorities.

Next, we identified the geographic and industrial attributes of nodes and categorized the types of linkages in accordance with the business activity they are specialized in. We define business entities registered in the national administrative system for industry and commerce in 31 provincial administrative regions in mainland China (excluding Hong Kong, Macau, Taiwan) as domestic business units, while those registered beyond these boundaries as foreign-based economic entities. For domestic business units, we refer to their registration information in the National Enterprise Credit Information Disclosure System (NECIDS) updated by the end of 2015 including their official name in Chinese, the address of registration, type of incorporation and ownership, year of foundation and registration, primary business specialization and registered capital. If the firm has experienced a significant restructuring process, the corporate information will be combined with self-provided information on their websites of financial reports as well as stock market information. For foreign-based firms, we mainly obtain these data based on the information disclosure on their web portals and publicly available financial reports. In addition, secondary data such as business news on aerospace industry and market research reports are also important references to determine the existence of linkages. The whole data collection took 4 months based on coherent selection criteria and credible sources as described above.

Finally, based on the list of connected partners, we incorporate all these linkages into comprehensive production networks. The formal inter-organizational business relationships are defined as "linkages" in the production networks. Based on the types of partnership, we categorized these linkages into two categories: (1) horizontal linkages: the collaborative alliances in the form of co-production, co-management and technological sharing activities based on the common knowledge base and mutual trust (Spencer, 2008; Giroud & Scott-Kennel, 2009; Buckley, 2011; Turkina *et al.*, 2016). (2) vertical linkages: arm's length supply chain relationships with suppliers, subcontractors, distributors and buyers in the sequential input-output flows (Giuliani *et al.*, 2005; Giroud & Scott-Kennel, 2009; Perri *et al.*, 2013). According to the types of linkages, we first combine all embedded economic entities in two separate production subnetworks, namely the horizontal collaborative network (hereafter referred to as Horizontal Network) and vertical supplier-buyer network (hereafter referred to as Vertical Network). Then we overlay the layout of both network by matching the nodes with the dyadic relationships and project them to a multiplex national production network of the Chinese aerospace industry (hereafter referred to as Multiplex Network). The Horizontal Network characterizes how firms collaborate with each other based on common knowledge base and similar organizational capabilities. The Vertical Network depicts the sequential order of the value chains between suppliers and buyers. The Multiplex Network combines the structural features of both subnetwork and presents the overall gestalt of the business relationships in the market.

The network configuration and visualization processes are conducted with R iGraph package (Version 3.1.2) and UCINET 6 Sofware (Borgatti *et al.*, 2002). (See Figure 3.1-3.3).

Figure 3.1-3.3 here

Finally, by applying social network analysis techniques, we calculate the degree centrality representing the relational embeddedness and eigenvector centrality representing the structural embeddedness of presented economic entity of all three production networks (See Table 3.1). To lessen the impact of heterogeneity of organizational governance, we only include firms in the empirical analysis.

Table 3.1 here

3.4 Methodology

In this study, we conduct two series of multiple linear regression analysis on network positions of both local and foreign-based firms embedded in the national production networks of the Chinese aerospace industry.

3.4.1 Dependent Variables

Since the concept of network position consists of structural embeddedess and relational embeddedness, we will include eigenvector centrality and degree centrality as the dependent variables respectively. Eigenvector centrality indicates a node's relational proximity to other well-connected nodes in the network. It represents a firm's closeness to the network core as well as its influence over all other nodes in the network hierarchy (Calculation see Appendix 1) (Katz, 1953; Bonacich, 1987). Degree centrality counts the number of direct linkages each node has in the network. It represents the direct range of social relationships and knowledge sources of individual firms (Nieminen, 1974; Ring & Van de Ven, 1992; Dyer & Singh, 1998).

3.4.2 Independent Variables

To assess the impact of value chain position and multiple geographic factors on the network position of firms in the national production networks, we include the following variables as the independent variables:

(1) VALUE_CHAIN_POSITION: In the aerospace industry, primary activities include aircraft parts, components and systems manufacturing, raw material supply, final aircraft assembly and delivery, Maintenance, Repair and Overhaul (MRO), along with airlines and airport companies. Support activities include supportive software development, logistics support, public relations, financial leasing, as well as managerial and IT consulting. Based on the generic value chain model(Porter, 1985), all firms are categorized in following five categories: (1) Original Equipment Manufacturer (OEM): aircraft manufacturers specialized in final assembly and end installation. This group is set as the base group for reference; (2) Upstream supplier: suppliers of raw material and primary aeronautical parts; (3) Downstream supplier: suppliers of integrated aeronautical components and systems; (4) Support service provider: business units that are not direct engaged in manufacturing process but provide support services; (5) Airline & Airport: final buyers of completed aeronautical products including airline companies and airports. For this categorical variable, the OEM is set as the base group.

(2) INDUSTRIAL_CLUSTER: Subnational regions with location quotient (LQ) of aerospace-related industry greater than 1. The LQ represents the share of employment of the subnational region over that of the national average (Delgado *et al.*, 2010; Bathelt & Li, 2013). In China, we referred to the employment information on *Civil Aviation Industrial Yearbook 2014* and *China Statistical Yearbook 2014*. For Europe and the Americas, we referred to the list of aerospace clusters provided by Turkina and Van Assche (2018) based on the same criteria. Additionally, worldwide influence aerospace clusters in Japan, Korea and Brazil with significant impact in the global aerospace network are added (Niosi & Zhegu, 2005). A detailed list of aerospace clusters is included in Appendix 2. (0=location outside clusters, 1=location inside clusters)

(3) FOREIGN: If the major establishment of the firm is located outside the administrative territories of 31 provinces in mainland China, it is regarded as a foreign-based firm. As the definition is based on geographic location rather than ownership structure, foreign subsidiaries located in mainland China are regarded as local firms (0=local, 1=foreign).

(4) DEVELOPMENT: If a firm is located in either one of the "advanced economies" defined by IMF World Economic Outlook (2016) or in a Chinese province where the GDP per capital exceeds 10,000 US dollar according to *China Statistical Yearbook (2015)*, this firm is regarded as being located in a developed region, otherwise developing region (0=developing, 1=developed).

To evaluate the moderation effect of economic development on liability of foreignness, in the regression model an interaction term of FOREIGN and DEVELOPMENT will be added.

3.4.3 Controls

Additionally, the following variables will be included as control variables:

DIVERSITY: Whether the firm manages to establish linkages in both horizontal and vertical networks. (0=No, 1= Yes)

AGE: The scale of years of market presence (base year 2016, 5-year gap). For local firms, the year of entry is determined by the year of foundation registered in NECIDS. For foreign-based firms, the year of entry is determined by the year of establishing first local subsidiaries, joint-ventures or partnership with local firms for foreign-based firms. The scales are as follows: (1= 1-5 years, 2= 6-10yeaers, 3= 11-15 years, 4=16-20 years, 5=more than 20 years).

HEADQUARTER: If the firm is the headquarter of the business group. (0=subsidiaries,1=headquarter)

BUSINESS_GROUP: If the firm is affiliated to a large aerospace business group (0=No, 1=Yes). A list of business groups is provided in Appendix 3.

Therefore, the regression models are constructed as follows:

Centrality= β_0+ β_1VALUE_CHAIN_POSITION+ β_2INDUSTRIAL_CLUSTER+ β_3FOREIGN+ β_4DEVELOPMENT+ β_5FOREIGN×DEVELPMENT+ λcontrols+ ε

3.5 Network Analysis

After the configurating process, Figures 3.1-3.3 demonstrate the structural layout of Chinese Aerospace Networks. At first sight of the diagrams, we observe a clear tendency of core-periphery distribution of these networks. All three networks are composed of a giant component surrounded by a few isolated small network communities. Within the giant component, a large portion of embedded nodes agglomerate towards the densely connected network cores. At the edge of these giant components, a large number of peripheral nodes get in connected to the core through a few bridging linkages leveraged by the intermediary brokers.

These observations are confirmed by the network statistics (See Table 3.2). First of all, the composition of nodes of all these networks is highly diverse. Firms represent the majority of all three production networks, while their geographic locations are evenly distributed between local and foreign-based ones. In terms of overall structural features, all three networks have "small world" features characterized by high cohesiveness in densely connected clusters, short average path length in sparsely connected network communication, and linkage through small fraction of coordinators in decentralized large-scale networks. (Watts & Strogatz, 1998; Gulati & Gargiulo, 1999; Baum *et al.*, 2003; Uzzi & Spiro, 2005; Kossinets & Watts, 2009). On the one hand, the density of all three production networks falls below 1% benchmark. Thus the overall connectivity of these networks is sparse, which can be explained by the large quantity of isolates and peripheral nodes with low degree centrality. On the other hand, all three networks have a strong tendency of central concentration dominated by nodes in the network core as the degree centralization are all above 10%. Comparing the network transitivity and degree centralization, we can further imply that, the power over the network hierarchy more evenly distributed among subnetwork communities in the horizontal network than in the vertical network, as the prior has a higher degree of transitivity while lower degree centralization than the latter. In reverse, the vertical network has more "structural holes" (Burt, 1992) to make up, while the dominance of highly influential players at the network core is relatively strong.

Table 3.2 here

Table 3.3 presents the descriptive statistics of dependent and independent variables of the multiple linear models. By definition, degree centrality and eigenvector centrality represent the relational and structural aspects of network embeddedness respectively. Therefore, the variance of dependent variables differs from each other in three production network frameworks. As for the independent variables and control variables, the linear correlation in between is low, as the absolute values of all significant correlation coefficients are below 50%.

Table 3.3 here

Next, we analyze the impact of value chain position and geographic factors on the network positions of firms in the production networks based on multiple linear regression analysis.

Table 3.4 presents the linear correlation between explanatory variables and firm's degree centrality in the production networks. In the production phases, OEMs have higher eigenvector centrality over upstream & downstream suppliers in the primary sectors and service providers in the supportive sectors in the production networks (except the coefficient for Upstream Supplier in Horizontal Network is negative but not statistically significant). However, airline companies and airports have higher eigenvector centralities in the Multiplex Network (Model 1.1: β=0.034, p= 0.010, σ=0.014), while neither of the coefficients for two subnetworks is significant. In the Multiplex Network, firms located in industrial clusters have higher eigenvector centrality than those located outside the clusters (Model 1.1: β_2=0.034, p= 0.011, σ=0.008). Hence, Hypothesis 2 is supported. This is also the case in Vertical Network (Model 1.3: β_2=0.024, p= 0.015, σ=0.010), but not in the Horizontal Network (Model 1.2: β_2=0.012, p= 0.141, σ=0.008). That indicates that the contribution of industrial clusters to a firm's proximity to the network core is more likely to be attributed to their dominance in the supply chain relationships rather than in collaborative partners. As the coefficients for variable FOREIGN all turn out to be significant and positive in all three models, we find that in the setting of the national production networks of foreign-based firms have universally higher eigenvector centrality than local firms. This conclusion is contrary to the proposition Hypothesis 3 implying that liability of foreignness is not equivalent to liability of outsidership. We need to explore further why and how foreign-based firms can reach the network core in the national production networks of the market they entry. Next, we find strong support for Hypothesis 4. Firms located in economically developed regions have higher eigenvector centrality in the Multiplex Network (Model 2.1: β_4=0.029, p= 0.003, σ=0.010) and the Vertical Network (Model 2.3: β_4=0.045, p= 0.001, σ=0.013), but the coefficient in the Horizontal Network is not significant. (Model 2.2: β_4=0.006, p= 0.532, σ=0.010). Finally, we find a negative moderation effect between foreignness and local economic environment in the Multiplex

Network (Model 2.1: β_4=-0.041, p= 0.029, σ=0.019) and Horizontal Network (Model 2.2: β_4=-0.050, p= 0.010, σ=0.019).

Table 3.4 here

At the same time, there are important nuances regarding the effect of independent variables on the degree centrality (See Table 3.5). First, we find significant evidence to support that OEMs have more direct linkages than other firms, as the coefficients of all referential categories including Airlines and Airports are negative. Therefore Hypothesis 1 is supported both in production stages and market sales. However, the impacts of geographic factors vary in different network configurations. We do not find significant evidence to confirm Hypothesis 2 that firms located in industrial clusters have more direct linkages than those located outside clusters. In terms of the geographic boundary, we only that foreign-based firms tend to have more direct contacts in the horizontal network (Model 2.2: β_3=2.656, p= 0.042, σ=1.301), which is contrary to the presumption of liability of foreignness in Hypothesis 3. As for economic development, foreign-based firms from developed countries or local firms located in economically developed provinces have more linkages than those from economically less developed countries/regions in the multiplex production network, thus Hypothesis 4 is supported (Model 2.1: β_4=3.632, p= 0.018, σ=1.526). In two subnetworks, this effect is only significant in the Vertical Network (Model 1.1: β_3=4.351, p= 0.018, σ=1.526), while not in the Horizontal Network (Model 2.2: β_4=0.858, p= 0.286, σ=0.803). These results are similar to the regression of economic development on eigenvector centrality. Finally, the interaction term FOREIGN×DEVELOPMENT is statistically significant and negative.

Table 3.5 here

As for the control variables, we find statistically significant evidence in the regression on all three networks that firms that are capable of establishing diverse partners are likely to have more direct linkages to access knowledge and are more proximate to the network core influencing the others in all three sets of production networks. Same conclusions apply to headquarters as well as firms affiliated to large business groups. Additionally, in the Horizontal Network, the coefficient for AGE is significant and positive in the regression on degree centrality (Model 2.2: λ_{AGE}=0.336, p= 0.010, σ=0.033). Hence, long market presence contributes to a firm's efforts to extend knowledge courses from direct partners.

3.6 Conclusions and Discussions

This study is an exploratory research on the relationships between the governance mechanisms of the global value chains and the embeddedness of individual firms in the national production network configurations. We imply that the interconnectivity in the global value chains and hierarchical order of the production networks entail the contribution of network position to a firm's competitive advantages. From a relational perspective, having a large number of direct linkages with partners extends a firm's range of knowledge sources in social exchanges. From a structural perspective, proximity to the network core enables a firm to establish its influence on the others by leveraging the direction of knowledge flows. The formation of production networks is coordinated by the governance mechanisms of the global value chain. In organizational terms, the networks are connected by the sequential order of input-output flows that combine primary and support value-adding activities. From the geographic perspective, the networks incorprates local knowledge generation within specialized regions and knowledg exchanges across geographic boundaries.

Introducing social network analysis techniques based on hand-collected relational data, this study brings in new methodological insights in understanding the structural configurations of production networks. Based on the diverse types of business relationships among local and foreign-based economic entities in the Chinese aerospace industry, we constructed three distinctive production network configurations - multiplex national production network, horizontal collaborative network and vertical supplier-buyer network. In the empirical analysis, we calculate eigenvector centrality and degree centrality that represent the structural and relational aspects of network embeddedness in all three network configurations. Then, we conduct a series of multiple linear regressions to analyze how value chain stages and geographic factors affect a firm's network position. Summarizing our findings, we come to the following conclusions:

Firstly, we display that the overall structural configurations of the production networks of the Chinese aerospace industry exhibit strong "small world" characteristics including low density of linkages among a large number of embedded players and high tendency of concentration and clustering. Comparing the network statistics, we also figure out that, the horizontal collaborative network is not as densely connected as the vertical supply chain networks. Meanwhile, the structure of the Vertical Network turns out to be more centralized and contains more structural holes than Horizontal Network. These structural differences reflect different mechanisms of how horizontal collaborative partnerships and vertical arm's length supply chain relationships are formed. The establishment of the former type of relationships is based on similar contextual framing, cognitive focus and learning and mutual trusts (Boschma, 2005; Bathelt & Henn, 2014; Turkina *et al.*, 2016). The relational reciprocity in the Horizontal network enclose the structural holes and decentralize the power dominance of core players (Kenis & Knoke, 2002). In the contrary, the establishment of vertical supply chain relationships is based on the supplementary knowledge that suppliers and buyers of different core competences possess (Buckley *et al.*, 2009). Depending on the market structure, the power distribution among suppliers and buyers vary. The weaker party becomes dependent on the brokerage the stronger to get connected in the network (Cox, 2001; Lonsdale, 2001; Ireland & Webb, 2007).

Secondly, we find that OEMs are the orchestrators of product manufacturing stages, as they tend to have more direct linkages and closer to the network core over upstream and upstream suppliers as well as the service providers (e.g.Gereffi & Memedovic, 2003; Quesada *et al.*, 2006). Nonetheless, in the consumer's market, the positional advantages of OEMs over their buyers, that is, airlines companies and airports, in the production networks are only pertinent in terms of the number of direct contacts. In the multiplex network, the OEMs are not as centrally positioned as the buyers in the network core. Thus, their bargaining powers in the buyer's market are not as high as in the manufacturing processes.

Kang *et al.* (2009) suggested that the relationship between OEMs and their buyers are dependent on the bonding dependence, capability leverage and reputation endorsement. Based on our discussions on vertical linkages, we suggest that in addition to intrinsic knowledge complexity of different value chain stages, extrinsic market power distributions in the competition should also be taken in to consideration to assess how the value chain coordination affect production network configurations.

Thirdly, we detected that agglomeration in industrial clusters contributes to a firm's proximity to the network core rather than to its range of direct contacts. This is especially in the case of the vertical supplier-buyer network, which is characterized by a high tendency of concentration toward the core and broad existence of structural holes over triadic relationships. As this conclusion confirms our assumption regarding the contribution of industrial clusters to a firm's position in the national production networks, we suggest further exploiting the policy implication of the global connectivity of local industrial clusters on enhancing local firms' competitiveness (e.g.Feldman *et al.*, 2005; Delgado *et al.*, 2010; Falck *et al.*, 2010; Turkina & Van Assche, 2018)

Fourthly, in contrary to the presumption of liability of foreignness (Zaheer, 1995),we find that foreign-based firms do not necessarily endure the challenge of liability of outsidership in the networks (Johanson & Vahlne, 2009). Through foreign-based firms may not all be capable of establishing as many business relationships as local firms, by concentrating on exploring exploiting relationships with highly influence local firms, foreign-based firms can reach the network core of the national production network and become network insiders. It is also suggested that foreign-based firms from developing countries can also become network insider by establishing direct contact with the local "national champions" in the target market in place of the reliance on the indirect brokerage of its home country gatekeepers (Calignano & Hassink, 2016). Therefore, we propose that when entering a new market, foreign-based firms should concentrate their available resources on detecting highly capable and trustworthy local partners, and prioritizing opportunity exploitation in acquiring insider's knowledge from them (Alvarez *et al.*, 2013; Foss *et al.*, 2013; Broekel & Mueller, 2018).

Finally, we figure out that economic development has strong impact on a firm's position in the multiplex national production network and vertical supplier-buyer network. Location in economically developed regions provides firms with more opportunities to extend its range of contacts and reach the network core. On the other hand, the negative moderation effect of economic development on foreignness is evident in the horizontal collaborative network. This can be interpreted from the "born-global" strategy of internationalization of firms from less developed regions that they tend to get direct contact with most influential player in the target market they enter on the first place rather than depend on the indirect brokerage of highly competent boundary spanners of the same regional origin to get global connectivity (Knight & Cavusgil, 2004; Freeman & Cavusgil, 2007; Calignano & Hassink, 2016). For instance, in the Chinese context, matching business relationships with less competitive firms from other emerging economies has become a pattern for Chinese firms, especially those "national champion" to explore new market niches and establish global influence (e.g.Lo, 2004; Konings, 2007; Glosny, 2009; Huang, 2016). It is worthwhile to study how the collaborations between emerging economies, which are often the result of top-down policy direction, challenge the convention of internationalization processes and contribute to the configurations of national production networks (Wright *et al.*, 2005).

Acknowledging the limitations in research design and analysis, we call for future works that continue exploring the relationships between the global value chain and production networks. In this study, we concentrate on the major specialized business sectors of firms as the criteria to categorize its value chain stage. However, since an increasing number of firms adapt diversification strategies and expand in new business sectors to enhance their market performance and competitiveness, the intra-firm organizational boundaries across value-adding processes has become blurred. Therefore, we suggest refining the categorizations of the generic value chain stage model and taking the effect of both sectorial specialization and diversification on production network configurations into consideration.

We also acknowledge that underneath the two-way categorization of horizontal and vertical linkages does not capture the full image of the plentiful nature of business activities. Neither have we taken the impact of a versatile portfolio of partners in defining relational diversity. Moreover, in this study, we only consider the impact of formal inter-organizational business relationships but do not sufficiently address the equivalent importance of informal inter-personal relationship among managers. Since we have detected the strong impact of partnership diversity on both relational and structural embeddedness, it is worthwhile to assess the contribution of a firm's organizational capability of forming partnerships with different types of organizational through both formal and informal business relationships on its network position.

In this study, we detect the complex impact of geographic factors on production network configurations. As some of the findings cannot be adequately explained by the economic rationale, we suggest including the impact of non-market forces and regional economic policy to explain the heterogeneous geographic determinants of production networks. The identification of industrial clusters is based on the location quotient calculation (Delgado *et al.*, 2010). However, in knowledge-intensive industries, the employment concentration does not necessarily lead to intense inter-organizational interactions or proliferating output in different regions. Thanks to the synergy of "local buzz" and "global pipelines" (Bathelt *et al.*, 2004), the modularization of densely connected subnetwork communities can reach beyond geographic boundaries of industrial clusters. Therefore, we suggest looking into the extent to which spatial proximity is related to intensive connectivity in subnetwork communities and how the two mechanisms simultaneously affect a firm's position in the production networks.

Finally, since this study is a static one-country and one-industry analysis, the contextual bias cannot be fully ruled out. For the future studies, we suggest extending the geographic and industrial range in multi-country and multi-industrial studies and compare the dynamics of network configurations to draw a more generalized conclusion on how firms' competitive advantages embedded in the production networks evolve over time (Ter Wal & Boschma, 2011).

Tables

Table 3.1: Descriptive Statistics of Chinese Aerospace Production Networks

		Multiplex Network	Horizontal Network	Vertical Network
Number of Economic Entities	Total	920	662	592
	Local	543	414	315
	Foreign	377	248	277
Number of Firms	Total	730	487	555
	Local	395	279	280
	Foreign	335	208	275
Number of Linkages		2549	1103	1577
Network Density		0.006	0.005	0.009
Network Transitivity		0.081	0.107	0.036
Degree Centralization		0.285	0.138	0.339

Notes:

Network density represents the portion of the actual number of all linkages over the number of all possible dyadic pairs. It indicates the intensity of dyadic connectivity among embedded nodes.

Network transitivity represents the portion of closed triplets of nodes over all possible triadic combinations. It indicates the tendency of clustering of the whole network.

Degree centralization represents the degree of concentration toward the core of the whole network.

Table 3.2: Eigenvector Centrality and Degree Centrality of Embedded Firms

Variable	Network	N	Mean	Median	Standard Deviation	Min	Max
EIGENVECTOR CENTRALITY	Multiplex	730	0.058	0.038	0.097	0	1
	Horizontal	487	0.037	0.011	0.072	0	1
	Vertical	555	0.072	0.044	0.104	0	1
DEGREE CENTRALITY	Multiplex	730	6.327	2.000	14.026	1	267
	Horizontal	487	3.637	2.000	5.724	1	94
	Vertical	555	5.586	2.000	12.671	1	205

Table 3.3: Descriptive Statistics of Independent Variables

Variable		*Mean*	*Std Dev*	*(1)*		*(2)*		*(3)*		*(4)*		*(5)*		*(6)*		*(7)*	
(1)	VALUE CHAIN POSITION	2.851	1.425														
(2)	CLUSTER	0.355	0.479	-0.188	***	1.000											
(3)	FOREIGN	0.459	0.499	-0.060		0.122	***	1.000									
(4)	DEVELOPMENT	0.725	0.447	0.011		-0.299	***	0.334	***	1.000							
(5)	DIVERSITY	0.429	0.495	0.062	*	0.127	***	0.024		-0.030		1.000					
(6)	AGE	3.170	1.574	0.092	**	0.020		-0.178	***	-0.050		0.264	***	1.000			
(7)	HEADQUARTER	0.578	0.494	0.129	***	-0.091	**	0.186	***	0.107	***	-0.134	***	-0.058		1.000	
(8)	BUSINESS GROUP	0.249	0.433	-0.020		0.142	***	-0.238	***	-0.169	***	0.307	***	0.155	***	-0.476	***

Table 3.4: Multiple Linear Regression on Eigenvector Centrality

	Model 1.1 Multiplex Network			**Model 1.2 Horizontal Network**			**Model 1.3 Vertical Network**		
VALUE_CHAIN_POSITION									
OEM (Base Group)									
Upstream Supplier	-0.035	(0.013)	**	-0.018	(0.013)		-0.055	(0.018)	***
Downstream Supplier	-0.055	(0.012)	***	-0.026	(0.011)	**	-0.076	(0.016)	***
Support Service	-0.041	(0.013)	***	-0.028	(0.012)	**	-0.059	(0.018)	***
Airline & Airport	0.034	(0.014)	**	-0.011	(0.013)		0.019	(0.018)	
CLUSTER	0.020	(0.008)	**	0.012	(0.008)		0.024	(0.010)	**
FOREIGN	0.057	(0.016)	***	0.054	(0.017)	***	0.045	(0.021)	**
DEVELOPMENT	0.029	(0.010)	***	0.006	(0.010)		0.045	(0.013)	***
FOREIGN×DEVELOPMENT	-0.041	(0.019)	**	-0.050	(0.019)	**	-0.033	(0.024)	
Controls									
DIVERSITY	0.056	(0.007)	***	0.021	(0.007)	***	0.031	(0.009)	***
AGE	0.002	(0.002)		0.002	(0.002)		0.001	(0.003)	
HEADQUARTER	0.019	(0.007)	***	0.027	(0.007)	***	0.016	(0.009)	*
BUSINES_GROUP	0.048	(0.009)	***	0.046	(0.008)	***	0.053	(0.011)	***
INTERCEPT	-0.004	(0.017)		-0.006	(0.016)		0.023	(0.022)	
N	730			487			555		
F-Value	27.150			7.420			13.390		
Prob>F	0.000			0.000			0.000		
R-squared	0.312			0.158			0.229		

Note: if $p < 0.10$, ** if $p < 0.05$; *** if $p < 0.01$. Standard errors in parentheses**.**

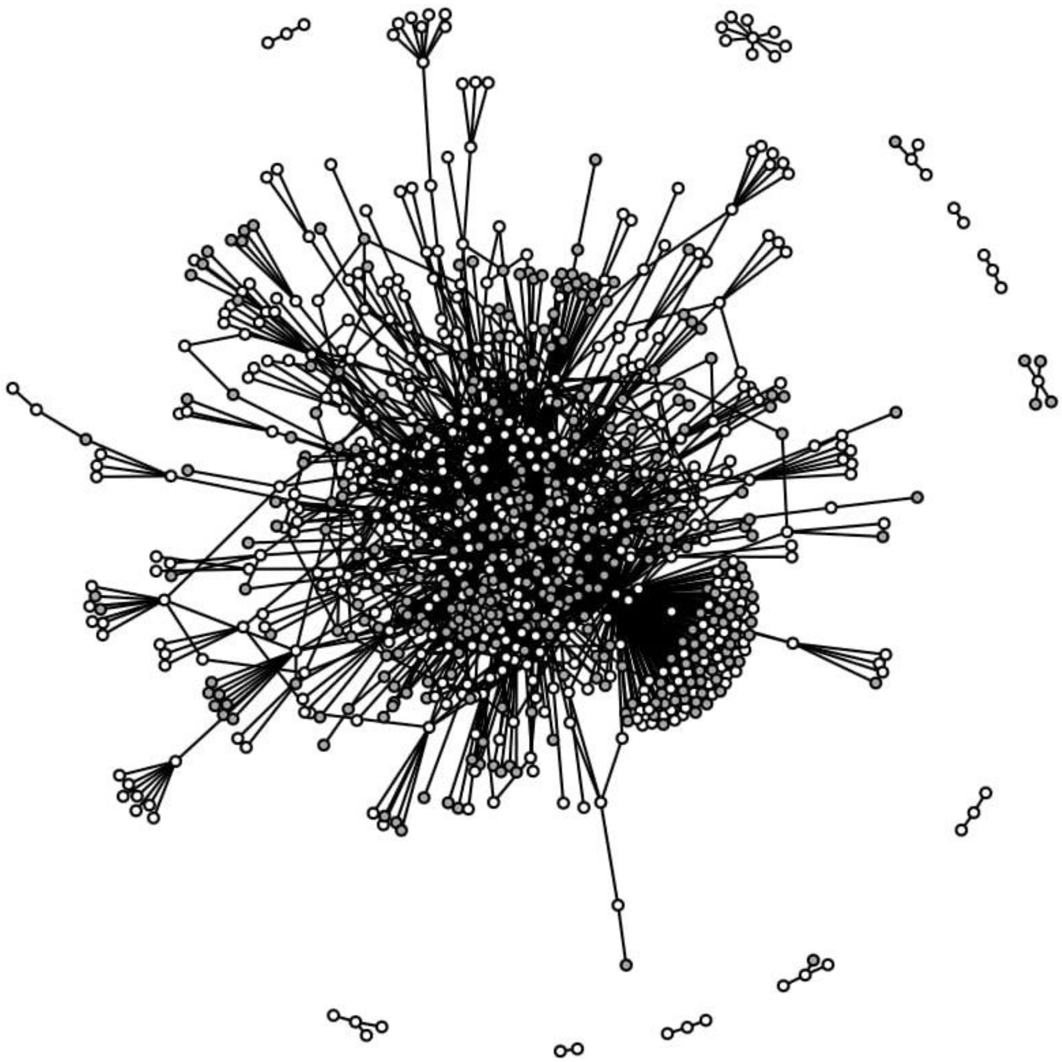
Table 3.5: Multiple Linear Regressions on Degree Centrality

	Model 2.1 Multiplex Network			Model 2.2 Horizontal Network			Model 2.3 Vertical Network		
VALUE_CHAIN_POSITION									
OEM (Base Group)									
Upstream Supplier	-10.634	(2.087)	***	-3.105	(1.024)	***	-12.113	(2.241)	***
Downstream Supplier	-11.988	(1.932)	***	-3.506	(0.890)	***	-13.358	(2.056)	***
Support Service	-10.811	(2.054)	***	-3.422	(0.971)	***	-11.942	(2.225)	***
Airline & Airport	-6.654	(2.119)	***	-2.639	(1.018)	**	-7.624	(2.212)	***
CLUSTER	1.817	(1.199)		0.506	(0.636)		1.762	(1.254)	
FOREIGN	3.660	(2.514)		2.656	(1.301)	**	1.383	(2.668)	
DEVELOPMENT	3.632	(1.526)	**	0.858	(0.803)		4.351	(1.669)	***
FOREIGN×DEVELOPMENT	-3.519	(2.903)		-3.126	(1.523)	**	-1.421	(3.064)	
Controls									
DIVERSITY	6.555	(1.037)	***	1.617	(0.542)	***	2.952	(1.122)	***
AGE	0.478	(0.315)		0.336	(0.157)	**	0.224	(0.348)	
HEADQUARTER	4.445	(1.081)	***	2.249	(0.568)	***	4.278	(1.148)	***
BUSINESS_GROUP	7.921	(1.339)	***	4.216	(0.649)	***	6.558	(1.393)	***
Intercept	3.603	(2.588)		1.062	(1.283)		5.792	(2.819)	**
N	730			487			555		
F-Value	16.960			9.180			10.230		
Prob>F	0.000			0.000			0.000		
R-squared	0.221			0.189			0.185		

Note: if $p < 0.10$, ** if $p < 0.05$; *** if $p < 0.01$. Standard errors in parentheses.

Figures

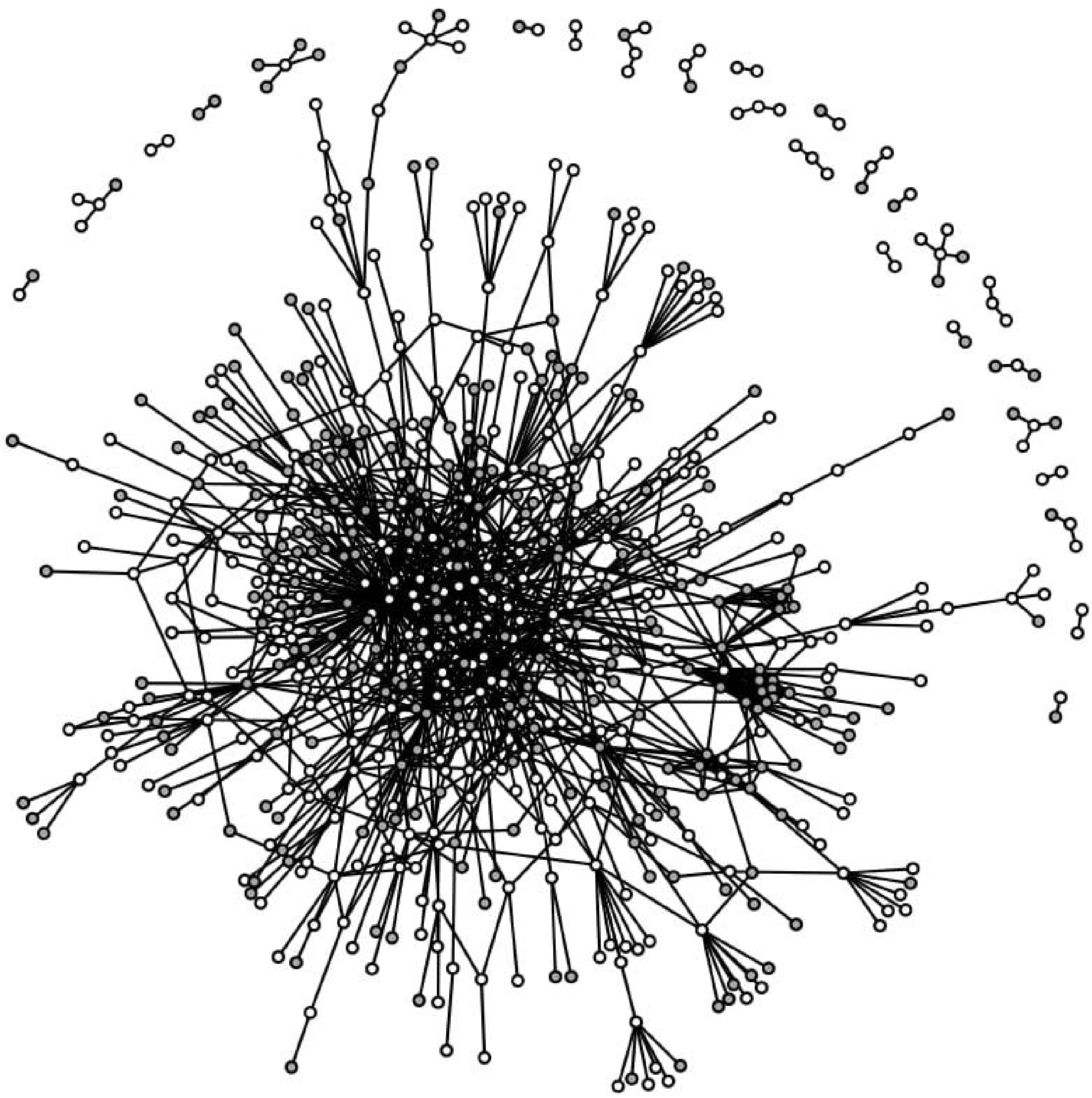
Figure 3.1: Configuration of Chinese Aerospace Multiplex Production Network



Note:

White nodes represent local economic entities, grey nodes represent foreign-based economic entities.

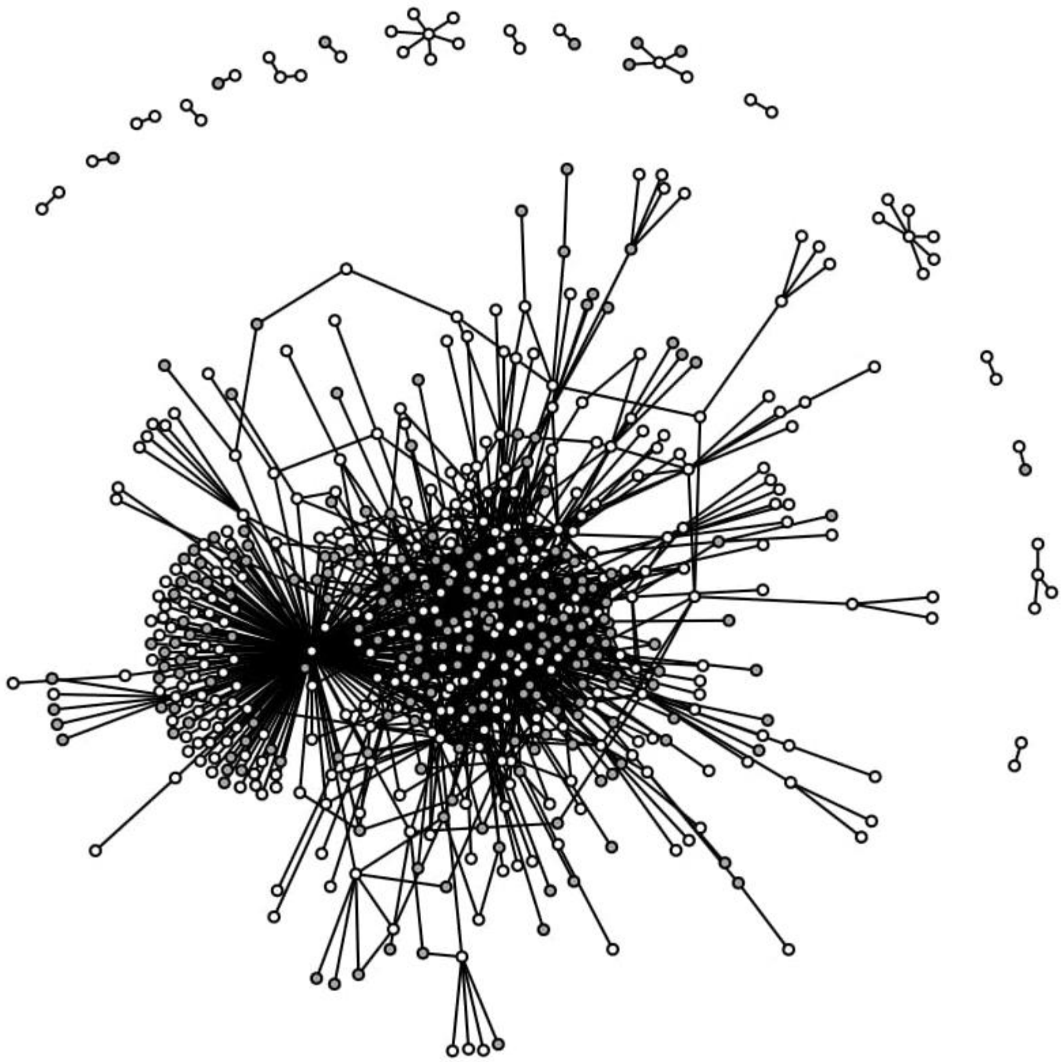
Figure 3.2: Configurations of Chinese Aerospace Horizontal Production Network



Note:

White nodes represent local economic entities, grey nodes represent foreign-based economic entities.

Figure 3.3: Configuration of Chinese Aerospace Vertical Production Network



Note:

White nodes represent local economic entities, grey nodes represent foreign-based economic entities.

Appendix

1. Calculation of eigenvector centrality

Let x_i denote the eigenvector centrality of node i and $\mathbf{x} = (x_1, x_2 ...)$ the vector of eigenvector centrality for the adjacent matrix of network $\boldsymbol{A}$, where the binary element A_{ij} represents if there is a connection between node i and neighbouring node j.

A constant eigenvalue λ meets the criteria that

$$\boldsymbol{A} \cdot \boldsymbol{x} = \lambda \boldsymbol{x}$$

The relative score of x_i is the eigenvector centrality of node i, so that

$$x_i = \frac{1}{\lambda} \sum_{j=1}^{n} A_{ij} x_j$$

2. List of Subnational Aerospace Clusters

China: Shaanxi, Guizhou, Liaoning, Jiangxi, Sichuan, Hunan, Heilongjiang, Hubei.

Asia-Pacific: Aviation/Aerospace Australia New South Wales Cluster, the Society of Japanese Aerospace Companies (SJAC) Tokoy-Osaka Clusters, Korea Aerospace Industries (KAI) Cluster

North America: Baltimore-Salisbury, Boston area, Central/Eastern, Washington, Dallas-Fort Worth-Kileen, Georgia, Hartford-Bridgeport, Little Rock area, Maine Aerospace Alliance (MEAA), Manchester-Concord, Metro Denver and Northern Colorado, North Alabama, Northwest Florida, Ogden-Salt Lake City, Southern Arizona, Southern California, Southwest Ohio, Vermont Aerospace & Aviation(VAAA), Washington DC-West Virginia, Wichita, Aeromontréal, Greater Vancouver, Nova Scotia, Southern Ontario.

Europe and CIS: Aerospace Valley, Andalusia, ASTech Paris cluster, BavAIRia, Berlin-Brandenburg Aerospace Alliance (BBAA), Belfast cluster, Campaniaerospace, Hamburg cluster, HEGAN Basque, Lombardia, Madrid, Northwest aerospace, alliance (NWAA), Pole-Pegase, Rhone-Alps, Skywin, Swiss, FLAG cluster, Moravian aerospace cluster, Transylvania aerospace cluster, Siberian cluster.

Latin America: Queretaro, Chihuahua, Sonora Northwestern, Jalisco, Baja California, Estado de Mexico, Aviation Valley, São Paulo EMBRAER cluster.

3. List of Large Aerospace Business Groups

China: AVIC-COMAC Group, HAECO-TAECO Group, CETC Group, Air China Group, China Southern Group, China Eastern Group, Sinotrans Group.

Foreign: AIRBUS Group, Boeing Group, SAFRAN Group, UTC Group, GE Group, BAE Group, Honeywell Group, Liebherr Group

4. Calculation of degree centralization

Let C_d denote the degree centralization of an adjacent matrix of network $\boldsymbol{A}$**,** $C_d(n_i)$ represent the degree centrality of node g_i, and $C_d(n^*)$ represent the largest observed value of the degree centrality.

$$C_d = \frac{\sum_{g_i=1}[C_d(n^*) - C_d(n_i)]}{\max \sum_{g_i=1}[C_d(n^*) - C_d(n_i)]}$$

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Conclusion

Addressing the increasing importance of network embeddedness in international business today, this thesis applies social network analysis techniques to explore the inter-organizational network coordination mechanisms and the determinants of network positions in the context of a knowledge-intensive industry in a large emerging economy. The chapters of the thesis concentrate on the impact of global value chain coordination, relationship leverage across topological communities and partnership diversity respectively. The theoretical frameworks of these chapters combine inter-disciplinary theories and practices in international business, economic geography, innovation and entrepreneurship. By applying social network analysis techniques, the empirical analyse highlight the effect of complex organizational and geographic factors that contribute to a firm's embeddedness in the networks that incorporate horizontal collaborative partnership and vertical supply chain sequences.

Chapter 1 uncovers how foreign-based firms can acquire insider's knowledge by leveraging diverse business relationships and embedding themselves in the host country production networks. Based on the mechanisms of complementary knowledge generation and supplementary knowledge transfer in opportunity development, it argues the relevance of insidership acquisition and subnetwork configuration of topological communities. Then it assesses the effectiveness of establishing horizontal and vertical linkages in bridging foreign-based firms with other members within the same community. It turns out that foreign-based firms primarily use "vertical" buyer-supplier linkages to integrate into host country communities. This differs from local firms which disproportionately use "horizontal" partnership linkages to embed themselves in communities.

Chapter 2 identifies the antecedents of network position of SMEs that intend to expand their egocentric network. It first specifies four strategic goals of network embeddedness for the SMEs measurements - direct access to resources and knowledge, brokerage bargaining power over the structural holes, reachability and efficiency in communication with other network players, and proximity to other well-connected market leaders in the network cores. Then it assesses how firm size, age and partner diversity are relevant to SMEs' effort in achieving these goals. Not fully in line with the presumption of liability of smallness and newness, it turns out that the impact of size is limited to the range of direct resources and proximity to lead firms, while this study does not provide sufficient evidence showing that age is significantly related to an SME's position in the production network. On the other hand, partner diversity has significant positive correlations with all four dimensions of network embeddedness. This implies the importance of partnership diversity for SMEs to reach the central position in the multiplex production network.

Chapter 3 underlines the high relevance of the relational coordination in the global value chains and structural configurations of the layout of national production networks. It confirms the dominance of OEM in production stages in terms of the total number of linkages and proximity to the network core. In addition, it specifies the contribution of co-location in industrial clusters to enhancing a firm's close relationship with the most influential players, especially in supply chain relationships. Moreover, this chapter provides evidence to distinguish liability of outsidership from liability of foreignness. For foreign-based firms, the negative impact of the unfamiliarity of the local context can be overcome by leveraging business relationships with local partners. This finding lies down the contextual premise of Chapter 2. Furthermore, the effect of local regional economic development on network embeddedness for local and foreign firms varies. Therefore, I also call for future research on non-market forces and economic policies with respect to the production network configurations.

Similar to most one-country-one-industry studies, the heterogeneity and representation of the sample is always a general concern that needs to be justified. As the network data is retrieved through publicly available secondary sources, the selection bias can hardly be avoided. Moreover, due to the different research subjects of each paper, it is still insufficient to generalize the overall conclusion on the causes and effects of an organization's position in production networks. Hence, I suggest continuing the width and depth of the research that will further enhance our understanding of network embedded in the international business by looking into:

- How sectorial specialization and regional specialization interact in the value chain to affect firms' embeddedness in the production networks.
- How firms' organizational capacity in forming different types of linkages contributes to their network embeddedness.
- How spatial proximity in industrial clusters and relational closeness in topological communities overlap to affect firms' network embeddedness.
- How intra-firm headquarter-subsidiary interaction and inter-firm partnership differ in faciliating foreign-based firms' acquisition of insidership knowledge.
- How its home country production network configurations contribute to a foreign-base firm's embeddedness in the host country networks.
- How the configurations of production networks evolve over time and affect firms' network embeddedness.
- How relational and structural embeddedness in the production networks contribute to a firm's financial performance and innovation output.
- How the corporate ownership structure affect the configurations of horizontal and vertical networks
- How the collaborations with non-incorproated economic entities (universities, R&D centers, governmental authorities etc.) contribute to a firm's network embeddedness.
- How informal inter-personal relationships among managers and policy makers are linked to formal inter-organizational partnership.

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