The interaction effects of sparse and interlocked connections in SMEs clusters

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Abstract

This study aims to examine the relationship between the structures of inter-organisation connections and innovation results in the context of small and medium enterprises (SMEs). Existing literature shows that SMEs can benefit from inter-organisation connections in SMEs development. However, there is a theoretical gap in how a combination of various structures of inter-organisation connections affects SMEs development results. In other words, the theoretical gap in this area is what structures of inter-firm connections can be more beneficial than the others. Thus, this study adopts the network theory and network analysis to explore the effects of network structures on SMEs performances in their development.

To close this gap, network theory is employed to support this study's hypotheses. Then, this study uses network analysis to generate network snapshots and test proposed hypotheses. Complementary to prior research, this study suggests that SMEs development results can benefit from having sparse connections, interlocked connections, centrality, and brokerage in their networks. Also, in contrast to prior research, this study emphasizes the influences of these four inter-firm connection structures, sparse connections, interlocked connections, centrality, and brokerage.

Chapter 1 Introduction

1.1 Introduction

The aim of this study is to investigate the relations between the structures of inter-organisation connections and small and medium enterprises (SMEs) development results. SMEs development is a process of co-development among SMEs and related parties (Stiglitz, 2000). This process relies on effective collaborations among them. Therefore, the management of SMEs development and growth requires new theories on the complex structures of SMEs collaborations and how these collaborations can influence SMEs development.

SMEs clusters are usually determined by strategy and collaborations together. Strategy wise, SMEs can achieve competitive advantages through strategic connections with others. Collaborations wise, SMEs can be benefited from rapid response and flexibility through collaborative connections with others. SMEs growth is considered as a result of their strategic choices and collaborations (Vos, 2005). However, it is not clear that the structures of SMEs connections and SMEs development results. Thus, in the context of SMEs development, this study aims to provide more knowledge about how SMEs can grow together rather than grow

individually.

This study uses network analysis to investigate how SMEs networks influence their development. The analysis in this study focuses on networks at inter-firm level. First, this study examines the relation between networks and SMEs development results. Second, this study analyses SMEs network patterns, including SMEs centrally located in the network (also known as brokerage) and the overall network structure. Finally, this study adopts network analysis to explore the network dynamics to find out how SMEs networks evolve during their development.

1.2 Context for this study

SMEs are considered as a source of product development, since they are more flexible and sensitive to changes in theologies than large companies (Thorpe et al., 2005). However, the definition of SMEs is not unified. The definition of SMEs has a few components. This includes number of employees, revenue level, legal status, and method of production (Storey, 1994). Size wise, SMEs have less than 50 workers and 50 million euros revenues, in contrast, large firms have 500 or more workers and 500 million euros or more turnovers (Elaian, 1996, Weston and Copeland, 1998). Using size to define SMEs has been challenged as that all firms are small in some sectors, for example, creative design, whilst no firms are small in some sectors, for example,

car (Storey, 1994). Thus, academics have formulated an "economic" and "statistical" definition of SMEs (Weston and Copeland, 1998). By "economic" definition, a SME has a relatively small share of their market. By "statistical" definition, a SME's contribution to GDP is a relatively small.

The nature of SMEs has been under debate for decades. There is no doubt that SMEs are distinguished from large firms by size. The original purpose of introducing this concept was for taxation (Mulhern, 1995; Berger and Udell, 2006). This is because SMEs need support and protections policies. In product development, SMEs as organisations have less research and development power than large firms (Thorpe et al., 2005). However, it has been argued that the size of firm is not related to the results in product development (Pittaway et al. 2004). Product development SMEs are more like to be based on increment changes in technologies rather than radical and fundamental changes (Thorpe et al., 2005). Thus, the firm size matters even less in product development. In this study, SMEs are treated as firms with less than 50 workers and 50 million euros turnovers.

SMEs development often requires joint work with other firms. Thus, the inter-firm connections play an important role in SME development (Zaheer et al., 1998; Watson and Papamarcos, 2002; Davidsson and Honig, 2003; Funk, 2012; Landsperger et al., 2012; Oparaocha, 2016). Previous literature (Burt, 1997) argued that SMEs can be strategically connected and contribute to SMEs development outcomes. However, the

structures of SME connections remain unclear. Also, how the structures of SME connections are formed as the results of SMEs dynamics. Furthermore, to what extent inter-firm connections can influence SMEs development results. Thus, this study is to explore the structures, dynamics, and influences of inter-firm connections in the context of SMEs development.

1.3 Significance of the study and contributions to knowledge

Previous research (Burt, 2007 and 2015) suggested there are three aspects of SMEs development results at the firm level, short, middle, and long term. The long term development results can be influenced by too many factors when firm development progress in a long time period, for example over 10 years (Rodan and Galanic, 2004). Thus, short and middle term development results are recommended as research focus. Previous research (Rodan and Galanic, 2004; Liao and Welsch, 2005; Cross, et al., 2015) applied this approach to evaluate SMEs development. The middle term development results tend to focus on firm's progress, especially the progress of financial growth. The short term of development results tend to focus on the effectiveness of development. Also, pervious research suggested financial returns are more representative than other measures, for example staff increase, firm expansion, and strategic changes (Rodan and Galanic, 2004; Liao and Welsch, 2005; Cross, et al.,

2015). Thus, this study uses the short and middle term financial returns to represent SME's development results.

Previous research (Fernandez-Olmos and Ramirez-Aleson, 2017) also suggested three levels of firm development analysis. They are the macro-level, industry-level, and firm-level. However, the theories in this area can still be improved by inter-firm level analysis. SMEs development emphasizes gaining access to resources and knowledge through connections with external parties (Weiblen and Chesbrough, 2015). Here, the analysis unit should be each connection between firms rather than each firm itself. A connection between organisations is a purposeful social unit that shares business information and resources to achieve the collective target (Levin and Cross, 2004). An inter-firm level analysis can directly investigate the process of collaborative development and growth among firms (Lynch, O'toole, and Biemans, 2016). Therefore, this study can improve the understanding how the process of collaborative SMEs activities influence their development results.

Also, this study compares different structures of inter-firm connections. By doing this, this study can provide a guide with different contexts to management practices and policies. This study can have implications on how SMEs can improve their external connections to achieve better development results. This study's findings can add evidences about network structures to guide future practices. For business managers, building particular structures of inter-firm connections can improve their

performances in SMEs development. For policy makers, encouraging particular structures of inter-firm connections can enhance SMEs development results.

In business practice, SMEs can only have a limited number of connections with others. Maintaining SMEs connections requires working time and resources. Once SMEs are connected, their connections constrain their ability to building new connections. The connections among SMEs enable information and business resources exchange meanwhile constrain their abilities to find alternatives. In a short term, a SME sticks to its own network structure and position. Thus, this study seeks efficient network structures, those connection structures that can lead to SMEs success in their development.

1.4 Theoretical gap

SMEs can benefit from inter-firm connections in their development, since inter-firm connections enable SMEs to combine their knowledge and skills to complete the tasks in SMEs development (Burt, 2004 and 2007). According to Burt's (2007) theory, the complex connections do not stay static in SME development. Obstfeld (2005) suggested that changing network dynamics is a process of creating both of new sparse

and interlocked structures between firms. A theoretical gap is how various structures of inter-firm connections influence SMEs development. Further, it is not clear that what are the structures, dynamics, and influences of inter-firm connections in SMEs development. Thus, this study can improve the understanding of inter-firm connections in SMEs development by exploring the structures, dynamics, and influences of inter-firm connections.

This study will fill the gap in how SMEs networks at the inter-firm level have impacts on SMEs development outcomes. There is a lack of understanding of what the network patterns are and how inter-firm level networks affect SMEs development outcomes (Borgatti, 2012). Managing the collaborations between firms is a challenge in firm development (Burt, 2007 and 2014; Aalbers, etal., 2016). In the context of this study, SMEs need to work together to achieve growth in their development. In other words, the gap in the theories is how inter-firm connections can be better organised in SMEs networks.

Research has suggested that SMEs can financially benefit from inter-organisation connections in SMEs growth (Burt, 1997). Meanwhile, interest in understanding how inter-firm connections influencing SMEs has recently increased (Gardet and Fraiha, 2012). However, these efforts have almost exclusively focused on to what extent inter-firm connections can influence innovation results, over-looking the structures of inter-firm connections. Consistent with prior research, this study focuses on the

influences of inter-firm connections on SMEs innovation results. In contrast to prior research, this study emphasizes the importance of inter-firm connection structures. Thus, this study proposes that SMEs development can be affected by a combination of different structures of inter-firm connections. And this can provide further understanding about the variety of inter-firm connections in the context of SMEs development.

1.5 Aim of the study, implications and contributions

This study aims to exam the relations between the structures of inter-firm connections and SMEs development results. In SMEs development, individual firm's resources and knowledge, albeit necessary, are not enough to enhance innovation results significantly (Thorpe, et al., 2005; Burt, 2014). The connections among firms can facilitate the integration and sharing of diverse resources and knowledge in their growth. Therefore, it is important to investigate inter-firm connections in SMEs development.

Under this study aim, there are there objectives. The first objective is to find out the structures of inter-firm connections frequently appear in SMEs development. The second objective is to test the relations between the structures of inter-firm connections and firm performance in SMEs development. The third objective is to

explain how networks evolve during SMEs development and result in certain structures.

Research has suggested that SMEs can financially benefit from inter-organisation connections in SMEs growth (Burt, 1997). Meanwhile, interest in understanding how inter-firm connections influencing SMEs has recently increased (Gardet and Fraiha, 2012). However, these efforts have almost exclusively focused on to what extent inter-firm connections can influence innovation results, over-looking the structures of inter-firm connections. SMEs development relies on collaborations between SMEs. These collaborations can be analysed as structures of inter-firm connections. In this study's literature review, sparse, interlocked connections, and the interaction effects are suggested as important structures of inter-firm connections. Thus, three research questions are proposed. Sparse connections are the brokerage processes in a SMEs network. Thus, the first research question is:

Research question 1: Do sparse connections positively influence on SMEs growth?

However, sparse connections as brokerage processes in SMEs network can also slow down SMEs development progress. In contrast, interlocked connections can progress faster than sparse connections, since most of the information exchanges are through direct contacts. Thus, the second research question is:

Research question 2: Do interlocked connections positively influence on SMEs growth?

Also, interlocked structures in the network provide efficiency; however, collaborations between different professional SMEs groups require sparse connections. Can a network have both sparse and interlocked structures in it? Thus, the third research question is:

Research question 3: Do sparse and interlocked connections jointly and positively influence on SMEs growth?

Consistent with prior research, this study focuses on the influences of inter-firm connections on SMEs development results. In contrast to prior research, this study emphasizes the importance of inter-firm connection structures. Thus, this study contributes to theories by explaining how SMEs development can be affected by a combination of different structures of inter-firm connections. And this can provide further understanding about the variety of inter-firm connections in the context of SMEs development.

1.6 Structure of thesis

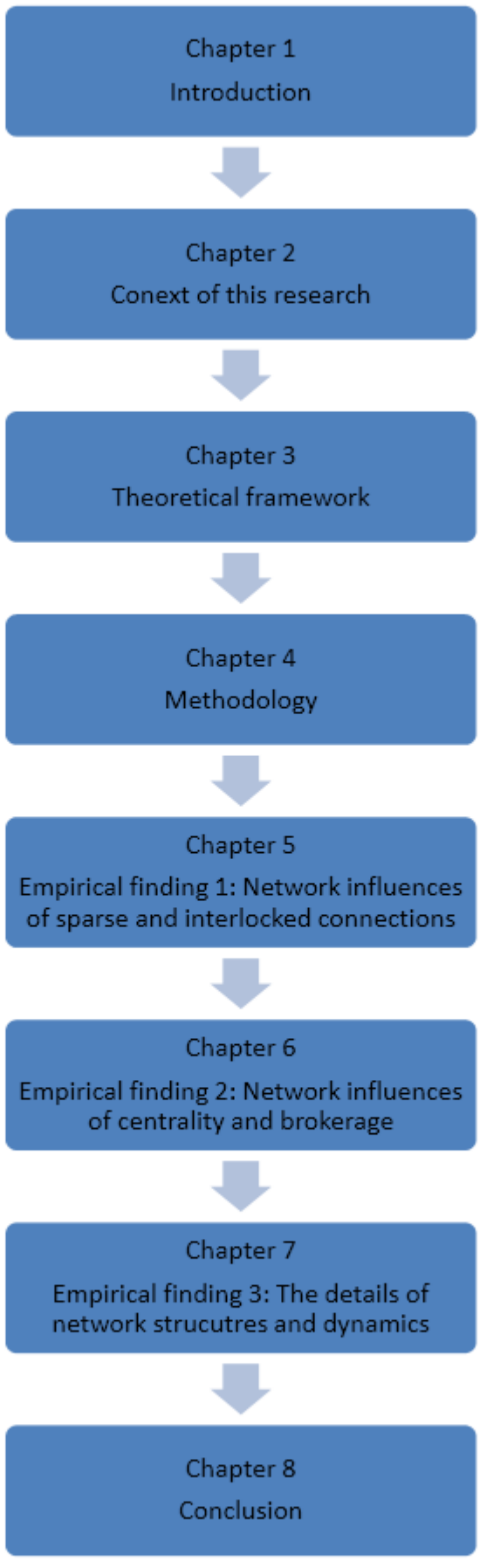
This study includes literature review provides a discussion about the relevant theories

in the area of SMEs development and its relationships with the structures of inter-organisational connections. This literature review starts with the context of SMEs development in Chapter 2. Then this study discusses the theoretical framework and proposes the research questions in Chapter 3. Network theory is adopted in the theoretical framework. In order to answer the proposed research questions, network analysis is discussed in the methodology Chapter 4. And the findings are presented and discussed in chapter 5, 6 and 7. Finally, Chapter 8 provides conclusion.

In more details, the structure of thesis is presented in Figure 1 and organised as follows. Chapter One reports the background, the significance of inter-firm connections and SMEs development, an overview of the underlying theories, and the overall purpose of the study. In general, Chapter One provides an outline of this study and the aim of this study. Chapter Two provides a more detailed overview of the relevant background literature. And it focuses on the characteristics of SME development and growth. Chapter Three provides a theoretical framework as a link between the earlier contextual chapters and the later primary research chapters. And it focuses on how inter-firm connections have an impact on SMEs development outcomes. The theoretical framework outlines the theoretical position of this study. It consists of theories about network dynamics, structure and influences. Chapter Four discusses why this study adopts network analysis as a methodological choice and then discusses the analysis adopted in this study. Chapter Four covers the research design, data collection, the selection of measurements, and data analysis. It then outlines the methodological issues in the data collection and analysis and how to response. The

research findings will be shown in Chapter Five, Six and Seven. These chapters present and analyses the empirical findings, the network snapshots and results of network analysis and provide a discussion comparing the findings with the previous theories. Finally, Chapter Eight summarises the study and provides the implications, limitations and future research directions.

Figure 1.1 Structure of the thesis


Chapter 1
Introduction
Chapter 2
Conext of this research
Chapter 3
Theoretical framework
Chapter 4
Methodology
Chapter 5
Empirical finding 1: Network influences of sparse and interlocked connections
Chapter 6
Empirical finding 2: Network influences of centrality and brokerage
Chapter 7
Empirical finding 3: The details of network strucutres and dynamics
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Conclusion

Chapter 2 The context of SMEs development

2.1 SMEs development and economic development

This section begins with the definition of SMEs and economic development. SMEs are defined as independent firms which employ fewer than 250 employees (OECD, 2016). A similar definition is that SMEs are defined as business organisations with employee numbers below 250 and turnovers fewer than 50 million euros (Jones, 2005). SMEs are considered as a bigger force than big companies in economy development, in terms of job creation and contribution to GDP (Stiglitz, 2000).

SMEs are different from big companies, since they have high dependencies between each other in their development (Verschoore, et al., 2017). Such dependencies are co-development between SMEs, in contrast, big companies usually internalise knowledge and resources to compete with each other. However, there is lack of theories about how SMEs develop together as clusters and the SMEs growth pathway. In the UK, SMEs outnumber larger companies and create more jobs by a wide margin (Nolan and Garavan, 2016). However, the development of SMEs is still a puzzle. The average SMEs survival rate in five years term is less than 5 percent in the context of developed economies (Abosede, Obasan, and Alese, 2016). In the UK, this number

was about 4 percent in 2016 for SMEs set up in 2011. Therefore, SMEs development is a significant topic in both academics and practices.

Stiglitz (2000) suggested that economic development is not only about increasing the supply of products or services, but also providing sustainable quality of life, structure of economy, adopting sustainable ways of production, finding a new source of supply, or even exploring a new market. Thus, economic development is different from product development which is a transformation process of turning market opportunities into available products (Badaracco, 1991; Krishnan, Ulrich, and Karl, 2001). Economic development is important since it is the way of achieving sustainable and competitive success (Drucker, 1985). Also, economic development can improve productivity in business (Rao, et al. 2001). Weiblen and Chesbrough (2015) suggested that economic development is about organisations getting sustainable involvements and having access to critical external resources and information. This definition is based on the resources view of economic development. From this view, economic development is about sustainably connecting organisations and critical external resources and information together. Thus, the connectivity among organisations is crucial to economic development.

Rogers (1995) suggested that economic development process as diffusion of technologies and information among people within an organisation or between orgnisations. This process is described as the information exchange through which

one firm communicates a new idea to one or several others. Rogers (1995) suggested that economic development is the sustainable diffusion of technologies and information in a social system. Thus, maintaining the process of diffusion is crucial to economic development (Drucker, 1985; Batjargal, 2003, 2006 and 2007; Gupta and Maltz, 2015).

Rogers' (1995) definition of economic development focuses on the processes of development. The processes of economic development are concerned as social processes. The importance of these social processes in economic development is to diffuse information among firms, especially when technologies play a vital role in information exchange. The diffusion processes through these technologies among firms are crucial in economic development. Therefore, economic development can be considered as a diffusion process, whereby information exchange and collaborations in a social system. Thus, it is also important to understand the mechanisms about how economic development activities are organised.

Economic development is important because it creates knowledge. Economic development is about managing information exchange in the diffusion process of technologies among the members of a social system (Schumpeter, 1934; Tsai and Ghoshal, 1998; Reagans and Zuckerman, 2001; Buchmann and Pyka, 2015). Information is the basis of economic development. And economic development does not happen without exchanging information. The nature of economic development is a

series of information exchange over a period of time among the members of a social system. Thus, this study suggests that the importance of economic development is providing knowledge about managing information exchange in various situations rather than only using technologies to enhance productivity. The next section will narrow this discussion into what the characteristics of SME development are.

2.2 SMEs development and growth

There is difference between SMEs development and growth. Last section discussed what SMEs development is. SMEs development is not only about increasing the supply of products or services, but also providing sustainable quality of life, structure of economy, adopting sustainable ways of production, finding a new source of supply, or even exploring a new market (Stiglitz, 2000). In contrast, SMEs growth is considered as the positive direction and result of SMEs development (Penrose, 1956). The definition of business growth was proposed as two aspects: one aspect is about the increases in the results of economic statistics, the other one is about the process of development. Thus, SMEs growth refers to the process of SMEs development in a positive direction.

SMEs growth is often an unclear concept across academic research and business activities. Oh et al. (2006) argued the definition of SMEs growth is a "flawed analogy"

due to lack of academic rigor. SMEs growth is considered as a result of their strategic choices (Vos, 2005). SME growth is usually determined by if its strategy can achieve competitive advantages of rapid response and flexibility. Evidences from quantitative analysis (Fernandez-Olmos and Ramirez-Aleson, 2017) suggested three factors that can influence SMEs growth. They are the economy conditions (macro-level), the business life cycle (industry-level), and the history and experiences of SME (firm-level). In addition, evidences from qualitative analysis (Solomon and Linton, 2016; van Weele et al., 2017) show how SME managers perceive valuable resource and useful information (individual-level) can also influence the success of SMEs.

SME growth as process or outcome is an increasingly popular academic debate. SME growth as process emphasizes the processes of choosing strategic choices, getting access to information and resources, collaborations, and interactions. On the other hand, SME growth as outcomes emphasizes the results of above processes. SME growth as process is more complex than SME growth as outcomes. Considering growth is a complex process, thus this study considers SME growth as process rather than outcome.

However, the theories in SME growth can still be improved by considering the strategic choices of SMEs connections at the micro-level (Ritala and Almpanopoulou, 2017). The increasing use of networks in SME growth is considered as a strategy to gain competitive advantage of rapid response and flexibility (Narula, 2004; Van

Lancker, et al., 2016). In economic development, the complex connections and inter-dependency among SMEs need to be examined and clarified (van de Vrande, et al., 2009; Zeng, et al., 2010). Complex SME growth processes cause that SMEs consider forming a network as a strategy. Therefore, it is important examine and clarify inter-organisational connections in SME growth.

The last section discussed the characteristics of SMEs and the processes of economic development. SMEs growth is a vital part of the processes of economic development. The processes of economic development are about exchanging information about technologies and new ideas among the firms (Rogers, 1995; Schultze and Leidner, 2002; Boland, et al., 2007). These processes in SME growth are communications among the team members which leads to increasingly shared information. However, information in SME growth can hardly be diffused. There are some barriers to information spread in SME growth. These barriers are: (1) diverse information sources from heterogeneous firms (Gabbay and Zuckerman, 1998; Burt, 2007; Phelps et al., 2007), (2) hierarchical organisation structure (Friedkin, 1982, 1993 and 1999; Levin and Cross, 2004; Platonov and Bergman, 2012), and (3) high risk in adopting new technologies (Burt, 2007). These characteristics about SMEs growth are discussed as below.

First, SMEs growth involves heterogeneous firms and diverse information sources (Podolny and Baron, 1997; Burt, 2004; Frishammar and Ake, 2005). For example,

information about design and engineering are usually difficult to be transferred and mediated (Dasgupta, 2000; Garud and Karnoe, 2001; Garud, et al., 2013). This created a 'new design pluralism' which requires redefining the roles of brokers who can put design and engineering information closely together (Parkhe et al., 2006; Lau et al., 2010; Funk, 2012; Iacobucci and Hoeffler, 2016).

Second, SMEs growth is difficult to be achieved in a hierarchical organisation structure (Walker et al., 1997; Shane and Cable, 2002; Levin and Cross, 2004). Many organisations realised the flexibility in team structure can enhance their quality of work and capacity. However, such flexibility creates a situation, where the SMEs growth is lack of control in time and expenses (Tymon and Stumpf, 2003; Qumer and Henderson-Sellers, 2008). Burt (2007) argued that the organisation structures require new models, tools and techniques for managing SMEs growth. However, most of the studies in the area of SMEs management have focused on SMEs growth outcomes, which link the SMEs growth with creating competitiveness and growth of revenue. It is necessary to investigate how the processes of SMEs growth can be implemented in organisations (Patulny and Svendsen, 2007; Mukherjee et al.,2016; Ozkan-Canbolat and Beraha; 2016).

Third, SMEs growth has to overcome a large number of risks and uncertainties in adopting new management and technologies (Chung and Gibbons, 1997; Cohe and Fields, 1999; Fleming and Waguespack; 2007). For example, technology and market

can be changed to result in replacing products and losing customers. These risks and uncertainties cannot be passed onto a management consultant, technology provider, or specialist through outsourcing. The adoption of a new management and technology requires that the relevant information can be articulated to all the firms and also can be understood by all (Newell et al., 2004; Kratzer et al., 2016). Otherwise, SMEs growth may create issues.

In sum, managing SMEs growth is a complex task. The barriers from heterogeneous firms, hierarchical organisation structure, and risks and uncertainties in adopting new management and technologies require new theories, models, and techniques for SMEs management. These inherent barriers in SMEs growth can hardly be changed. It requires a new way of managing SMEs growth to fit this context. Thus, the next section is going to discuss the importance of SME connections in SMEs development.

2.3 SME connections

This section provides a discussion about from why SME connections are important for SMEs development. This discussion also provides a link between SME connections and SMEs networks. The last section suggested that factors including economy conditions (macro-level), the business life cycle (industry-level), the history and experiences of SME (firm-level), SME managers' perception and vision

(individual-level), and strategic choices (strategy-level) can influences SMEs growth. Further empirical evidence on SME growth shows formal SME clusters can significantly increase the net asset and add value to SME growth (Rogers, 1995; Watson, 2004). A large data set of SMEs over the time period from 1992 to2008 suggests that the participation in government-supported SME clusters program can improve SME growth (Schoonjans, et al., 2013). In general, SMEs clusters are considered as valuable assets that can facilitate the exchange of SMEs' knowledge and resources. This is not only essential for SME survival but also important for growth. SMEs in particular can benefit from including other and being included in clusters. This is the reason why growth is important for SMEs.

The importance of SME connections includes three aspects: 1) getting access to resources, 2) collaborations and 3) interactions. First, SME connections involve getting access to scarce resources and information. Varying knowledge and skills are needed to identify needs. Also, various technologies are adopted to meet the needs. Burt (2007) summarised five challenges in getting access to scarce resources and information: (1) governance structures; (2) overlapping technological skills; (3) trust; (4) cultural similarity; (5) organisational similarity. Acquiring information has a significant impact on SME development. Badaracco (1991, P12) states, "for one organisation to acquire knowledge embedded in the routines of another, it must form a complex, intimate relationship with it".

Second, SME connections as collaborations can help to clarify opportunities and

reduce risks in business development (Pittaway et al., 2004). Collaboration between firms from different knowledge backgrounds in SME development has been noted in virtually all economies (Gupta and Maltz, 2015). Schleimer and Faems (2016) Collaborative activities consist of: (1) mutual communication (i.e., participation in meetings, committees, phone conversations, exchange of mail, fax, email); (2) teamwork and sharing responsibilities (i.e., joint decision-making, equal contributions, sharing responsibilities for outcomes). Schleimer and Shulman (2011) found that successful firms can not only be based on previously experiences but also direct or indirect collaborations. These collaborations can considered as a complement to SMEs' experience and knowledge, compensating for their internal limitations by acquiring external expertise.

Third, SME connections as interactions include teamwork and information exchange. SME connections also involve interactions with business partners. New business development is a complex task of understanding and anticipating customer needs. The interactions with business partners happen concurrently with other activities in company development. Interactions with business partners have a positive effect on firm growth (Matthing et al., 2004). Firms can gain a better understanding of business development directions with those interactions.

Despite a large number of academic works in SME management, SME connections still rarely explored. Most SMEs have gone through rapid changes in the last ten years.

This section has discussed SME connections as a process involving 1) getting access to a resource, 2) collaborations, and 3) interactions. Thus, the major challenge in managing such a complex process will be that SMEs as a highly complex network consists of a large number of dyads relations and require an analysis of network dynamics and structure.

To answer the question how to manage SMEs growth, this section will discuss SME connections from two aspects of managing SMEs growth: 1) what SME connections are not about and 2) what SME connections are about. SME connections are considered as an external competitive advantage. From the resource based view, competitive advantages can be either internal or external. For example, low cost, better quality, and rapid delivery as internal competitive advantage usually can put SMEs at a favorable business position. This study argues that a SME's competitive advantage may span across organisational boundaries and may be abilities to get access to external resources and routines. Thus, SME connection is an increasingly important concept for understanding external competitive advantages. These external competitive advantages are the relationships among organisations. Previous research (Dyer and Singh, 1998; Burt, 2007) identified four types of external competitive advantages: (1) complementary capabilities and resources, (2) information sharing routines, (3) relation-specific assets (like gatekeepers), and (4) effective consultancy. Dyer and Singh (1998) and Burt (2007) suggested that this view of external competitive advantages can offer better solutions for firm-level strategies than internal competitive advantages offered by a resource-based view

Form Burt's (2007 and 2014) perspective, SME connections mean that SMEs are usually inter-connected organisations. Each unit needs information from each other to achieve SMEs growth. In SMEs growth, these units can benefit from new information developed by other units. Such information exchange among organisational units provides opportunities for SMEs growth. Gulati (1999) noticed that managers pay more attentions, time, and resources on information exchange in SME connections. However, information crucially related to SMEs growth is often "sticky" and difficult to spread (Grootaert, 2001; Landsperger et al., 2012; Popkova, et al., 2015). When information is being transmitted, people cross function may not be able to fully understand each other. For example, a realistic problem is that a designer usually does not understand the technical terms in engineering. This usually leads to ineffective communication among firms in SME connections. However, the structure of information exchange between cross function has rarely been explored. In other words, how people work together across function groups in the SMEs growth? How can SMEs gain useful information from each other to enhance its SME connections?

As discussed above, there are complex network structures in SME development. Thus, it is necessary to discuss how networks can influence SME development in theories and practices. Previous research suggested that brokerage in the network can influence SME growth (Burt, 2009). Tsai and Ghoshal (1998) modeled business diffusion between business units and presented this as a barter process, in which

agents exchange different types of knowledge. They highlighted that brokers are located in a network and are directly connected with a larger number of specialists and a small number of other brokers. These brokers control the network as roughly 90 percent of connections are across business units. Their study confirmed that networks can provide an analysis of this broker phenomenon. The various forms of knowledge tend to form separated clusters in this case. Specialists across function groups are linked by a few brokers at the intersection between the groups. Walker et al. (1997) suggest that the number of specialists is not associated with high-impact business growth. This result showed the contradiction between theory and practice. The researchers suggested that a repository of knowledge between specialists, the effective integration of knowledge and the capabilities of organising versatile specialists within and outside the boundaries of the function group, lead to more significant impacts on business growth.

The inter-firm connection in collaboration across functions mostly relies on such "brokers". In other words, when the collaboration evolves across disciplines, specialists are usually connected by the "brokers" who are centrally located (Granovetter, 1974 and Burt, 2004). This broker influence can be analysed by adopting network analysis (Burt, 2004). Network structures such as brokerage (Fukuyama, 1995 and 1997; Burt, 2004) have been used to describe the general patterns of SME networks.

Further, Burt (2007 and 2015) suggests network analysis can provide a representative view for analysing SME growth process, and focusing on inter-firm level collaborations. This includes: 1) to what extent networks with brokerage can influence SME growth, and 2) what the roles of brokers and to what extent they can influence SME growth are. Related to this, Fleming and Waguespack (2007 and 2014) confirmed that this study area has been rarely explored. As the discussion above, analysing the inter-fiorm level networks can help to understand the SME growth process.

Moreover, there are reasons to expect positive interaction effects between sparse and interlocked connections for SME growth. From the network structure perspective, A SME's connection can either be sparse or interlocked, but cannot be both within a short time period (Burt, 2007). In addition, sparse connections increase the diversity of business resources and knowledge, and interlocked connections increase common understandings of complex implementation problems. Sparse connections typically resolve the issues about what are more easily available in SME development. Consequently, interlocked connections could be determinant of the extent to generate growth.

SME connections also mean brokerage between SMEs. Galison (1997), Rodan and Galunic (2004), Boland et al. (2007) also found that there are 1) highly frequent information exchange among firms and 2) intensive information exchange between firms with different skills and knowledge backgrounds in SME connections. They

called this phenomenon as information brokerage in SMEs development. This appears as that information exchange in SMEs growth is central to some firms located at the intersection between different professional groups. Also, Boland et al (2007) suggested people as information brokerage roles. It appears as some people are frequently and densely placed at the intersection between professional groups in the networks. Therefore, managing collaborations between SMEs are crucial to SMEs growth. The following section discusses SMEs networks in SMEs development.

2.4 SMEs networks

SME connection in SMEs development is defined as co-development among SMEs and related parties (Stiglitz, 2000). SME connections mean collaborations and technical knowledge sharing. However, each SME is usually specialised in its own business area. Successful SMEs are focused rather diversified in their development (Abosede, Obasan, and Alese, 2016). SMEs development relies on the collaboration and knowledge inter-dependency among them. This is considered as the major barrier to SMEs development. Thus, the management of SME connections requires theories in how the inter-dependency among SMEs influences their development.

SMEs development does not necessarily follow the framework for increasing their sizes and improving their capabilities (Gupta, 2014). Many studies have demonstrated there is no a direct relationship between long term vision, value chain structure, Porter's five forces and SMEs development (Herrera, 2015 and 2016). Prior studies have also claimed that SMEs in general do not fit to or follow these theories and frameworks (Narula, 2004). Moreover, the majority of small business managers do not engage in these theory frameworks and thinking, due to lack of training, budget, or time (Fernandez-Olmos and Ramirez-Aleson, 2017). The reasons are: 1) SMEs in general cannot be simply classified as suppliers or customers, and 2) the competitors and alliances are not clear to SMEs. Thus, prior studies suggested that SMEs with insufficient resources and ineffective information can still be successful on unstructured and irregular pathways.

The inter-dependency among SMEs can be analyzed through links amongst them. These links include operational collaborations and knowledge sharing (Burt, 2007). Relevant theories in this area have moved from analyzing SMEs as units to SMEs as clusters (see Figure 2.1). This trend in theories has moved from explaining SMEs success from the organisational level to inter-organisational level. The early research in this area focused on the factors of SMEs themselves. And the recent theories tend to focus on the connections among SMEs in their development. This change represents why the interdependency among SMEs is getting more important in theories. The rest of this section gives a detailed discussion about these theories in

Figure 2.1.

Figure 2.1 Theory map from SMEs development to SMEs networks

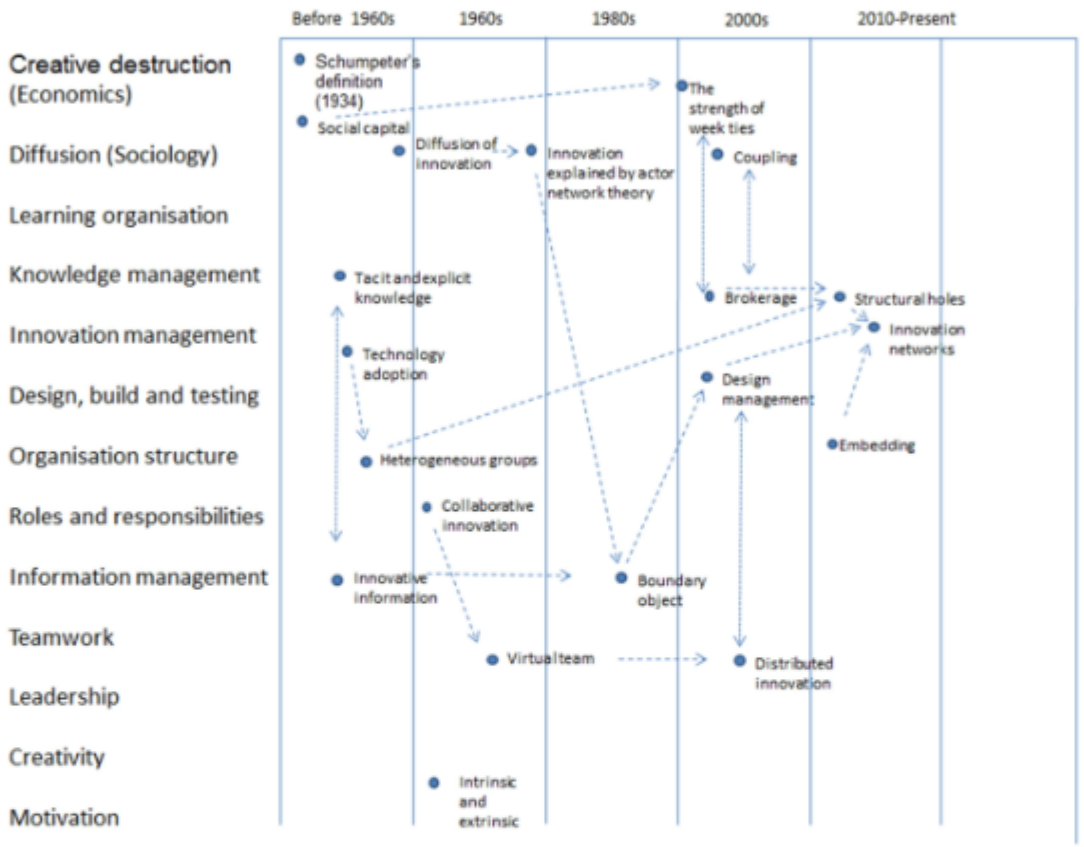


Figure 2.1 begins with Schumpeter's definition of operational collaborations. Operational collaborations among SMEs result in business growth by the integration of products, services, knowledge and skills (Schumpeter, 1934). In SMEs development, there are a large amount of transactions and information exchange among them (Jones, 2005). These transactions and information exchange can be seen as diffusion processes. Rogers (1995) suggested the concept of diffusion in order to

explain how SMEs can achieve development by diffusing their products, services and knowledge. The diffusion theory suggested that SMEs were in the diffusing processes had better performance than those were not. However, the diffusion theory did not answer the question 'how'. How SMEs can be get involved in the diffusing processes.

Figure 2.1 show that another important theory in SMEs development is diffusion of innovation. The diffusion processes have two features in the theory and connected with other theories below. First, operational collaborations between different SMEs professional groups are important to their development. Such operational collaborations provide opportunities to SMEs to combine their abilities to develop and grow together. Operational collaborations in SMEs development appear as combining explicit and tacit knowledge (Blau, 1968 and 1982; Rodan, and Galuni, 2004), sharing innovative information (Roger, 1995; Reagans and Zuckerman, 2001), and technology adoption (Roger, 1960, Boudreau and Robey, 2005). Second, SMEs development can be seen as collaborative activities. When SMEs development requires transactions and information across SMEs borders, different SMEs can work as a virtual team (Brass, et al., 2004). SMEs as a team together can combine SMEs' abilities and SMEs' common interests (Tsai and Ghoshal, 1998; Tasi, 2000). However, these theories still did not answer the question 'how' yet.

As discussed above, operational collaborations and diffusion of innovation did not answer the question 'how' SMEs can co-develop together, thus, theories are improved

to answer this question. The importance of inter-firm connections was highlighted by Granovetter (1973). This leads to research focuses on inter-organisational level analysis. Then, network analysis was introduced to analyse inter-firm connections. Brokerage (Uzzi, 1996) and structural holes (Burt, 2004) were proposed as two effective network structures in firm development. Further, innovation network theory highlighted the importance of inter-firm connection structures (Burt, 2007). Table 2.1 below provides a summary of these changes in theories.

Table 2.1 Theories in the area of SMEs development and SMEs networks

Author	**Theory contribution**
Schumpeter's (1934) definition of operational collaborations	Highlight the importance of collaborations
Diffusion of innovation (Roger, 1960)	Clarify the process of collaborations
The strength of weak ties (Granovetter, 1973)	Highlighted the importance of inter-firm connections
Brokerage (Uzzi, 1996) and structural holes (Burt, 2004)	Introduce network analysis to analyse inter-firm connections
Innovation network (Burt, 2007)	Highlighted the importance of inter-firm connection structures

SMEs usually connected in networks (see Figure 2.2). SMEs can achieve success as networks (Burt, 1992 and 1997; Adler, 2001; Adler and Kwon, 2002). The network theory suggests that resource and information endowments can only be effective on

SMEs development when they are strategically connected to the other. Walker et al. (1997) suggested that the initial resource and information endowments and advantages of SMEs do not influence their development significantly. The significant influences are the organisations they are connected with. In other words, it does not matter who they are, it matters who they are connected with. A similar theory refers these connections to boundary objects, such as transaction, information sharing, contract and so on (Watts, 2004; Parkhe, et al., 2006). Comparing to the network theory, the boundary object theory tends to focus on the connections as units rather than the whole networks. Furthermore, it suggests information sharing as connections is more influential than the other types of connections, such as contracts and transactions, on SMEs development.

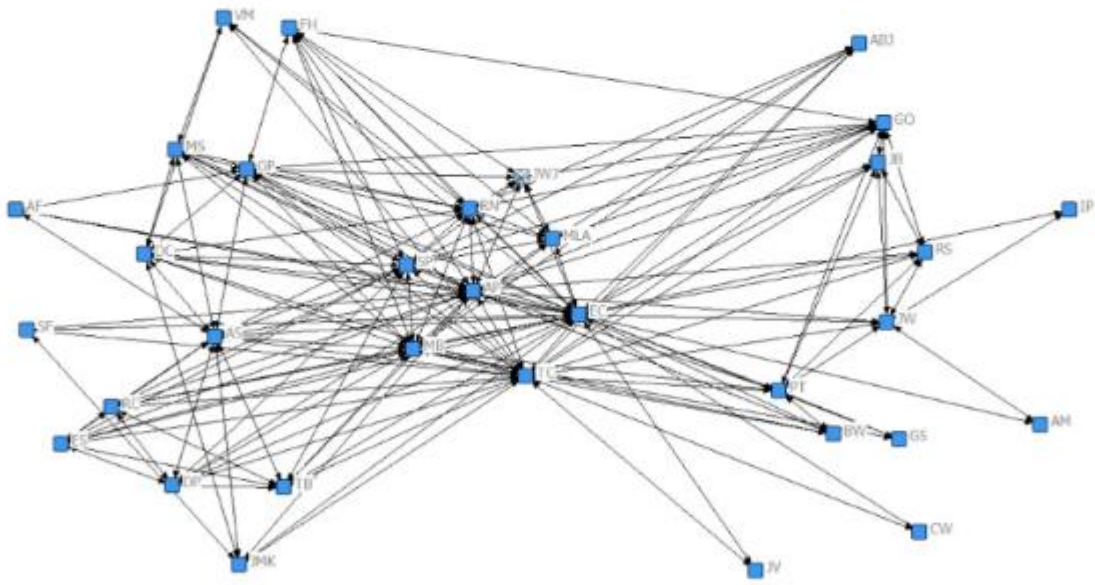


Figure 2.2 A SME network example

In the later research, theories suggested that SMEs development is significantly affected by the structures of their networks (Burt, 2007), especially in the structure of brokerage and weak ties, coupling, independent design, distributed networks. These theories suggested that not only the connections are important, but also the unique connections link otherwise isolated organisations are important. Burt (2007) suggested the structural hole theory as a more unified theory in this area. The structural hole theory suggests that: SMEs network positions can affect their development. Structural holes are loosely connected SMEs with unique connections among them. However, it is not clear that loosely connected SMEs clusters can be more efficient in development. Also, it is not clear that what the cluster structures in SMEs development are.

2.5 SMEs networks in firm development

Before discuss SMEs networks, it is necessary to clarify that network is a cause of SMEs development or a result. In other words, either networks cause SMEs development or SMEs development results in networks. Borgatti's (2011) suggested network structures are correlated with firm future performance rather than past performance. Similarly, Obstfeld (2005) suggested changes in network structures can cause firm's performance differences afterwards. Thus, this suggests that network is a

cause rather than a result of SMEs development.

The previous section suggests that SMEs can be benefited from strategically connecting with others in networks. Interest in understanding how inter-organisation connections influencing business growth and development has recently increased (Borgatti, 2011). However, these efforts have almost exclusively focused on the type of inter-organisation connections that influence SME growth, over-looking one of the structures of them. Thus, it is necessary to investigate how the combination of different structures of inter-organisation connections can influence SMEs development.

Network was suggested as a cause of SME development (Burt's 1997 and 2007). SME's knowledge and business resources can be complementary to each other, thus collaborations between them can improve their ability and competence. Kilduff and Tsai (2003) suggest that firm's knowledge and business resource differences cause them to form networks. SME growth is usually consists of collaborative work to combine formerly separated knowledge into new knowledge and ideas (Aalbers, et al., 2016). SME growth emphasizes gaining access to resources and knowledge through connections with external parties (Weiblen and Chesbrough, 2015). Especially, inter-organisation connections are critical to SMEs growth in getting external resources and knowledge (Cooke and Wills, 1999; Batjargal, 2003 and 2007; Liao and Welch, 2005). Thus, this study draws on literatures on the network theory to examine the relations between the various structures of inter-organisation connections and SME growth

results.

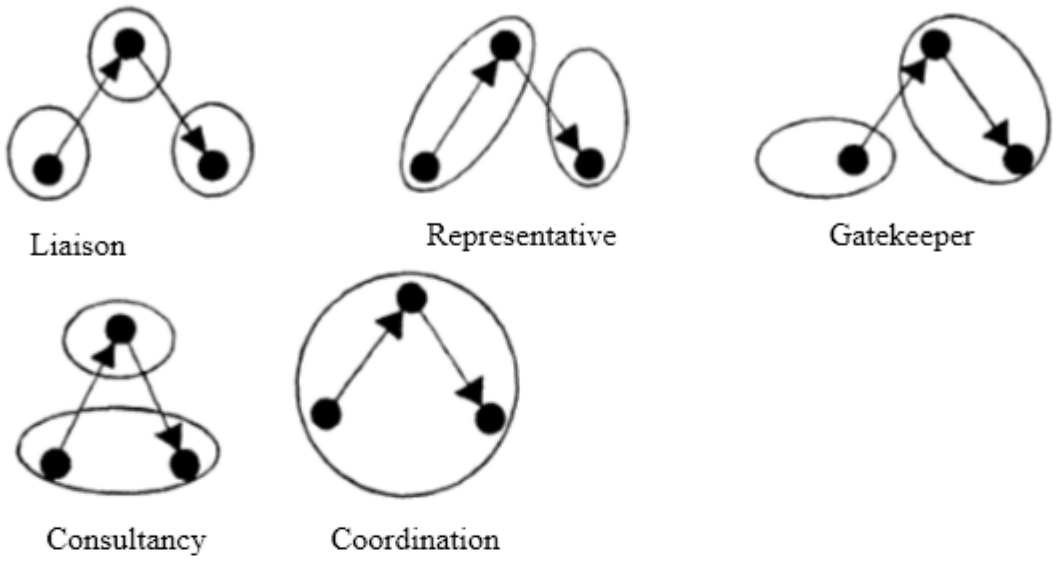
The agents of combining separated knowledge are firms, network analysis has emerged as a robust method to link these micro-behaviors of firms and the macro-results of them (Levin and Cross, 2004). The work of Uzzi (1996) and Burt (1992 and 1997) suggest that efficient network structures of firms are either interlocked featuring dense clusters of firms or sparse featuring loosely connected firms with a few connections. 'Connections' represent collaborations and investments in firm relationships, so to combine knowledge and resources at minimum cost, firms should avoid similar or redundant connections between them. The advantages of sparse networks are usually taken by centrally located firms who aggregate knowledge and resources from the others (Lynch, O'toole, and Biemans, 2016).

On the other hand, interlocked networks have short connection (or path) lengths which are conducive to the quick spread of knowledge and resources. Thus, firms in high density networks are likely to be effective in business growth (Schleimer and Faems, 2016). Those firms in interlocked networks may not have the same intellectual reach as firms in sparse networks, but have higher levels of efficiency. Thus, both sparse and interlocked network structures are related to a firm's growth.

SMEs can be benefited from connections in either sparse or interlocked network structures. A gap in the current theories is whether firms can take advantages from the

combination of both sparse and interlocked network structures in SME growth. SMEs are usually connected together in complex structures to achieve growth. It is important to find out if the combined sparse and interlocked structures of SMEs connections are valuable to growth. Thus, the results of this study can advance the network theory from seeking for the effect of each network structure to the interaction effects of combined various network structures.

Figure 2.3 Five roles of brokerage in SMEs development



According to Burt's (207) theory, SMEs can act as different roles in networks (see Figure 2.3). And they do not stay identical in SMEs development. This study suggests that SMEs development over time is a process of developing these five types of roles. Such dynamics in SMEs development can be seen as combining knowledge and skills in a pathway by setting up connections in networks. Especially, in a large SMEs network, some SMEs can develop in a way by connecting the gaps between the disconnected others. And some SMEs can develop in another way by connecting to these 'broker' SMEs.

From this perspective, it is clear that SME connections are about connecting disconnected SMEs. In SMEs development, the SMEs can facilitate new connections to the disconnected others or control the existing connections by moving to a better

connected position (Sydow and Windeler, 1998; Svendsen and Svendsen, 2004). For example, both A and B have "weak connections" in the network or can be seen as having relative "weaker connections" comparing to C. Thus, A and B in development usually require C to be the third parties surrounding them. In this case, SME C is more likely to be successful in development by taking a better position in the network.

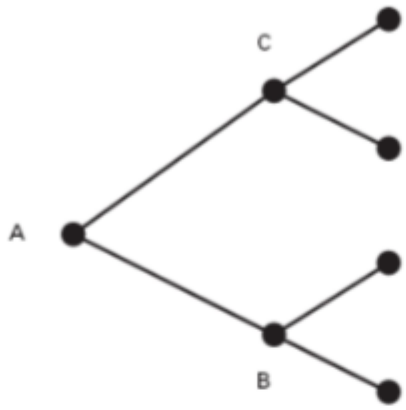
As discussed before, the SMEs theories are moving from SMEs as units to SMEs as clusters. This change requires new theories and analysis approaches. Prior theories focused on the characteristics and behaviors of SMEs and SME managers. This study's theoretical framework focuses on how those connections among SMEs are developed and influential, how SMEs connect to each other, how SMEs connect others and get connected, and the influence of those connection structures. However, these five types of SMEs roles have not been fully studied and understood in research (Burt, 2007), especially, how they influence SMEs development and how other SMEs in the network can be benefited from them.

2.6 Complexity in SMEs networks in firm development

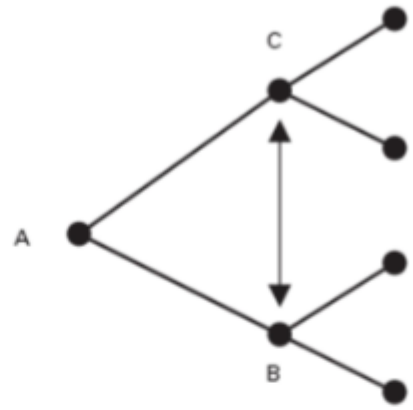
According to Burt's (2007) theory, the complex connections do not stay static in SME growth. Obstfeld (2005) suggested that changing network dynamics is a process of creating both of new sparse and interlocked structures between firms. Network

dynamics is about introducing disconnected firms and facilitating information exchange between connected firms. In network dynamics, brokerages are ongoing activities rather than just static network structures. For example, there is a gap between B and C connected by A at the first stage (see Figure 2.4). Firm A acts as a broker between B and C (stage 2) and a new information exchange tie is built up between B and C (stage 3). Such brokerages (stage 2) connect the gaps between firms in the network. Then B can also become a broker to connect A and a new Firm D (stage 4). Thus, sparse and interlocked structures are created at the same time.

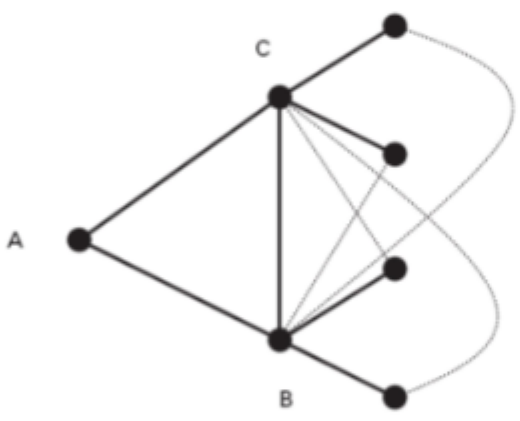
Figure 2.4 Network dynamics in SME development



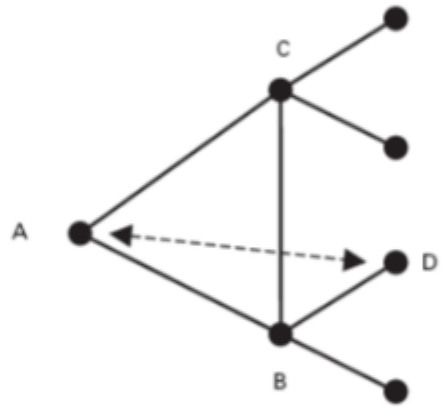
Network at Time 1



Time 2: Network after *tertius iungens* introduction



Time 3: New structural holes created



Time 4: Second reciprocal *tertius iungens* introduction

Source: Obstfeld (2005)

A similar dynamics in business growth is also suggested by Rogers (1995). Information exchange among the firms in business growth over time is to combine different knowledge and skills. Such dynamics in business growth is described as a firm that has the relevant knowledge or skills, another firm that does not yet have relevant knowledge or skills, and setting up a communication tie connecting the two.

In a large network, this dynamics can apply to between one and several firms (Ostrom, 1994 and 1998; Gabbay and Zuckerman, 1998; Afuah, 2013; Garud, Tuertscher, and Van de Ven, 2013). Following this process to draw a network, the result is similar to Figure 4. Thus, business network dynamics is about bridging the gaps between disconnected SMEs. During this process, both of sparse and interlocked structures are created. The network can facilitate new coordination and information exchange between otherwise disconnected SMEs. Thus, network dynamics are important in SME growth. An in-depth discussion is provided in the next section to discuss what the influences of networks in SME development.

Chapter 3 Theoretical framework

3.1 SME connections in SMEs development

This theoretical framework focuses on network theories about the relations between the structures of inter-organisation connections and SMEs development results. These theories explain how SMEs can be benefited from the inter-organisation connections in collaborations (Burt, 2007). Then, this study proposes the theoretical gap, how a combination of various structures of inter-organisation connections influences SMEs development results.

A connection between organisations is a purposeful social unit connecting business information and resources (Levin and Cross, 2004). Networks can reflect the synthesis process of business growth. SMEs interact through networks, exchanging business resources and information and retaining resources and ideas that are innovative or growth related. In this synthesis process among SMEs, the choice is usually not random (Carroll and Teo, 1996; Candi, et al., 2013). For a synthesis to be innovative, business resources and information being combined are often sufficiently 'distant' from each other that their combinations are not 'obvious'. Before a good idea is known, this collective ideation among SMEs search or consider what choice is worth and productive (Edelman, et al., 2004; Fleming and Waguespack, 2007). Thus,

networks can be abstracted away from the business communication aspects of SMEs to focus on the structures. A successful innovation is usually initially unknown or unfamiliar to the most of SMEs in their networks. It is assembled by combining a series of information and resources from connected SMEs.

Building up connections between SMEs is usually time consuming and therefore have an opportunity cost. This is because SMEs only have finite or limited capacity for collaborations with each other. Collaborations take time and labour cost and SMEs usually have a small number of staff with limited working hours in a day. Therefore, SMEs can only have a finite number of connections with others. SMEs connections are not easily replaced or alternated by new connections. The connections among SMEs enable information and business resources exchange meanwhile constrain their abilities to find alternatives. Once SMEs are connected, their connections constrain their ability to building new connections. In a short term, a SME sticks to its direct connections (also known as ego network), once its connections are built up. Thus, this study seeks efficient SME network structures, those that can lead to SME success.

The connections among organisations can facilitate the integration of diverse resources and knowledge in SME growth. Particularly in the case of SMEs innovation, accessing diverse resources and knowledge in other SMEs through collaboration, albeit necessary, are not enough to enhance innovation results significantly (Thorpe, et al., 2005). SMEs also need interlocked connections and to be embedded in a cluster.

Those interlocked connections help SMEs to confirm and corroborate the view that innovation is developing in a promising area and the technological expertise attained is generating innovation. For instance, SMEs share and recombine of diverse resources and knowledge into innovative outcomes, a new product or service. At the same time, they work against the difficulties associated with the uncertainties in their market, substitutes and technological evolutions. In fact, an innovation can easily be replaced or wiped out in the market by other similar innovation or newly emerged technologies, even before it is formally launched (Gabbay and Zuckerman; 1998; Edelman, et al., 2004; Fleming and Waguespack, 2007). Building on these insights, this study argues that connections among SMEs are combined structures consisting of not only sparsely bridging ties but also interlocked.

Although prior empirical evidence demonstrated that bridging connections between SMEs correlate positively with their SME growth, less attention has been devoted to combining various structures of those connections and the effects of combined connection structures. The literature on organisational connections in SME management has recognized the sparse ties are positively associated with getting access to external knowledge and resources. Also, interlocked connections provide SMEs a number of equivalent communication channels which can monitor and confirm the directions of growth. SME growth is considered as behavioral consequences of SMEs with both sparse and interlocked connections. Both of sparse and interlocked connections are important drivers of innovative results for

organisations (Inkpen and Tsang, 2005; Galaskiewicz, 2007).

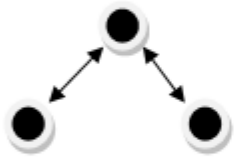
3.2 The sparse connections in SMEs development

Sparse connections are inter-organisational ties between an ego organisation and otherwise disconnected alter organisations. There are no connections among those alter organisations. They are connected centrally to an ego organisation. The number of a SME's sparse connections is positively associated with the diversity of accessible external resources and knowledge (Burt, 2015). Sparse connections are beneficial to firms' innovative capabilities. Sparse connections reaching outside an organisation are significantly related to individual (Gilsing and Nooteboom, 2005; Ibarra, et al., 2005; Cross et al., 2015) and organisational-level of innovative results (Walker, et al., 1997; Tsai and Ghoshal, 1998; Tsai, 2000). For instance, McEvily and Zaheer (1999) found that resource and advice seeking can be effective through sparse connections across organisational boundaries. SMEs with sparse connections can effectively gather the required business resources and information.

Sparse connections are concerned as ties centrally to an organisation. In this case, an organisation has the advantage in recombining business resources and knowledge from the others. For instance, a disconnected pair of an IT device design firm and

engineering firm can be bridged to create a new device by a third firm. This third firm does not only take the advantage from the innovative products, but also can be a representative to lead this three firm cluster. Meanwhile, firms with sparse connections can usually be a gatekeeper to this recombined new business, given by getting and managing access to one firm takes less time and resources than separated two. Thus, SMEs with sparse connections are more likely to be successful than those without.

Figure 3.1 Sparse connections



SMEs development relies on collaborations between SMEs. These collaborations are through brokerage. Sparse connections are the brokerage processes in a SMEs network. Sparse connections are the regular patterns of SMEs clusters in their development. Loosely connected SMEs with unique connections in their clusters can be more efficient in development. Thus, sparse structures of connections can be positively associated with SMEs' growth results. Base on above discussion, this study proposes the first research question.

Research question 1: Do sparse connections positively influence on SMEs development?

3.3 The interlocked connections in SMEs development

Although sparse connections are effective in gathering and getting access to external resources and knowledge, those connections do not automatically and directly generate SME growth (Gulati, 1999; Obstfeld, 2005). As the external business resources and knowledge acquired across organisational boundaries are usually heterogeneous and diverse (Burt, 2015), sparse connections may lack the necessary common base to integrate them (Granovetter, 1973 and 1985; Krackhardt, 1992; Sydow and Windeler, 1998; Joshi, 2006). Moreover, as business resources and knowledge are hard to mobilized and transferred across organisational boundaries, because of the lack of a common business language and shared approach (Podolny and Baron, 1997).

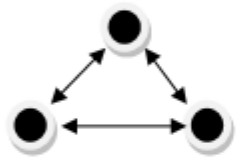
Another limit to SMEs growth through sparse connections is that having new business resources and ideas is fundamentally far away from turn them into business products or services. As Obstfeld (2005) and Burt (2007) noted, getting new business resources and ideas through different perspectives and implementing them are two distinct innovative processes. The diversity of business resources and knowledge provided by sparse connections might be an obstacle to the implementation of them. For instance, people belonging to different organisations might be subject and limited to their own

responsibilities and tasks toward the implementation and transfer of business resources and knowledge into separated innovative results. Thus, SMEs growth through sparse connections often loses control and is lack of coordination.

The features of interlocked connections among SMEs could help to overcome those limitations of sparse connections. Interlocked connections refer to inter-connected ties among organisations (Granovetter, 1985; Nohria and Eccles, 1992). Interlocked connections are usually considered as structural redundancy in networks. In this case, each organisation in interlocked connections is not considered as a unique bridge to connect any others. Prior research has shown some specific advantages associated with interlocked connections. Besides connecting cross-organisation resources and knowledge, the innovative prospect and value of these external resources and knowledge can be compared and confirmed by organisations located in different parts of a interlocked structure. Although certain resources and knowledge are not significantly valuable to some organisations, they can still be hugely beneficial to the others who are able to implement them in business development (Kraatz, 1998; Koka and Prescott; 2002). The efforts of sharing resources and knowledge may not reach the target due to lack of comparison and advices (Nebus, 2006). Interlocked connections are better than sparse ones when the resources and knowledge are clearly valuable from the source organisation's view but not certain from the recipient organisation's view. Reagans and Zukerman (2001) highlighted that interlocked connections are positively associated with the results of knowledge transfer. And other

prior research showed advantages of interlocked connections in achieving a common view in inter-organisational collaborations (Krackhardt, 1992; Uzzi, 1996; Pittaway, et al., 2004). In the specific case of SME growth, interlocked connections can facilitate mutual understanding and help to build a common basis of implementing new ideas. Therefore, interlocked connections can support the transfer and implementation of diverse business resources and complex information.

Figure 3.2 Interlocked connections



However, sparse connections as brokerage processes in SMEs network can also slow down SMEs development progress. In contrast, interlocked connections can progress faster than sparse connections, since most of the information exchanges are through direct contacts. SMEs with interlocked connections in their clusters can be more efficient in development. Thus, interlocked structures of connections are positively associated with SMEs' growth. Base on above discussion, this study proposes the second and third research question.

Question 2: Do interlocked connections positively influence on SMEs growth?

Question 3: Do sparse and interlocked connections jointly and positively influence

on SMEs growth?

3.4 A summary of key points in identifying theories and the theoretical gap

The last few sections discussed the regular patterns in SME connections. This section summarises those regular patterns in SME network structures. The empirical findings in the previous studies in networks can be classified into: (1) those that encourage an sparse structures with structural holes and brokerage, and (2) those that findings encourage the opposite of an sparse structure, an interlocked structure with embedding and closure. The empirical findings encouraging sparse structure focuses on structural holes. Structural holes are the gaps between firms with different backgrounds and skills. The empirical findings encouraging the sparse structure network found that diverse information from firms with different backgrounds and skills can advance the social capital and benefit both the individuals and organisations. Also, there are empirical findings encouraging the opposite of an sparse structure network, interlocked structure network with embedding and closure. Embedding is the opposite of structural holes. Structural holes treat the gaps between firms as an asset. Quite the contrary, embedding treats the strong ties between firms as an asset.

Previous studies suggest that both sparse (Grootaert, 2001; Burt, 2007) and

interlocked (Portes and Sensenbrenner, 1993; Uzzi, 1996 and 1999; Kumar and Worm, 2003; Landsperger, et al., 2012) network structures can have positive impacts on SME growth. The findings from previous studies can be divided into two groups. The first group's findings emphasise the positive impacts of loosely connected network structure. Loosely connected network structure can combine diverse knowledge and skills from different professional groups. The information exchange in a loosely connected network usually relies on brokers due to the structural boundaries between professional groups. A loosely connected network is usually very creative since it can combine diverse knowledge and skills from different professional groups. However, SME development in a loosely connected network is usually slow since the information exchange between professional groups relies on brokers.

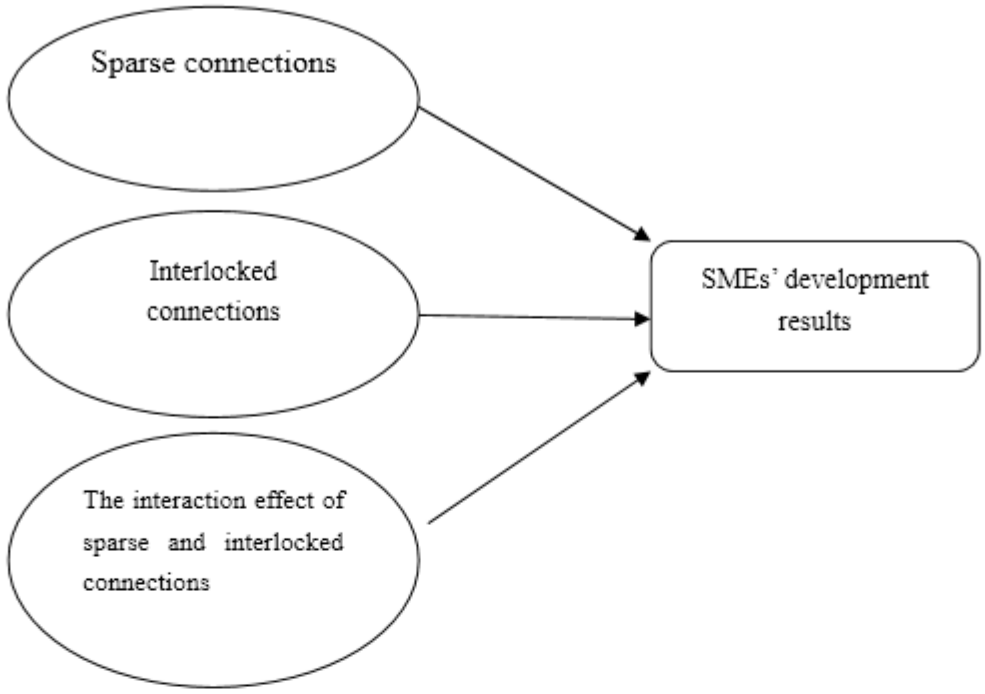
The other group's findings emphasise the positive impacts of fully connected network structure in SME growth. In contrast to loosely connected networks, a fully connected network does not rely on brokers. Information exchanges between firms a fully connected network are usually direct contacts. Thus, SME development in a fully connected network is usually very fast. However, a fully connected network is usually not creative, since firms are usually surrounded by direct contacts from the same professional group. A fully connected network cannot include different professional groups without brokers (Hargadon, 2003).

Burt (1997 and 2007) suggested that while loosely connected networks can combine

the knowledge and skills from different professional groups, in contradiction, fully connected networks can speed up SME development progress. The structure of network seems like a double blade sword. SME development usually requires collaborations between different professional groups. Brokers in loosely connected networks can bridge information exchange between different professional groups. However, the brokerage process in the network can also slow down SME development progress. In contrast, a fully connected network can progress fast since most of the information exchanges are through direct contacts. Thus, a loosely connected network is usually creative (Burt, 1997 and 2007) and a fully connected network is usually efficient (Friedkin, 1981 and1982; Dasgupta, 2000; Davidsson and Honig, 2003; Burt,2007).

Can a network have both loosely and fully connected structures in it? Fully connected structure in the network provides efficiency; however, collaborations between different professional groups require loosely connected structure. In other words, how can a SME network be efficient and creative? Base on above discussion, this study proposes the theoretical framework as below (see Figure 3.3).

Figure 3.3 The theoretical framework of this study



3.5 Research questions

This literature review suggests that the regular structure patterns of SMEs cluster and their influences are crucial and can be explored by using network theories. According to the network theory, these structure patterns in SMEs clusters include: 1) loosely connected SMEs with unique connections can be more efficient in development, and 2) SMEs with interlocked connections can be more efficient in development.

SMEs can be benefited from the inter-organisation connections in collaborations (Burt, 2007). A theoretical gap is how a combination of various structures of inter-organisation connections influences SMEs growth results. Thus, this study aims to exam the relations between the structures of inter-organisation connections and SMEs development results. This literature review proposes three refined research questions as below.

Research question 1: Do sparse connections positively influence on SMEs growth?

Research question 2: Do interlocked connections positively influence on SMEs growth?

Research question 3: Do sparse and interlocked connections jointly and positively influence on SMEs growth?

This literature review highlights the gap in the theories of SMEs development. This study suggests that the frameworks for increasing SMEs sizes and improving their capabilities do not fit to SMEs development. The inter-dependency among SMEs is crucial in their development and has rarely been explored. Thus, the regular patterns of SMEs cluster structures and their influences need to be explored. Table 3.1 summarises the research questions and variables identified in the previous sections.

Table 3.1 The identified research questions and hypotheses

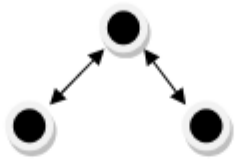
Previous literature	Research questions
Research about the structure of connections in firm development: Walker, et al., (1997); Tsai and Ghoshal, (1998); Tsai, (2000); Gilsing and Nooteboom, (2005); Ibarra, et al., (2005); Burt, (2015); Cross et al., (2015); Gargiulo and Sosa, (2016)	Research question 1: Do sparse connections positively influence on SMEs growth?
Research about the dynamics of connections in firm development: Granovetter, (1985); Krackhardt, (1992); Nohria and Eccles, (1992); Uzzi, (1996 and 1999); Reagans and Zukerman, (2001); Pittaway, et al., (2004)	Research question 2: Do interlocked connections positively influence on SMEs growth?
The influence of firm connections are highlighted by Borgatti, and Everett, (1999), Borgatt (2011), and Burt (1997 and 2007), however it has not been studied yet	Research question 3: Do sparse and interlocked connections jointly and positively influence on SMEs growth?

3.6 Hypothesis development

Sparse connections are concerned as ties centrally to an organisation. In this case, an organisation has the advantage in recombining business resources and knowledge from the others. For instance, a disconnected pair of an IT device design firm and engineering firm can be bridged to create a new device by a third firm (Dan, 2014; Javaid, 2014). This third firm does not only take the advantage from the innovative products, but also can be a representative to lead this three firm cluster. Meanwhile, firms with sparse connections can usually be a gatekeeper to this recombined new business, given by getting and managing access to one firm takes less time and resources than separated two. Thus, SMEs with sparse connections are more likely to

be successful in SMEs development than those without.

Figure 3.4: Sparse connections



Based on above discussion, this study proposes this study's first hypothesis.

***Hypothesis 1**: Sparse connections are positively associated with SMEs' development results.*

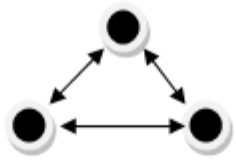
Although sparse connections are effective in gathering and getting access to external resources and knowledge, those connections do not automatically and directly generate growth (Gulati, 1999; Obstfeld, 2005). As the external business resources and knowledge acquired across organisational boundaries are usually heterogeneous and diverse (Burt, 2015), sparse connections may lack the necessary common base to integrate them (Granovetter, 1973 and 1985; Krackhardt, 1992; Sydow and Windeler, 1998; Joshi, 2006). Moreover, as business resources and knowledge are hard to mobilize and transferred across organisational boundaries, because of the lack of a common business language and shared approach (Podolny and Baron, 1997).

Another limit to SMEs generating SMEs development through sparse connections is that having new business resources and ideas is fundamentally far away for them to turn them into SMEs development results. As Obstfeld (2005) and Burt (2015) noted,

getting new business resources and ideas through different perspectives and implementing them into SMEs development are two distinct innovative processes. The diversity of business resources and knowledge provided by sparse connections might be an obstacle to the implementation of them. For instance, people belonging to different organisations might be subject and limited to their own responsibilities and tasks toward the implementation and transfer of business resources and knowledge into separated innovative results. Thus, SMEs that innovate through sparse connections often loses control and lack of coordination.

Interlocked connections are better than sparse ones when the resources and knowledge are clearly valuable from the source organisation's view but not certain from the recipient organisation's view. Reagans and Zukerman (2001) highlighted that interlocked connections are positively associated with the results of knowledge transfer in SMEs development. Furthermore other prior research showed advantages of interlocked connections in achieving a common view in inter-organisational SMEs development (Krackhardt, 1992; Uzzi, 1996; Pittaway et al., 2004). In the specific case of SMEs development, interlocked connections can facilitate mutual understanding and help to build a common basis of implementing new ideas. Therefore, interlocked connections can support the transfer and implementation of diverse business resources and complex information in SMEs development.

Figure 3.4: Interlocked connections



Based on above discussion, this study proposes this study's second hypothesis.

Hypothesis 2: *Interlocked connections are positively associated with SMEs' SMEs development results.*

Moreover, there are reasons to expect positive interaction effects between sparse and interlocked connections for SMEs development results. From the network structure perspective, a SME's connection can either be sparse or interlocked, but cannot be both within a short time period. In addition, sparse connections increase the diversity of business resources and knowledge, and interlocked connections increase common understandings of complex implementation problems. Sparse connections typically resolve the issues about what are more easily available in SMEs development. Consequently, interlocked connections could be determinant of the extent to generate SMEs development.

The features of interlocked connections among SMEs could help to overcome those limitations of sparse connections. Interlocked connections refer to inter-connected ties among organisations (Granovetter, 1985; Nohria and Eccles, 1992). Interlocked connections are usually considered as structural redundancy in networks. In this case,

each organisation in interlocked connections is not considered as a unique bridge to connect any others. Prior research (Uzzi, 1996; Borgatti andHalgin, 2011) showed some specific advantages associated with interlocked connections. Besides connecting cross-organisation resources and knowledge to create SMEs development, the innovative prospect and value of these external resources and knowledge can be compared and confirmed by organisations located in different parts of an interlocked structure. Although certain resources and knowledge are not significantly valuable to some organisations, they can still be hugely beneficial to the others who are able to implement them in SMEs development (Kraatz, 1998; Koka and Prescott; 2002). The efforts of sharing resources and knowledge may not reach the target due to lack of comparison and advices (Nebus, 2006).

Hypothesis 3: *Sparse and interlocked connections jointly and positively influence SMEs development results.*

Chapter 4 Methodology

4.1 Research philosophy of this study's research design

This section is to discuss the research philosophy for this study. This study discusses what we can know from network analysis research (ontology) and how we know things from network analysis research (epistemology). Ontology is about 'what' can be known (Blaikie, 2007). Epistemology is about 'how' to know (Blaikie, 2007). Then, this section discusses the philosophical perspective in this study.

This study adopted a 'three-layer' analysis. This 'three-layer analysis' is based on conceptualising networks, the analysis of network data, and regression modeling with the network analysis results. This study uses network analysis as an extra 'layer' of analysis. Most of the research only analyse collected data. This study not only analyse the collected data, but also the data generated by the collected data through network analysis. This 'three-layer' analysis offered a combined position of positivism and network analysis. Positivism emphasises denying or accepting the hypothesis. Network analysis is often about descriptive results. This study's 'three-layer' analysis

made a combination of both. The base of this 'three-layer' is network analysis using the collected data. And the middle layer of this paradigm is regression modeling using the data generated from network analysis. Then, the results provide both hypothesis testing results and network descriptions.

Ontology-wise, what can be known about SME networks? Blaikie (2007) suggests that knowledge is unembroidered evidence of the sense. A philosophical question here is not just what networks are but the network is a cause of SME development or a result of SME development. Burt's (1997 and 2007) explanation is that firm's knowledge and skill differences shape the structures of networks. Kilduff and Tsai's (2003) argument is that the structures of networks cause firm's knowledge and skill differences. Another explanation from Borgatti's paper On Network Theory (2011), his argument is that the correlation between network structures and firm performance can disappear when controlling for firms' past performance. Thus, he suggests that a significant part of the variance in firm performance is caused by the variance in network structures rather than the other way around. In this study, the networks are formed with the progress of SME development. The network did not exist before firms collaborate together or it can be concerned as network with no relation among the firms. Then, the network was building up while the SME development progressing. Therefore, this study suggests that networks are formed by SME development which requires firms across different functional roles working together.

Epistemology-wise, how can we get to know about SME networks? Network reflects the activities occurred in firm collaborations (Blau 1982; Castells, 2000). This study uses networks as the independent variables, it actually reflects and represents the patterns of inter-firm structure in SME development. Then, this study uses SME development outcomes as the dependent variables to test the relationship between networks and SME development outcomes. In other words, this study treats networks as one of the causes of SME development. Thus, this study's research design is to explore network dynamics, structure and the impacts of networks.

Then, what is the philosophical perspective of the network analysis? In other words, where is it located in research paradigms? Is network analysis positivism or structuralism? In terms of research philosophy, the research design of this study is network analysis with positivism rather than structuralism. Network analysis focuses on the structural patterns of social exchange (Wasserman and Faust, 1994). And the analysis of network is to describe the characteristics of networks. The results from network analysis are usually descriptive. For example, network analysis can be adopted to quantify firm's position, broker's roles, and the connectivity in networks (Branco and Valsiner, 1997, Amaral and Uzzi, 2007). However, this study uses the results of network analysis to test the relations between SME network and development outcomes. In other words, the data in regression modelling are the results of network analysis. Positivism emphasises hypothesis testing to discover the cause-effect relations. Thus, this study's research philosophy position is a

combination of network analysis and positivism. Based on above discussion, this study's research paradigm is located positivism.

4.2 Method choices

The method choice for this study is to analyse network dynamics, structure and influence in SME development. The fundamental aim of this study design is not only to collect accurate data but also to choose the appropriate analysis approaches. The purpose of this study design is to analyse both of the processes and cause-effect relations in SME networks. Due to this purpose, this study has the needs of analysis as below.

The needs of analysis 1: The dynamics of SME networks

SME networks do not only represent individual firm's work but also how those work together. In SME development, firms usually work as a cluster and concurrently exchange information with each other rather than as individual firms on separate tasks (Rogers, 1995). To analyse these activities, this study requires a method which is able to explore the relations among of SMEs. For example, how do the SME connections evolve among all firms in a network? Network dynamics can be presented as several

sets of snapshots at different stages of SME development. The analysis of those network snapshots need to be able to show the changes in relationships across different stages of SME development. For example, those network snapshots can be used to compare the changes in relationships and brokers among firms at different stages of SME development. Thus, this study requires an analysis to provide network snapshots about the connectivity and interdependence between firms across different stages of SME development.

The needs of analysis 2: New broker roles in SME development

New broker roles in SME development require reconfiguration of analysis approaches (Burt, 1997 and 2007). These new broker roles cannot be readily dealt with by case study or structural equation modelling. These new broker roles do not emerge with formal titles appointed by an organisation. For example, a firm can act as a broker to bridge information gaps between other firms, but this firm's perception of its own role in SME development may still be its specialty rather than a broker. To explore the new broker roles, this study require an analysis to be able to analyse firm connections at the inter-firm level.

The needs of analysis 3: The structure of SME networks

This study requires not only analysing the snapshot of the overall network structure but also each firm's own sub-network structure (also known as ego network, Hanneman and Riddle, 2005). The comparison of each firm's own sub-network structure can provide further analysis about the complexity of SME development. Case study and equation modelling can only deal dyadic relations (relations between two parties) in networks (Burt, 2007). Those traditional analysis approaches cannot provide information about the complex structure of relations, such as triad relations (relations among two three) and centralities (relations between one to the others in a network). Also, there are arguments about case studies can result in inaccurate results about networks (Borgatti, 2011). Snijders et al. (2010) argued that it is difficult to identify the overall network structure without analysing sub-network structures. Thus, this study requires a method to analyse network structure.

The needs of analysis 4: Quantification

The complex connections among firms usually need quantification in the analysis (Burt et al., 2013). Quantitative results about network patterns can provide comparison. This study requires quantification of the structure of ties in each network, broker roles, and each firm's location in the network. These complex network patterns are difficult to be quantified by traditional analysis approaches. Quantified network patterns can also be used in regression modelling. This can help to find out the

network influences on SME development outcomes. To explore the SME network influence, this study requires an method to provide quantification of SME networks.

Method choice 1: Qualitative approach

First, qualitative approach can be adopted to analyse network dynamics. The complex interactions between participants can be drawn as network snapshots through the analysis of interview data. These network snapshots can present how networks evolve. Then regular patterns of network dynamics can be revealed. Comparing to qualitative approach such as case study, network analysis can quantify network dynamics patterns then enable actor-based modelling. The network modelling approach can provide quantified and comparable results about SME network. Thus, the analysis results in network dynamics can provide not only details about regular patterns but also quantified results which can be used in regression modelling to test network influence.

Method choice 2: Quantitative approach

Regression modelling focuses the relationships between variables. However, the details of these variables are usually missing. Regression modelling can provide analysis in network influence, but have a very limited contribution to the understanding of the details about network dynamics and structure. Comparing to

regression modelling, network analysis provides more details about SME network structure. Also, pre-defined findings and concepts in research may restrict research to develop new findings and concepts. In this study, network analysis is used to explore the regular patterns of SME network structure rather than confirm pre-defined findings and concepts.

Method choice 3: Network analysis

The advantages of network analysis are 1) abstraction and 2) theory building (Borgatti, 2011). First, network analysis research usually abstracts SME connections into networks and focuses in the network structure and the changes during time. The abstraction can cover the details of the SME networks. For example, the inter-firm structures are represented in a network. From the network perspective, a network covers the ties and presents them as diagrams. Second, theory building by using network analysis has an assumption that the position of each firm in a network is an indicator of firm development outcomes. However, the position of each firm in a network is difficult to be defined and measured. For example, who are in the centre of the network, e.g. well-connected people or gatekeepers. To overcome this issue, network analysis provides a way to measure the position of each firm in a network.

Comparing to qualitative research, the results of network analysis can provide quantitative modelling of network influence. Some qualitative designs are purely

inductive (Glaser and Strauss, 1967) such as case studies. However, it is difficult to provide accurate modelling or prediction of network influence by using qualitative approaches. The reason is that case studies with interviews use the mass of qualitative data to relate more strongly to theory and the results from case studies are difficult to be generalised (Yin, 2003). In order to provide the results of network analysis, a careful strategy of sample selection is required.

Based on above discussion, this study suggests that 1) network analysis can provide analysis in network dynamics, 2) comparing to quantitative method, network analysis can provide better analysis in the details of network patterns, and 3) comparing to qualitative method, network analysis can quantify network patterns and test network influence. Network analysis can help to understand the complex dynamics of networks (Burt, 2007). It can also help to understand the cause-effect relations in SME networks (Bogartti, 2011). Thus, this study chooses them as the analysis approaches.

4.3 Network analysis and the reasons for using network analysis

Network analysis (SNA) is a method for investigating structures, dynamics and influences caused by multiple actors with complex connections (Wasserman and Faust, 1994; Snijders, et al., 2010). Networks are conceptualised as nodes and ties

connecting them. Network analysis usually provides quantitative analysis and network visualisation.

Network analysis can quantify and compare network patterns (Wasserman and Faust, 1994; Watts, 2004; Snijders, et al., 2010). For example, this study focuses on the SMEs who act as brokers in the centre of the network. Network analysis takes account of three elements in networks, actors, ties, and mechanism (Conway and Steward, 2009).

Actors: In this study, actors are the SMEs in each network. Information exchange activities (Rogers, 1995) are relationships between SMEs. Thus, a SME network represents activities between SMEs in their development (Burt, 1997 and 2007).

Ties (or links): In this study, the ties represent information exchange relationships among SMEs. Information exchange ties include both providing and receiving information. Information exchanges are concerned as directed relational ties among SMEs. The content of each information exchange is related to SMEs development. The content of information exchange includes proposing ideas, confirming information, and decision-making related information.

Mechanism: In this study, the mechanism is brokerage in SMEs network. This network mechanism is based on network theory (Lin,1999; Burt, 2007). This network

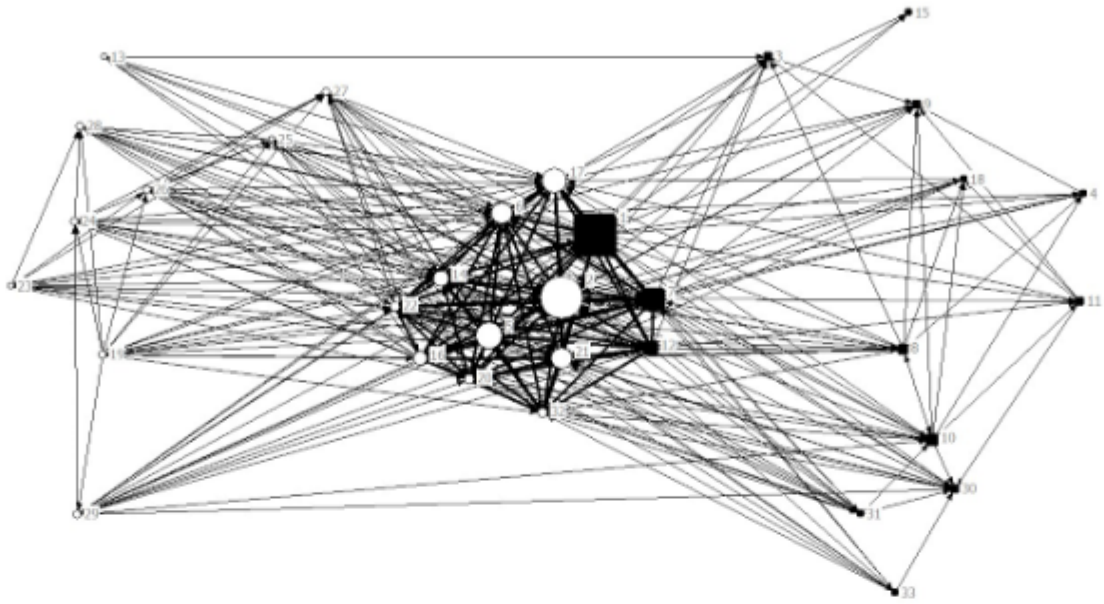
mechanism can help to find out the patterns in each SMEs network. For example, some types of brokers can be found as significantly important in SMEs networks.

Network analysis has been adopted to analyse SME activities (Burt and Minor, 1983; Law and Callon, 1992; Portes, 1998; Burt, 1992, 2004 and 2007). This study adopts network analysis to analyse how SMEs co-develop together. Especially, how information are exchanged among SMEs. Network analysis can provide the visualisation of information exchange structure among SMEs. Each network visualisation is presented as a network snapshot. A network snapshot represents the information exchange relationships among the SMEs. In this study, network analysis is used to visualise the structure of SMEs network.

Figure 4.1 provides a hypothetical example of SMEs network snapshot. In this snapshot, the nodes with different shapes represent different SMEs (for example, circles represent design SME and squares represent engineering SME in Figure 4.1). The ties among them show the information exchange relations occurred in development. These information exchange relations can include proposing ideas, confirming information, and decision making. The thickness of each tie represents the frequency of information exchange, which means how often this information exchange happens. The SMEs in the center of the network have high power controlling information exchange in the network. This is measured by betweenness centralities (the details about measuring betweenness centralities are discussed in the

later section). The size of each node represents the SME's brokerage score, which measures to what extent the SME is a broker (the details about brokerage score are discussed in the later section). Also, each type of broker can be represented in a different shade of colour.

Figure 4.1 A network example



Designer SME Engineering SME

Information exchange tie

Based on the main elements in network analysis, network analysis can provide results about network dynamics, structure and influence. Network structure and dynamics can be analysed by visualising the network across time during SMEs development. And then the regular patterns of how SMEs network evolve can be analysed. The network structure can be quantified as regular patterns in the network, such as brokerage and centrality (the details about brokerage score and centrality are discussed in the later section). For example, brokerage score can specify that to what extent a SME is an information broker or not. Centrality values can quantify SME's network location in terms of the SME's connections in the network. Eventually, network influence can be found out from these quantified network patterns. These

quantified network patterns can be tested against SMEs development outcomes using statistic modelling. Therefore, network analysis is to represent, analyse and theorise about activities and systematic characteristics in networks (Freeman, 1979). Such activities and characteristics are, for example, brokers, the network locations of them (centrality), and the network dynamics. The details about this are discussed in the independent variable section.

4.4 Network data

The data requirements for this study are based on the existing network research and with modification for this study's purpose. This study's data requirements are based on network data items from Burt's (2007) and Krackhardt (1992). Items in these two research projects are considered as templates for developing network data requirements (Borgatti, 2011). These existing data items are modified and recombined into a new SMEs network items, particularly covering network dynamics, structures and influences. The data items used by Burt (2007) and Krackhardt (1992) can effectively identify network dynamics and structures. These items are conventional and typical in network research to capture dyad relations in networks.

This study extends the data items for the purpose of assessing network influences. Table 4.1 summarises the data items in this study.

Table 4.1 Data items

Data items	Related research question
● Who the SME collaborate with the SMEs network	Research question 1
● How the SME collaborate with the others	Research question 2
● What is the collaboration related to, for example, design, engineering or management?	Research question 2
● How frequent and critical is this collaboration	Research question 2
● When did this particular collaboration happen (specify by which week)	Research question 2
● Evaluation of SMEs growth from financial reports	Research question 3

In sum, the data items consist of three major parts: (1) SME profile (2) information exchange relations in SMEs network (including who you send/receive information

to/from), and (3) SMEs work details. The data about the SMEs networks can be collected from Orbis OECD database. And the data about each SME's development outcomes can also be collected from the financial reports in the database. Each SME has two development outcome scores (one is short term and one is middle term from the financial reports). The details about the development outcome data are discussed in the dependent variable section. The next few sections are to discuss the variables in this study's network modelling.

4.5 Data collection approaches and data requirements

Krackhardt (1992) recommended the 'name list' approach. The 'name list' approach starts with getting the data about who are included in the network. In this study, the name lists are the SMEs. All these organisations are potential targets of SMEs clusters. These names of SMEs are the 'name list'. The data collection focuses on data about the firms' connections within the name list. Burt (2007) raised two potential constraints about using the 'name list' approach. The name list might result in the overstated connections between firms in the network. Thus, the network data gathered by the 'name list' approach should be confirmed from both parties' data to avoid the false or exaggerated connectedness. In this study, each connection between two firms is confirmed from both of their data items.

Firm are not in the 'name list' are difficult to be identified by the 'name list' approach.

Those firms can be the missing data and result in an incomplete network structure in the findings. To resolve this issue, this study combines Burt's (2007) "snowballing" approach with the 'name list'. The "snowballing" approach starts with a group of firms who are the potential targets of SMEs cluster. Then, every firm is not included in the 'name list' approach can be found by using the 'snowballing' approach. It has been noticed that the "snowballing" without a 'name list' might mislead to some firms who are not in the network (Hanneman and Riddle, 2005). Thus, the 'snowballing' and 'name list' approaches can be complimentary to each other. In order to collect the data about the entire network, this study combines both of 'name list' (Krackhardt, 1992) and 'snowballing' (Burt, 2007) approaches.

Burt (2007) and Krackhardt (1992)'s research are designed for research in inter-firm connections in networks. This study adopts data items from both of them. Burt (2007) focused on the structure of connections within networks. Krackhardt (2007) examined the overall structure of network as a system. The data contains the following items based on data items from Krackhardt (1992) and Burt (2007):

- SME's profile
- Information about whom the SME receives information
- Information about whom the SME sends information
- Information about the mode of interactions in information exchange
- Information about the content of information exchange

- What is the nature of the SMEs network?

4.6 Data collection details

This study collected data from Firm-Level Micro-Data in OECD ORBIS Database. According to OECD firm category (2016), the data includes small firms with employees less than 250 and turnover fewer than 50 million euros. This study collected data for 1056 SMEs. All the firms are from the information and communication technology (ICT), as this sector is one of the most innovative and interconnected. This study identified each firm based on whether the firm has product development expenditure in the dataset. Thus, the data covers all firms that financially declared product development.

The data covers joint SMEs development bank loan between 2011 and 2015 in the region of Beijing and Shanghai in China. The reason for using this dataset is that recent research (Potrafke, 2015) has suggested that they are the most active areas and time period in product development, in term of volume of products and number of firms. Data covering active areas and time period is more likely reflect the influences of networks (Burt, 2007). The data contains detailed firm-specific information including company profiles, collaboration partners, investment, sales, number of employee, and revenue. The data regarding collaboration partners provide information about the name list and connections in product development, which is then used to

generate this study's independent variables. The dataset includes 1056 firms and 1088 product development collaboration amongst them. Firms' profiles, such as number of employee and revenue, are used to generate this study's control variables to distinguish the effects of firm size from the effects of firm connections.

This study collects information about joint SMEs development loan as the firm connections. The nature of firm connections in product development is considered as inter-firm level collaborations (Gulati, 1999; Burt, 2012 and 2015; Cross et al., 2015). To reflect more relationships amongst firms, this study uses the data about joint financial commitments in product development. The nature of connections is analyzed as collaborations and joint investments in firm relationships. To combine knowledge and resources at minimum cost, firms need connections between them (Baker, et al., 2016; Lynch, O'toole, and Biemans, 2016). Firms aggregate knowledge and resources with each other in product development. In product development, connection between two firms is a purposeful social unit that shares business information and resources to achieve the collective target (Levin and Cross, 2004; Lovejoy and Sinha, 2010). Thus, the nature of these firm connections in product development is collaborations and joint investments. Joint financial commitments are formal collaborations among firms and also have no ambiguity. Since informal connections are often ambiguous and mixed with other types of connections, it is not recommend for analyzing big dataset (Burt, 2012 and 2015). Thus, this study uses joint SMEs development loan as the firm connections in product development.

4.7 Independent variables: measuring network patterns

The previous sections discussed network analysis and how to collect the data for this study's analysis purposes. This section deals with how to measure SMEs networks. In order to measure SMEs networks, this study needs to quantify the patterns in SMEs networks. As discussed in the theoretical framework, these network patterns are brokers and each SME's network location (also known as centralities). These network patterns are the independent variables in this study.

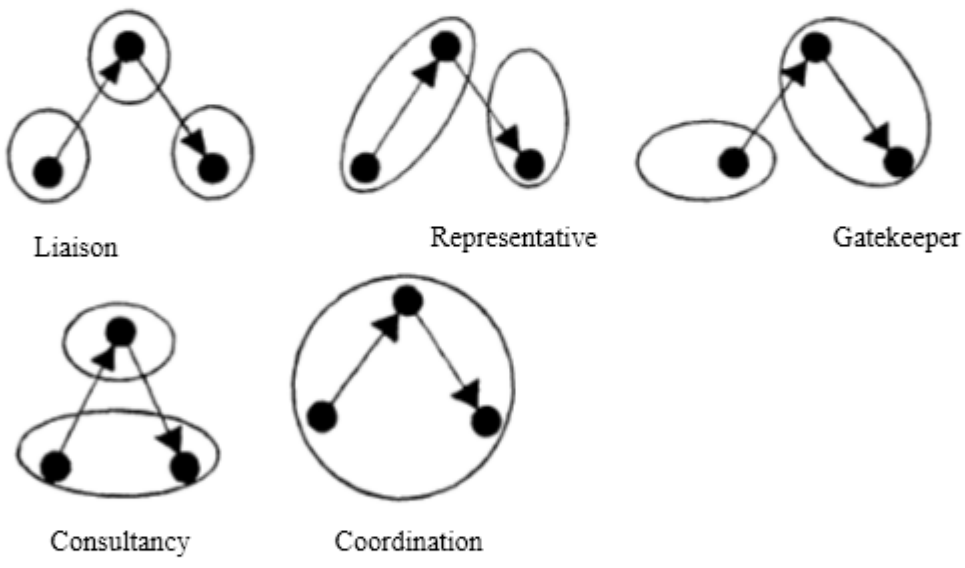
This study's first set of independent variables is about brokerage in networks. As discussed in the theoretical framework, the brokerage can reflect the broker roles in a given network. Thus, this study uses brokerage as independent variables. A brokerage is a firm who connects other firms in a network (Burt, 2010 and 2015). Brokerage as a variable reflects how many times a firm connects the other firms in a network (Burt, 2015). Brokerage in the network is identified as five structurally distinct forms (Gould and Fernandez, 1989). These five forms of brokerage (e.g. five types of brokers) are liaison (as independent variable 1), representative (as independent variable 2), gatekeeper (as independent variable 3), consultant (as independent variable 4) and coordination (as independent variable 5). The SMEs in networks are divided into different groups based on what there are specialised in, for example design, engineering, and management. Thus, these brokerage variables represent the broker

roles either among (independent variable 1, 2, 3, and 4) or within (independent variable 5) these three groups.

The first variable is the "liaison" broker, a third firm links two groups (see Figure 4.2). A liaison broker provides a connection between two distinct groups but does not belong to either group. For instance, design firms and engineering firms are two separate professional groups, and a technology advisor can act as a liaison broker to provide a link between them in the network. The second variable of broker is "representative", a firm represents a group to connect with outsiders. Representative brokers act as delegates to provide connections between its group and other groups. For example, an engineering firm gathers information from design firms and distributes them to engineering firms. The next variable is the "gatekeeper" broker, a firm offers access to its own group (see Figure 4.2). A gatekeeper broker provides connections between his or her own group and outsiders. Comparing to representative brokers, gatekeeper brokers grant access to information and representative brokers gain access to information. The fourth variable is the "consultancy" broker, an outsider firm provides within-group brokerage (see Figure 4.2). A consultancy broker usually acts as expertise and provides links between members within a group. For example, designers usually require technology advisors to transmit information among them and provide technology supports to the design work. The last broker variable is the "coordinator" broker. A coordinator provides connections within his or her own group (see Figure 4.2). Those connections are completely internal brokerages.

For instance, a management consultancy firm provides connections between the members of the management group to coordinate frims managing on different tasks. In network theory (Burt, 2007), connections between firms can be treated as networks. Networks can be analysed by using brokerage scores to measure each firm's broker activities.

Figure 4.2 Five types of brokerage in sparse structures



This study's second set of independent variables is about SMEs' network locations, also known as centralities. Centralities provide measures about each SME's ego

network structure. These can reflect the importance and prominence of each SME in a given network. Thus, this study uses centralities as independent variables. There are four centrality measures, degree, betweenness, closeness, and eigenvector centrality (Freeman, 1979; Borgatti, 2011). Each of them provides distinct measure about how a SME centrally located in a given network. A SME can be centrally located in a network and have different influences in four ways as below.

Independent variable 6: Degree centrality (Well connected)

Degree centrality measures how many connection an actor has in a given network (Freeman, 1979; Borgatti, 2011). This measure can reflect the SME's direct influence to the other SMEs in a network. Degree centrality is expressed by the number of SMEs directly connected to a given SME. However, the well-connected SMEs may not play the important roles in a network (Borgatti, 2011). Thus, the other three centrality measures are introduced to provide more systematic measures about network structure.

Independent variable 7: Betweenness centrality (Information control)

Betweenness centrality measures how many times that an actor connects two others as the shortest path in a given network (Freeman, 1979; Borgatti, 2011). This measure can reflect the SME's information control power in a network. A SME's betweenness

centrality is expressed by the number of shortest paths in the network passing through that SME. Thus, this study uses betweenness centrality to reflect SMEs' network location advantages in information exchange.

Independent variable 8: Closeness centrality (Proximity to all firms in the network)

Closeness centrality measures an actor's network distance from all others (Freeman, 1979; Borgatti, 2011). This measure can reflect a SME's information passing through how many firms to arrive the others. It is regarded as an indicator of the expected time-until-arrival for a SME to spread information to all others in a network. Closeness centrality measures the optimal paths a SME has. Thus, this study uses closeness centrality to reflect the proximity of SMEs in a given network.

Independent variable 9: Eigenvector centrality (Connected to well connected)

Eigenvector centrality measures an actor's connections to the well-connected actors in a given network. This measure can reflect a SME's indirect influences in the network. Such indirect influences are through the connections with well-connected firms in the network. In contrast to degree centrality measuring direct connections, eigenvector centrality measures the indirect connections. This can help to distinguish SME's network advantages when they have the same number of direct connections in a

network. Thus, this study uses eigenvector centrality as an independent variable.

4.8 Dependent variable: measuring SMEs development outcomes

In the theoretical framework, this study defined the dependent variable as SMEs development outcomes following the previous research (Burt, 2007 and 2015). The proposed research questions require analysis about the relationships between SMEs network patterns and development outcomes. In order to test the relationships, this study needs to measure both network patterns and development outcomes at the firm level. Thus, this study uses each SME's development outcome as the dependent variable.

This study measures each SME's development outcomes from both short (3 years) and middle (5 years) term financial reports. Previous research (Rodan and Galanic, 2004; Liao and Welsch, 2005; Cross, et al., 2015) applied this approach to avoid the bias in evaluating SMEs development. The middle term outcomes about development outcomes tend to focus on firm's progress, especially the progress of growth. The short term financial aspects of development outcomes tend to focus on the effectiveness of the results. To avoid this bias, this study includes both short and

middle financial reports. In other words, this study adopts both short and middle reports about SMEs development outcomes.

Also, to make sure the consistency of SME connection influences, the same regression modeling procedure are run on these two different dependent variables. This is to make sure the robustness. The regression modeling results of these two dependent variables are presented separately in the findings. The model as an equation is:

A given SME's revenue growth = The influence of Firm's age + The influence of Number of employees + The influence of Revenue + The influence of Budget + if that SME is in IT design industry or that SME is in IT engineering industry + The influence of Sparse connections + The influence of Interlocked connections + The Interaction effects

4.9 Control variables

Control variables are the other potential influences on the dependent variables. Those influences should be taken into account alongside with the independent variables.

This study uses the control variables to rule out those alternative influences on SMEs development outcomes. As discussed below, the control variables used in this study are drawn from the literature. The control variables are 1) age of the firm, 2) number of employees, 3) revenue, and 4) budget.

1 Age of the firm

Age of the firm measures how long a firm has been working in an area. For instance, how long a design firm has been working in a design related works, or how many years an engineering firm has been working in engineering?) The long-term served professionals tend to have more experiences, and consequently, they tend to have better results in SMEs development (McEvily and Zaheer, 1999; Reagans and Zuckerman, 2001; Rodan and Galunic, 2004; Gilsing and Nooteboom, 2005). Since firm's age can have effects on development results, yet it is not network impact, therefore this study uses firm's age as a control variable.

2 Number of employees

Number of employees is measured by how many people are working in the firm. The development results can be affected by SME's labor inputs (Sydow and Windeler, 1998; Tsai, 2000; Thorpe et al., 2005). Also, number of employees can represent the size of business. Thus, this study includes number of employees as a control variable.

3 Revenue

Number of employees measures the business size of labour. Revenue measures the business size of finance. Previous research suggests that revenue is positively associated with SMEs development outcome (Reagans and Zuckerman, 2001; Wellman, et al., 2001; Green and Brock, 2005; Lissoni, 2010). Since revenue can have impacts on SMEs development results, however, it is not network effect, thus, this study includes revenue as a control variable.

4 Accessible budgets

Accessible budgets measure the available amount of money can be used by each SME. Accessible budgets include the SME development task related cost, for example, purchasing software and hardware, employing advisors, travel expenses and so on.

Financial inputs can be positively associated with SMEs development results (Hacket and Dilts, 2004; Rodan and Galunic 2004). Well-planned budgets can support SMEs to complete their tasks more efficiently. Lacking financial supports can hinder the development of SMEs (Watson and Papamarcos, 2002; Rodan and Galunic, 2004; Westlund and Nilsson, 2005). Since accessible budgets can have impacts on SMEs development results, yet it is not network impact, therefore this study includes accessible budgets as a control variable. To quantify accessible budgets as a variable, this study uses the amount of SME development loan each firm received in the SME joint development loan program.

This study includes four control variables: 1) firm age, 2) number of employees, 3) revenue, and 4) accessible budgets. These four variables are chosen from those have been used in the related previous research. In general, these four variables are the elements which can have impacts on SMEs development results, yet they are not network impacts. These control variables are set up to distinguish network and non-network impacts SMEs development results.

4.10 Data analysis

The previous sections discussed the variables in this study. These variables are network patterns as independent variables, SMEs development outcomes as dependent variables, and non-network factors influencing SMEs development as control variables. This section discusses how to test the relationships between SMEs networks and SMEs development results. This discussion covers the regression technique and network visualisation used in this study. In other words, which regression modelling technique fits the research purpose and the data? Also, how networks can be presented as snapshots?

Network data can be visualised as snapshots by using software Ucinet and Netdraw. Network snapshots can present the overall structure of SMEs network. These network snapshots consist of two elements: (1) firms as the actors (or nodes) and (2) interactions between firms as the ties (or links). Complex networks usually have regular patterns in structures and dynamics, these patterns can be observed from the network snapshots. In a network snapshot, Network has general patterns in its evolvement which can be observed and analysed at the inter-firm level. Network snapshots provide the depictions of network patterns. It is important to analyse networks from snapshots, for example, by stages and structures. Stage models conceptualise the process as a sequence of events (Fombrun, 1982). Network structure changes in each stage represent the shift of communications and interactions among

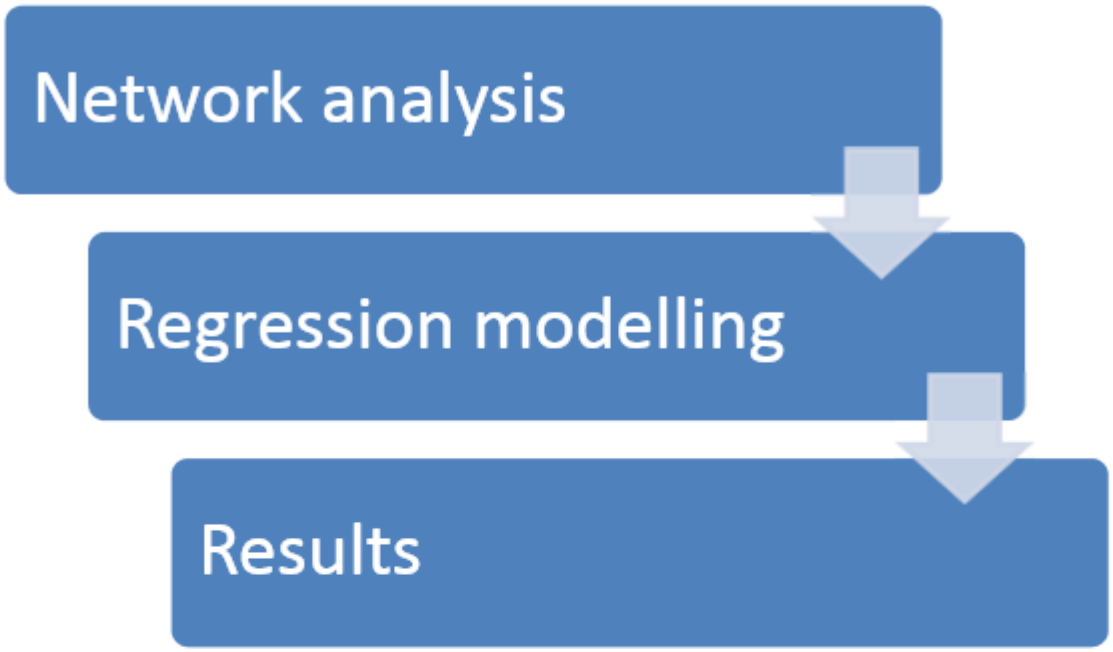
SMEs in the network (Galison, 1997; Ibarra, et al., 2005). The tendency of those changes in network data represents the complexity of the network. A series of network snapshots can provide the sequence of network development. Those network snapshots can contain information about network patterns and help to understand the overall structure of the network (Nohria and Eccles, 1992; Marsden, 2002).

Randomised permutation regression can be used to test the relationships between SMEs network and development results. Comparing to one of the most common regression choice ordinary least squares regression (OLS), network data can be analysed more accurately by using randomised permutation regression (Hanneman, and Riddle, 2005). Randomised permutation regression can produce a better estimation of the model coefficients, especially for analysing networks which usually have some outliers in the data (Hanneman, R.A., & Riddle, 2005). Network data with outliers can overly influence the regression modeling results in OLS regression due to the normality assumption (OLS regression assumes the data is normally distributed). Comparing to OLS regression, randomised permutation regression fits better to network data distribution by testing the data against random distributions. This will provide more accurate analysis results and robust model.

Therefore, this study adopts randomised permutation regression to test the correlations between firms' connection structures and the SMEs development. Network data about organisational connections can have some outliers in distribution.

Randomized permutation regression can provide better results of the model coefficients to resolve the issue of overly influencing outliers in network data (Wasserman and Faust; 1994; Hanneman and Riddle, 2005). Thus, this choice of analysis provides a more robust model. Non-network factors influencing product development are used as the control variables. Specifically, this study controls the number of employees and the revenue to rule out the effects of firm size on product development. The independent variables are network structures including each firm's sparse connections and interlocked connections. SMEs development results are the dependent variables. This study uses revenue growth form new product developments as the measure of each firm's SMEs development results.

Figure 4.3 Data analysis



	Research Question 1	**Research Question 2**	**Research Question 3**
Data analysis	Network snapshots	G&F analysis	Network regression modelling
Expected test	SMEs loosely or densely connected in their clusters	Five roles of SMEs and centralities	Network influences

Chapter 5 Finding 1: The influences of sparse and interlocked connections

5.1 Introduction

Interest in understanding how inter-organisation connections influencing has recently increased (Borgatti and Halgin, 2011). However, these efforts have almost exclusively focused on the variety of inter-organisation connection structures that influence innovation results, over-looking one of the interaction effects between them.In this study aims to answer the question how SMEs development can be affected by a combination of different structures of inter-organisation connections.

Inter-organisation connection in SMEs development is usually an ambiguous concept across academia and business practice. Oh et al. (2016) argued the concept is a "flawed analogy" and lack of rigor. In collaborative SMEs development, the complex inter-dependency and connections among organisations need to be clarified and examined (Ritala and Almpanopoulou, 2017). Previous research (Fernandez-Olmos and Ramirez-Aleson, 2017) suggested three factors of SME can affect the success of SMEs development. They are the macro-economic condition (macro-level), the life cycle of business (industry-level), and the age of SME (firm-level). In addition, how entrepreneurs perceive business information and resource (individual-level) can also affect the success of SMEs development (Solomon and Linton, 2016; van Weele et al.,

2017). However, theories in this area can still be improved by considering the effects of inter-organisational connections among SMEs from a micro-level perspective (Van Lancker, et al., 2016). Complex SMEs development processes cause SMEs to form networks in SMEs development to obtain access to external information and resources (van de Vrande, et al., 2009; Zeng, et al., 2010). The growing use of networks in SMEs development is considered as a competitive advantage providing flexibility and rapid response (Narula, 2004; Vos, 2005). Thus, it is necessary clarify and examine the effects of inter-organisational connections in SMEs development.

SMEs development usually consists of collaborative work to combine formerly separated knowledge into new knowledge and ideas (Aalberset al., 2016; Leenders and Dolfsma, 2016). SMEs development emphasizes gaining access to resources and knowledge through connections with external parties (Weiblenand Chesbrough, 2015). Especially, inter-organisation connections are critical to SMEs development in getting external resources and knowledge (Cooke and Wills, 1999; Batjargal, 2003 and 2007; Liao and Welch, 2005).Thus, this study draws on the literature on network theory to examine the relations between the various structures of inter-organisation connections and SMEs development results in SMEs.

The agents of combining separated knowledge are firms, and as such network analysis has emerged as a robust method to link these micro-behaviors of firms and the macro-results of them (Cross, et al., 2015). The work of Uzzi (1996) and Burt (1992 and

2015) suggest that efficient network structures of firms are either interlocked featuring dense clusters of firms or sparse featuring loosely connected firms with a few connections. 'Connections' represent collaborations and investments in firm relationships, so to combine knowledge and resources at minimum cost, firms should avoid similar or redundant connections between them. The advantages of sparse networks are usually taken by centrally located firms who aggregate knowledge and resources from others (Baker, et al., 2016; Lynch, O'toole, and Biemans, 2016). On the other hand, interlocked networks have short connection (or path) lengths which are conducive to the quick spread of knowledge and resources. Thus, firms in high density networks are likely to be effective in SMEs development (Schleimer and Faems, 2016). Those firms in interlocked networks may not have the same intellectual reach as firms in sparse networks, but have higher levels of efficiency. Thus, in this study's model, this study assumes both sparse and interlocked network structures are related to a firm's SMEs development results.

A gap in the current theories is whether firms can take advantages from the combination of both sparse and interlocked network structures in SMEs development. SMEs are usually connected together in complex structures to achieve SMEs development. It is important to find out if the combined sparse and interlocked structures of SMEs connections are valuable to SMEs development. Thus, the results of this study can advance network theory from seeking for the effect of each network structure to the interaction effects of combined various network structures.

5.2 The purposes of analysis

A connection between organisations is a purposeful social unit that shares business information and resources to achieve the collective target (Levin and Cross, 2004; Lovejoy and Sinha, 2010). SMEs networks can reflect the synthesis process of SMEs development. SMEs interact through SMEs networks, exchanging business resources and information and retaining resources and ideas that are innovative or SMEs development related. In this synthesis process among SMEs, the choice is usually not random (Carroll and Teo, 1996; Candi et al., 2013).For a synthesis to be innovative, business resources and information being combined are often sufficiently 'distant' from each other that their combinations are not 'obvious'. Before a good idea is known, this collective ideation among SMEs search or consider what choice is worth and productive (Edelman, et al., 2004; Fleming and Waguespack, 2007). Thus, SMEs networks can be abstracted away from the business communication aspects of SMEs to focus on the structures. A successful SMEs development is usually initially unknown or unfamiliar to the most of SMEs in their networks. It is assembled by combining a series of information and resources from connected SMEs.

Building up connections between SMEs is usually time consuming and therefore have

an opportunity cost. This is because SMEs only have finite or limited capacity for collaborations with each other. Collaborations take time and labour cost and SMEs usually have a small number of staff with limited working hours in a day. Therefore, SMEs can only have a finite number of connections with others. SMEs connections are not easily replaced or alternated by new connections. The connections among SMEs enable information and business resources exchange meanwhile constrain their abilities to find alternatives. Once SMEs are connected, their connections constrain their ability to building new connections. In the short term, a SME sticks to its ego network structure and position, once its connections are built up. Thus, this study seeks efficient SMEs network structures, those that can lead to SMEs development success.

Although prior empirical evidence demonstrated that bridging connections between SMEs correlate positively with their SMEs development results, less attention has been devoted to combining various structures of those connections and the effects of combined connection structures. The literature on organisational connections in SMEs development has recognized the sparse ties are positively associated with getting access to external knowledge and resources in SMEs development. Also, interlocked connections provide SMEs a number of equivalent communication channels which can monitor and confirm the directions of SMEs development. SMEs development is considered as behavioral consequences of SMEs with both sparse and interlocked connections. Both sparse and interlocked connections are important drivers of

innovative results for organisations (Inkpen and Tsang, 2005; Galaskiewicz, 2007).

Sparse connections are inter-organisational ties between an ego organisation and otherwise disconnected alter organisations. There are no connections among those alter organisations. They are connected centrally to an ego organisation. The number of a SME's sparse connections is positively associated with the diversity of accessible external resources and knowledge in SMEs development. Sparse connections are beneficial to firms' innovative capabilities. Sparse connections reaching outside an organisation are significantly related to individual (Gilsing and Nooteboom, 2005; Ibarra et al., 2005; Cross et al., 2015) and organisational-level of innovative results (Walker et al., 1997; Tsai and Ghoshal, 1998; Tsai, 2000; Gargiulo and Sosa, 2016).For instance, McEvily and Zaheer (1999) found that resource and advice seeking in SMEs development can be effective through sparse connections across organisational boundaries. SMEs with sparse connection can effectively gather the required business resources and information in SMEs development.

The connections among organisations can facilitate the integration of diverse resources and knowledge in SMEs development. Particularly in the case of SMEs development, accessing diverse resources and knowledge in other SMEs through collaboration, albeit necessary, are not enough to enhance SMEs development results significantly (Thorpe, et al., 2005). SMEs also need interlocked connections and to be embedded in a cluster. Those interlocked connections help SMEs to confirm and

corroborate the view that SMEs development is developing in a promising area and the technological expertise attained is generating SMEs development. For instance, SMEs share and recombine of diverse resources and knowledge into innovative outcomes, a new product or service. At the same time, they work against the difficulties associated with the uncertainties in their market, substitutes and technological evolutions. In fact, SMEs development can easily be replaced or wiped out in the market by other similar growth or newly emerged technologies, even before it is formally launched (Gabbay and Zuckerman; 1998; Edelman, et al., 2004; Fleming and Waguespack, 2007). Building on these insights, this study argues that connections among SMEs are combined structures consisting of not only sparsely bridging ties but also interlocked. Based on above discussion, this study proposes three hypotheses and model (see Figure 5.3).

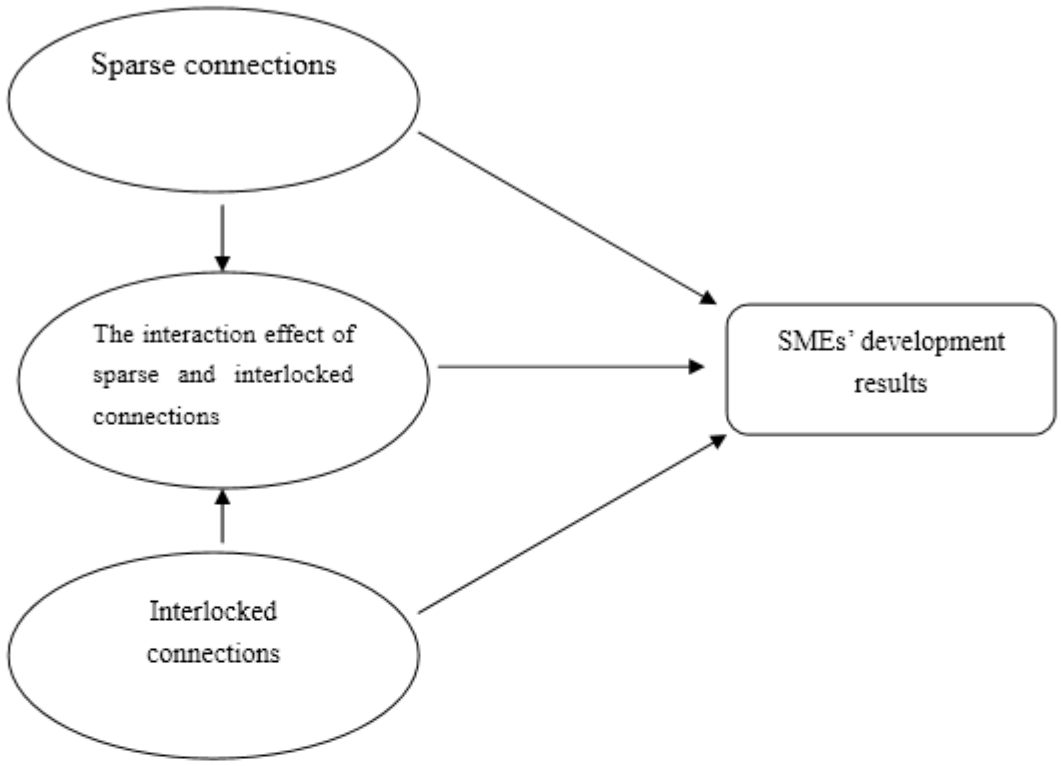
Hypothesis 1.1*: Sparse connections are positively associated with SMEs' development results.*

Hypothesis 1.2: *Interlocked connections are positively associated with SMEs' SMEs development results.*

Based on the above discussion, this study proposes this study's third hypothesis

Hypothesis 1.3: *Sparse and interlocked connections jointly and positively influence SMEs development results.*

Figure 5.3: The testing model



5.3. Analysis procedure

This study used a new method on a unique set of data. The data was collected for the purpose of calculating firm's sparse and interlocked connections. Previous, sparse and interlocked connections are tested separately. This study used a new method to test both of them together and also includes the interaction effects between them. In summary, this study used a new method on a unique set of data collected for this study.

The connections between small and large firms are concerned as effective for the rapid spread of knowledge and resources (Burt, 2007). Small firms are considered as 'satellites' surrounding large firms. Large firms usually have high density of connections which are likely to be effective in product development (Schleimer and Faems, 2016). Small firms interact with large firms through these connections, exchanging business resources and information and retaining resources and ideas that are product development related. In this study's results, the connections do not tend to connect with either small or large firms. They are almost evenly distributed in the results. The extent of connection is analyzed as the total network level. This study included all the firms in the dataset to generate a total network rather than partial. All the firms with product development activities in the region are included. These include firms with all different level of sizes and all contracted product development partners. Since the dataset only include company information, the analysis results do not cover connections between firms and non-profitable organisations, such as universities and governments.

This study performed network visualization by using Netdraw function in software Ucinet. Firms are analyzed as nodes in the network snapshots (see Figure 4 and 5), joint SMEs development loan are lines between firms representing their collaborations in product development, and each firm's overall revenue growth in 3 years after joint SMEs development loan approved are distinguished by the size of the node. Then, each firm's connections are quantified as the number of each firm's

sparse connections and the number of each firm's interlocked connections by using the Netdraw function. The numbers of each firm's sparse and interlocked connections are calculated using the Ego Network Structure Count function in UCinet. They are this study's proposed independent variables. Later on, they are tested against firm's revenue growth in regression modelling to show the effect of firm connections. The snapshots provide information about the overall structure of firm cluster as a whole and each firm's network structure of sparse and interlocked connections.

5.4. Results & Discussion

Before present the results, F-test is used to support the point that networks cause SMEs growth rather than SMEs growth results in networks. The F value is 38.78. According to the rule of thumb (Hanneman and Riddle, 2005), F which is greater than 10 suggests the causality is not reversible. This supports that networks cause SMEs growth rather than SMEs growth results in networks. Also, F value is a ratio of explained variance out of unexplained variance in the data (Hanneman and Riddle, 2005). Thus, this result also suggests the model is robust.

Figure 5.4 and 5.5 show the SME connections in information and communication technology (ICT) sector in Beijing and Shanghai. The nodes are SMEs. The lines

between them are joint SMEs development loan from Bank of Communication, which represents SMEs development collaborations and partnerships in this study. The size of each node represents each SME's overall revenue growth 3 years after joint SMEs development loan approved. This is used to measure SMEs development results in this study. Table 1 shows the descriptive statistics.

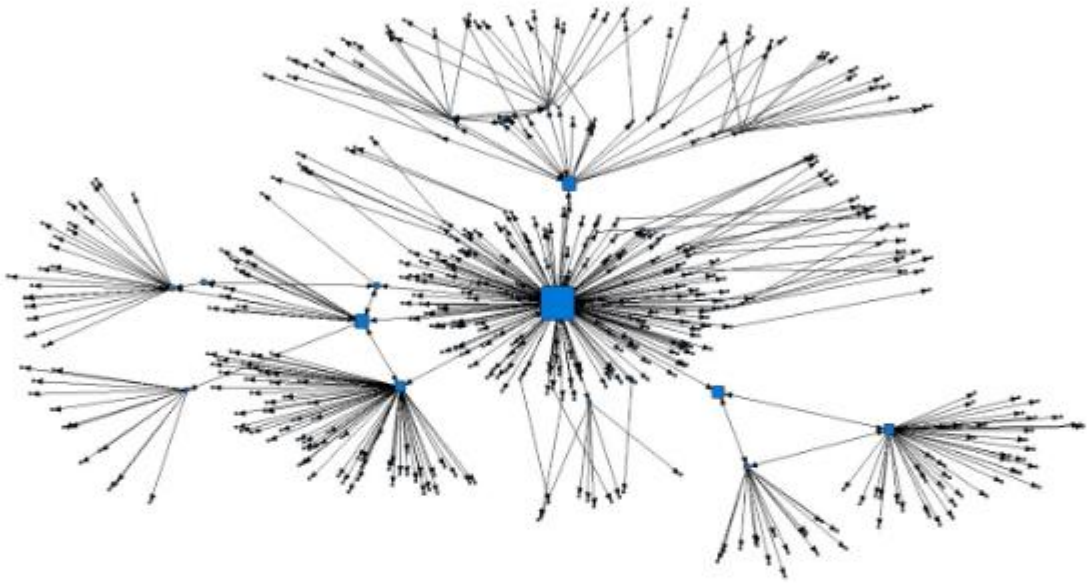
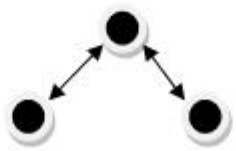
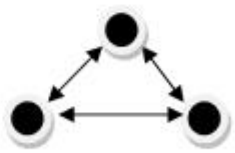


Figure 5.4: SMEs network in information and communication technology (ICT) sector in Beijing (Sample size: 511 firms, nodes are firms, lines are joint SMEs development loan from Bank of Communication, the size of the node represents each firm's overall revenue growth in 3 years after joint SMEs development loan approved)

Number of firms	Number of ties	Number of sparse connections 	Number of interlocked connections 
511 (369 SMEs and 142 large firms)	527	1172	123

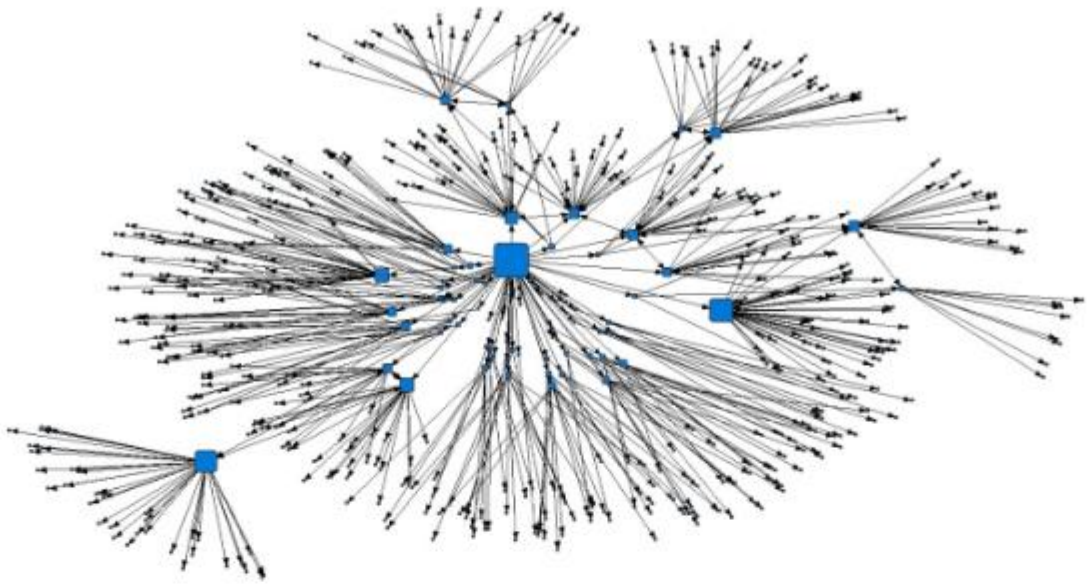


Figure 5.5: SMEs development network in information and communication technology (ICT) sector in Shanghai (Sample size: 545 firms, nodes are firms, lines are joint SMEs development loan from Bank of Communication, the size of the node represents each firm's overall revenue growth in 3 years after joint SMEs development loan approved)

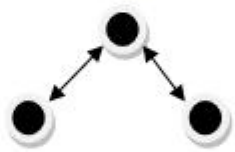
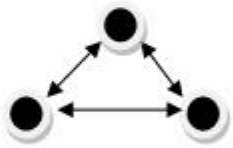
Number of firms	Number of ties	Number of sparse connections 	Number of interlocked connections 
545 (355 SMEs and 190 large firms)	561	1612	107

Table 5.1: Descriptive statistics

Variable	Mean	S.D.	1	2	3	4	5	6	7	8
1 3 years revenue growth	2.71	6.16								
2 5 years revenue growth	3.97	7.72	0.77**							
3 Company age	9.36	8.68	−0.27**	−0.32**						
4 Budget (SMEs development loan received in million GBP)	3.62	3.12	−0.21†	−0.04	0.03					
5 IT design SME	0.12	0.29	−0.09	0.03	0.01	−0.07				
6 IT engineering SME	0.32	0.47	−0.30**	−0.29**	0.17*	0.41**	0.23*			
7 Number of employee	24.80	14.90	0.37**	0.32**	0.05	0.16†	−0.07	0.11		
8 Sparse connections	2.64	17.01	0.38**	0.47**	0.29**	0.04	0.03	−0.04	0.03	
9 Revenue (million GBP)	17.23	6.56	0.21*	0.17	0.01	0.03	0.10	0.09	−0.29**	−0.09
10 Interlocked connections	0.22	1.40	0.24*	0.27**	0.12	−0.06	−0.10	−0.01	−0.09	0.08
11 Sparse connections x Interlocked connections	0.21	1.12	0.10	0.14	0.01	−0.14	−0.06	−0.12	0.04	0.06

†p < 0.1; *p < 0.05; **p

As discussed earlier, sparse and interlocked connections can influence SMEs development results. Table 5.2 shows the results of regression modelling. This study uses two separated sets of data to measure the SMEs development results. They are 3 years revenue growth and 5 years revenue growth. The dependent variable in model 2, 3 and 4 is each SME's overall revenue growth in 3 years after joint SMEs development loan approved. The dependent variable in model 5, 6 and 7 is each SME's overall revenue growth in 5 years after joint SMEs development loan approved to test the longer term effect of inter-firm connections. In Model 1, this study uses only the control variables to show the difference without the proposed independent variables.

Table 5.2:Multivariate regression models with all firms

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	3 years revenue growth				5 years revenue growth		
Constant	−0.507 (0.721)	−0.423 (0.812)	−0.202 (0.890)	−0.176 (0.891)	0.1231 (1.007)	0.0117 (0.928)	0.0221 (0.912)
Company age	−0.022** (0.014)	−0.0211** (0.012)	−0.0231* (0.011)	−0.0276* (0.016)	−0.0221* (0.012)	−0.0217** (0.019)	−0.0233** (0.017)
Number of employee	−0.0052 (0.024)	−0.007† (0.022)	0.0023* (0.029)	0.0027* (0.007)	0.0362 (0.024)	0.0407* (0.023)	0.0421* (0.021)
Revenue	0.0521 (0.104)	0.1201* (0.117)	0.1262 (0.126)	0.1337 (0.132)	0.1711* (0.122)	0.2873* (0.231)	0.2986* (0.21)
Budget (SMEs development loan received)	0.077 (0.11)	0.0063 (0.114)	0.0327 (0.147)	0.0331 (0.152)	0.1122 (0.177)	0.0671 (0.151)	0.0517 (0.143)
IT design firm	0.2172 (0.293)	0.0526 (0.322)	0.0817 (0.361)	0.0822 (0.367)	−0.5273 (0.371)	−0.427 (0.322)	−0.402 (0.306)
IT engineering firm	0.2721 (0.572)	0.2132 (0.636)	1.007† (0.592)	1.006† (0.581)	−0.7003 (0.682)	−0.2272 (0.608)	−0.2009 (0.601)
Sparse connections		0.2717* (0.17)	0.3239** (0.142)	0.3367** (0.136)	0.2709* (0.187)	0.3221** (0.171)	0.3373** (0.167)
Interlocked connections			0.2802** (0.135)	0.2861** (0.136)		0.4716** (0.146)	0.4691** (0.152)
Sparse connections x Interlocked connections				0.1721** (0.072)		0.1602** (0.062)	
R^2	0.4421	0.5617	0.6771	0.6993	0.5762	0.7116	0.7217

N =1056 firms and 1088 ties; †$p \leq 0.1$;* $p < 0.05$;** $p < 0.01$; Robust standard errors in parentheses.

Table 5.3:Multivariate regression models with large firms only

	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
	3 years revenue growth				5 years revenue growth		
Constant	−0.306 (0.517)	−0.306 (0.517)	−0.306 (0.517)	−0.306 (0.517)	0.2533 (0.985)	0.2533 (0.985)	0.2533 (0.985)
Company age	−0.012** (0.007)	−0.0012** (0.007)	−0.012** (0.007)	−0.012** (0.007)	−0.015** (0.009)	−0.015** (0.009)	−0.015** (0.009)
Number of employee	−0.0033 (0.012)	−0.007† (0.012)	−0.0033 (0.012)	−0.0033 (0.012)	−0.0037 (0.015)	−0.0037 (0.015)	−0.0037 (0.015)
Revenue	0.0367 (0.085)	0.0367 (0.085)	0.0367 (0.085)	0.0367 (0.085)	0.1856* (0.125)	0.1856* (0.125)	0.1856* (0.125)
Budget (SMEs developmen t loan received)	0.067 (0.09)	0.067 (0.09)	0.067 (0.09)	0.067 (0.09)	0.1218 (0.168)	0.1218 (0.168)	0.1218 (0.168)
IT design firm	0.1977 (0.269)	0.1977 (0.269)	0.1977 (0.269)	0.1977 (0.269)	0.1798 (0.353)	0. 1798 (0.353)	0. 1798 (0.353)
IT engineering firm	0.2518 (0.563)	0.2518 (0.563)	0.2518 (0.563)	0.2518 (0.563)	0.2385 (0.673)	0.2385 (0.673)	0.2385 (0.673)
Sparse connections		0.0000 ** (0.000)	0.000** (0.000)	0.0000** (0.000)	0.0000** (0.000)	0.0000** (0.000)	0.0000** (0.000)
Interlocked connections			0.0000** (0.00)	0.0000** (0.000)		0.0000** (0.000)	0.0000** (0.000)
Sparse connections x Interlocked connections				0.0000** (0.000)		0.0000** (0.000)	
R^2	0.4001	0.4001	0.4001	0.4001	0.5218	0.5218	0.5218

N =332 firms and 0 ties; †$p \leq 0.1$;* $p < 0.05$;** $p < 0.01$; Robust standard errors in parentheses.

Table 5.4:Multivariate regression models with SMEs only

	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20	Model 21
	3 years revenue growth				5 years revenue growth		
Constant	−0.579	−0.499	−0.298	−0.226	0.1581	0.0577	0.0785
	(0.857)	(0.898)	(0.925)	(0.937)	(1.235)	(1.002)	(0.997)
Company age	−0.035**	−0.0297**	−0.0331**	−0.0358**	−0.0299**	−0.0297**	−0.0307**
	(0.019)	(0.017)	(0.015)	(0.021)	(0.019)	(0.025)	(0.023)
Number of employee	−0.0049	−0.003†	0.0017	0.0023	0.0407	0.0402	0.0477
	(0.022)	(0.019)	(0.025)	(0.012)	(0.026)	(0.025)	(0.033)
Revenue	0.0491	0.1007	0.1035	0.1123	0.1557	0.2569	0.2659
	(0.097)	(0.105)	(0.109)	(0.117)	(0.125)	(0.229)	(0.238)
Budget (SMEs development loan received)	0.089	0.0082	0.0395	0.0407	0.1257	0.0698	0.0596
	(0.09)	(0.102)	(0.107)	(0.122)	(0.197)	(0.168)	(0.137)
IT design SME	0.2387	0.0775	0.0907	0.0929	−0.6189	−0.5091	−0.4978
	(0.305)	(0.339)	(0.387)	(0.392)	(0.395)	(0.351)	(0.316)
IT engineering SME	0.2996	0.2378	1.175	1.196	−0.9589	−0.2657	−0.2279
	(0.607)	(0.689)	(0.615)	(0.603)	(0.719)	(0.698)	(0.682)
Sparse connections		0.3395**	0.3523**	0.3788**	0.3078**	0.3556**	0.3869**
		(0.217)	(0.229)	(0.256)	(0.209)	(0.235)	(0.251)
Interlocked connections			0.3077**	0.3386**		0.4925**	0.5016**
			(0.207)	(0.218)		(0.215)	(0.229)
Sparse connections x Interlocked connections				0.1998**			0.1968**
				(0.097)			(0.092)
R^2	0.4007	0.5973	0.6985	0.7118	0.5869	0.6899	0.7298

N =724 firms and 1088 ties; †$p \leq 0.1$;* $p < 0.05$;** $p < 0.01$; Robust standard errors in parentheses.

Table 5.3 shows the regression results with the 332 large firms only. This study's models show no significant correlations between large firm connections and 3 years revenue growth. Similarly, the correlation between large firm connections and 5 years revenue are not significant either. On the other hand, Table 5.4 shows the regression results with the 724 SMEs only. This study's models show significant correlations between SME connections and 3 years revenue growth. Similarly, the correlation

between SME connections and 5 years revenue are significant too. Thus, the results suggest that the size of firm does not decide the result of product development.

This study's result suggests sparse and interlocked connections have significant influence on SMEs development results. Sparse connections calculated by each SMEs structural hole count are added in Model 2. This study's results show that Sparse connections are positively associated with SMEs development results ($\beta = 0.2717$, $p = 0.042$). This finding is consistent with previous research (Burt, 2015; Cross et al, 2015; Gargiulo and Sosa, 2016). Model 3 adds interlocked connections calculated by each SME's triad connection count. This study's Model 3 shows that the correlation between interlocked connections and 3 years revenue growth is positive and significant, meanwhile sparse connections are also positively associated with the revenue growth (βsparse-connections = 0.3267, $p = 0.007$ and βinterlocked-connections = 0.2861, $p = 0.004$). This finding adds a new point to the existing theories (Burt, 2015; Cross et al, 2015; Gargiulo and Sosa, 2016). This new point is that sparse and interlocked connections together can influence SMEs development outcomes.

This study's Models 5 and 6 show similar results about the correlations between these two structures of SMEs connections and SME's 5 years revenue growth. Model 4 suggests sparse connections can contribute to SMEs development results ($\beta = 0.2709$, $p = 0.041$). This study's Model 5 includes interlocked connections, the influence on 5

years revenue grow this increased (βsparse-connections = 0.3221, p = 0.006 andβinterlocked-connections = 0.4716, p = 0.005). Model 4 and 7 show the interaction effects are also significant.

The R^2 increase indicates this study's hypotheses are supported and the model is robust. In this study's results, the R^2 increase shows the influence of SMEs connections on SMEs development results (see Table 2). For example, comparing to Model 1, R^2in Model 2 is increased by adding sparse connections. Adding interlocked connections in Model 3, the results show increased R^2 comparing to Model 2. Model 4 adds the interaction effects of sparse and interlocked relations, the R^2increased further. Similar results are shown in Model 5, 6 and 7 testing against 5 years revenue growth.

Table 5.5: Results of regression analysis

	3 years revenue growth	5 years revenue growth
Sparse connections	0.3367**	0.3373**
Interlocked connections	0.2861**	0.4691**
Interaction effects	0.1721**	0.1602**
Constant	−0.176	0.0221
R^2	0.6993	0.7217
R^2Increase	0.2572	0.2796

†$p \leq 0.1$;* $p < 0.05$;** $p < 0.01$.

The results support this study's three hypotheses (see Table 5.5). Whilst Model 1 shows SME's characteristics matters for SMEs development, the results show sparse and interlocked connections have more significant influences. Moreover, the influence of sparse connections is even more significant when interlocked connections are added in the model. This suggests that sparse connections alone are less beneficial without interlocked connections. Finally, this study's Model 4 and 7 show there is significant interaction effect between sparse and interlocked connections.

Table 5.6: Summary of findings

	3 years revenue growth	5 years revenue growth
Sparse connections	Hypothesis 1.1 supported	Hypothesis 1.1 supported
Interlocked connections	Hypothesis 1.2 supported	Hypothesis 1.2 supported
Interaction effects	Hypothesis 1.3 supported	Hypothesis 1.3 supported

5.5 Conclusion

This study's results show that sparse and interlocked connections have significant influence on SMEs development results. In particular, there is an interaction effect of sparse and interlocked connections in firm networks which can influence SMEs development. This study presents two findings. First, both sparse and interlocked connections are beneficial to SMEs development. Second, the presence of both sparse

and interlocked connections provides further impetus for SMEs to be more active and innovate further.

The data consists of 1056 firms (511 in Figure 4 and 545 in Figure 5). This includes 724 SMEs (with less than 50 workers and 50 million euros revenues) and 332 large firms (with more than 50 workers or 50 million euros revenues). Although, SMEs are defined as firms with less than 50 workers and 50 million euros revenues (Storey, 1994), however, the nature of SME connections in networks is considered as inter-firm rather than only inter-SMEs (Gulati, 1999; Burt, 2012 and 2015; Cross et al., 2015). Especially, the connections between small and large firms are concerned as effective for the rapid spread of knowledge and resources in product development (Burt, 2007). Therefore, in the analysis, the samples are inter-firm connections rather than inter-SMEs connections.

The nature of this study's analysis unit is the connections between firms. This includes connections between two SMEs, and also, connections between one SME and one large firm. Due to this, if this study runs comparative regression analysis for only SMEs or only large firms, this study will not be able to cover the connections between SMEs and large firms in the analysis. Thus, in order to investigate the similarity and disparity between SMEs and large firms, this study used number of employee and revenue as this study's control variables. In consistent with previous literature, this study's finding suggests that the size of firm is not related to the results

in product development (Pittaway et al. 2004; Thorpe et al., 2005). This study's models show that the correlations between number of employees and the results in product development are not significant. Similarly, the correlations between firm's revenue and the results in product development are not significant either. Thus, this study suggests the size of firm does not decide the result of product development.

Joint financial commitments in product development are considered as the connections among firms in this study. In the analysis, this study tested the after-effect of those inter-firm connections on 3 years and 5 years revenue growth. Model 2, 3 and 4 show the significant influence of inter-firm connections on SME's overall revenue growth in 3 years after joint SMEs development loan approved. In model 5, 6 and 7, this study tested each SME's overall revenue growth in 5 years after joint SMEs development loan approved to show the longer term effect of inter-firm connections. The influence is also significant.

With regard to theory, this study fills the gap on different combination of structures that have impact on inter-organisation connections and the subsequent impact on their ability to innovate. This study's results are consistent with prior empirical evidence in supporting both sparse and interlocked connections are positively associated with SMEs development results (Burt, 1992 and 2015). These prior empirical evidence showed a positive correlation between organisational connections and SMEs development results (Rodan and Galunic, 2004; Lovejoy and Sinha, 2010). This

study's results confirm this positive correlation between the number of sparse and interlocked connections and SMEs development results. More importantly, sparse and interlocked connections have similar level of effects. The R^2 changes from sparse and interlocked connections are almost equal. This means that they can influence SMEs development results almost equally.

However, prior research did not combine different structures of organisational connections. This study's findings show that a combined network structure of sparse and interlocked connections is more beneficial to SMEs development than either only sparse or interlocked. This combined structure provides extra effects as the interaction effects in the model showed. This means having a combination of sparse and interlocked connections can provide the positive effect of each plus an extra effect on SMEs development results. On the other hand, the results show that sparse and interlocked connections do not reduce each other's effect on SMEs development results. One does not decrease the other. Thus, sparse and interlocked connections are an effective combination in SMEs development.

Also, this study's findings provide evidence and motivations for seeking more effective combinations in the future. Firm connections are highly complex in the nature of their SMEs developments. Sparse and interlocked connections are simple structures. This study includes the combined structure of both as a more complex structure. The results showed that this complex structure has more effects than these

simple structures. Thus, in order to understand the complex structures of firm connections, more effectively, combined structures need to be explored. This can further improve the understanding about how firms can collaborate together more effectively.

In terms of the contributions to management practices and policies, this study has implications on how firms can improve their external connections to achieve better SMEs development results. This study's findings add evidence regarding the combined network structures to this study area. This study's findings suggest that firms with both sparse and interlocked connections are more likely to have better SMEs development results. Managers can contribute to the innovative nature of their firms by exploring networking opportunities possible amongst dispersed and interlocked connections. More specifically SME managers need to take a very active role in exploring the nature of the connections in their own industry. Policy makes need to develop policies that encourages SMEs to make use of both sparse and interlocked connections.

Further research is planned to improve this study's model with more data cross different sections and context. This study's results show the importance of combining various inter-organisational connection structures in the context of SMEs development, this finding can be more generalised with similar data from different business contexts.

Brokering activities are important since they bridge the knowledge and resources between firms. Information brokering activities enable firms to combine their knowledge and resources. However, what types of information brokering activities and where they located in firms cluster remain unclear. Thus, this study adopts brokerage theory and network analysis to explore data including 1056 firms in their clusters. Brokering activities and network locations are measured G&F test and centralities. Regression modeling is used to test the influences of brokering activities and network locations on firm performance. The results of this study show that not only brokering activities can influence firm performance significantly, but also their network locations in firm clusters. Brokering activities in firm clusters take over most of the connections between firms and contributed to their performances. Network locations are considered as firm advantages.

Chapter 6 Finding 2: The influences of centralities and brokerage

6.1 Introduction

This chapter's results are based on the same set of data to explore brokering activities. Brokering activities are firms or people bridging information exchange and resources in clusters (Bayat, Schøtt, and Zali, 2014; Shazi, et al., 2015; Burt, 2016). The gaps between firms in clusters are concerned as business opportunities. These gaps between people can be strategically connected to affect their behaviours in networks (Burt, 2007 and 2015). Bridging the gaps between disconnected contacts in networks can potentially create new products and markets (Bourdieu, 1985; Nohria and Eccles, 1992; Shane and Cable, 2002; Brass, et al., 2004). Thus, those gaps are the constraints and opportunities in networks (Burt, 1992 and 2004). Brokering activities are the linkages between firms in networks and structural holes are the gaps between firms can be bridged by those brokering activities.

Previous research noticed a large number of information brokering activities across different professional groups in SMEs development (Bayat, Schøtt, and Zali, 2014;

Shazi, et al., 2015; Burt, 2016). And there are always a certain number of firms have prominently central positions in networks. These firms are important as "brokers". And more impressively, the connections across functional groups mostly rely on those "brokers". In other words, firms usually connected by the "brokers" who are centrally located in networks. This study suggests that information is transmitted in business network with "brokers" rather than networks where pairs of firms tend to be connected by only a few paths of short length. Accordingly, brokerage and centralities are the key features of firm networks (Granovetter, 1974 and Burt, 2004; Inkpen and Tsang, 2005).

This study provides a theoretical framework and analysis which are adapted to analyse network centrality and brokerage and influences in SMEs development. This study's theoretical framework is based on network theory (Burt, 2007 and 2015). Network theory argues that the gaps between firms in a network can be strategically bridged and contribute to SMEs development. Based on network theory, this study derives additional implications to the structures and influences of network.

6.2 The purposes of analysis

Brokerage is the action of coordinating across the gaps with bridges between firms. Business advantages and opportunities, in this case, accrue to the firms which are the ones that bridge these clusters. Burt (1992) suggested firm performance can be

positive correlated with the number of brokering activities in the networks. Information exchange relations are concerned as ties among firms in networks (Aalbers, Dolfsma, and Koppiu, 2013). The structure of those connections among firms needs to be analysed to reveal the brokering activities. Networks can present the cross-function collaborations between professional groups (Friedkin, 1993 and 1999). Those cross-function collaborations in networks can be analysed at interpersonal level to reveal the brokering activities (Gulati, 1999; Paldam, 2000). Thus, network structures are very important to firm clusters, since it means advantages and opportunities lead to better performance.

Network theories are increasingly important in improving the understanding of SMEs development since the regular patterns in inter-firm connections can be revealed (Borgatti, 2011). Furthermore, Podolny and Baron (1997) and Burt (2007 and 2015) suggest analysing SMEs development activities from a network perspective, since SMEs networks can present the structures of connections among firms in SMEs development. The regular patterns in SMEs networks can be found in networks.

The major barrier to SMEs development is that information can hardly be diffused across professional groups (Kristensen, 1999; Newell, et al., 2004; Burt, 2007; Aalbers, et al., 2013). Thus, it is important to find out how to facilitate SMEs development across different professional groups. In SMEs development, connections among firms are highly complex. Firms exchange information concurrently. These

connections between firms form a complex network (Nebus, 2006; Burt, 2007). Thus, managing SMEs development has switched from managing a firm to network.

SMEs networks have the following features in theories. Connections among different professional groups are crucial to SMEs development. Such connections enable professionals to combine their knowledge and skills to complete the tasks in SMEs development. Those connections in SMEs development appear as communications between peers across different professional groups (Boudreau and Robey, 2005). In SMEs development, there is a great amount of information that needs to be exchanged between among designers, engineers, and managers (Bayat, Schøtt, and Zali, 2014). Connections between different professionals result in the integration of knowledge and skills and create SMEs development (Shazi, et al., 2015). When SMEs development requires knowledge across different professional groups, collaborations between these professional groups have a significant influence on performance (Adler, 2001; Adler and Kwon, 2002; Oh, et al., 2006; Bayat, Schøtt, and Zali, 2014).

SMEs networks are crucial in achieving a high level of performance outcomes (Burt, 2014 and 2015). Walker et al. (1997) analysed how resource endowments contribute to SMEs development. They found that initial resource endowments do not significantly affect SMEs development outcomes. SMEs development outcomes are significantly affected by networks. A similar finding was also suggested by Burt (2004), who found that a firm's network position can affect innovativeness. This

study provided an overview of SMEs network.

6.3 Analysis procedure: Centrality

This section is to discuss the regular patterns of SMEs network structures, the regularity of SMEs networks. Network structures can change during SMEs development. Network theory (Burt, 1992 and 2015) suggests that network evolves in the way of bridging the gaps between firms. A SMEs network usually starts with many gaps between firms. During SMEs development, those gaps between firms are strategically connected. In other words, SMEs network structure usually begins with sparse structure (or non-redundant structure) and evolves towards interlocked structure (or redundant structure). The gap here is what network location advantages are.

Thus, the focus is to find firms' network locations, also known as centralities. Centrality represents each firm's network location. Centrality provides measures about each firm's ego network structure. These can reflect the importance and prominence of each firm in a given network. Thus, this study uses centralities as independent variables. There are four centrality measures, degree, betweenness,

closeness, and eigenvector centrality (Freeman, 1979; Borgatti, 2011). Each of these provides distinct measure to what extent firm centrally located in a given network. A firm can be centrally located in a network and have different influences in four ways as below.

Degree centrality (Well connected)

Previous research (Burt, 2004; Uzzi, 1996) suggests that high performance cluster appears in a form of that most of the firms in the network are well connected. Well-connected firms tend to have direct influence to the other firms in a cluster and more likely to be involved in brokering activities. Degree centrality measures how many connection a firm has in a given network (Freeman, 1979; Borgatti, 2011). This measure can reflect the firm's direct influence to the other firms in a network. Degree centrality is expressed by the number of firms directly connected to a given firm. However, the well-connected firms may not play the important roles in a network (Borgatti, 2011). Thus, the other three centrality measures are introduced to provide more systematic measures about network structure.

Betweenness centrality (Control power)

Firm's power of information control in a cluster is positively related to performance

(Borgatti, 2011). Firms have a high power of information control which can be seen as the shortest connection between the others. Previous research (Burt, 2007; Ibert and Müller, 2015; Buchmann and Pyka, 2016) suggests only a few firms have a high power of information control in the network. Although there are lots of brokering activities in networks, but only a few of them can bel the shortest path in network. Also, it is noticed information control is not absolutely high. Only a few firms can have total control of the shortest path in a network. Firm often exchange information and resources freely in clusters. Betweenness centrality measures how many times that a firm connects two others as the shortest path in a given network (Freeman, 1979; Borgatti, 2011). This measure can reflect the firm's information control power in a network. A firm's betweenness centrality is expressed by the number of shortest paths in the network passing through that firm. Thus, this study uses betweenness centrality to reflect firms' network location advantages in collaborations.

Closeness centrality (Proximity to all firms in the network)

Firm's network distance can be seen from how many firms is in the middle to connect two firms. Clusters with firms are very close to each other or toward to be closer to each other can perform better (Borgatti, 2011). Due to a large number of brokers in the network, this network is a very dense network with short network distant between firms. Information transfer between firms can be completed by going through just few

brokers. More important, previous research (Adler, 2001; Adler and Kwon, 2002; Oh, et al., 2006; Bayat, Schøtt, and Zali, 2014) suggests that firm cluster is a "small world" network characterised by short path lengths. The result suggested the "two degrees of separation" in firm cluster that any two firms in a cluster may be linked by through just less than two broker firms in the middle. Closeness centrality measures a firm's network distance from all others (Freeman, 1979; Borgatti, 2011). This measure can reflect a firm's information passing through how many firms to arrive the others. It is regarded as an indicator of the expected time-until-arrival for a firm to spread information to all others in a network. Closeness centrality measures the optimal paths a firm has. Thus, this study uses closeness centrality to reflect the proximity of firms in SMEs networks.

Eigenvector centrality (Connected to well connected)

These are also connections between firms involved in brokering activities. These firms are not only well-connected but also are connected to the well-connected firms in the network. Well-connected firms are also inter-connected like a cluster (Uzzi, 1996 and 1999). Also, brokering activities are not only bridging firms otherwise disconnected, they are also bridging well-connected firms to be inter-connected like a cluster. Eigenvector centrality measures a firm's connections to the well-connected firms in a given network. This measure can reflect a firm's indirect influences in the network. Such indirect influences are through the connections with well-connected

firms in the network. In contrast to degree centrality measuring direct connections, eigenvector centrality measures the indirect connections. This can help to distinguish firms' network advantages when they have the same number of direct connections in a network. Thus, this study uses eigenvector centrality to reflect firms' indirect connections.

Overall, network structures are shaped by the flows of SMEs development (Galbraith, 1974; Koka and Prescott, 2002; Labianca and Brass, 2006; Burt, 2007; Gardet and Fraiha, 2012). For example, designers need to discuss the task with engineers or managers. This can be seen as 'pairing' firms together in the network. Each time when 'pairing' occurs, a connection between two firms is created in the network. Form Burt's (2015) view, this is the mechanism which can bridge the gaps in networks. Although Frequent interactions contribute to the collaborations between firms. Also, dirms are bound together by brokers in networks. Previous studies (Coleman, 1988 and 1990, Walker et al. 1997; Gupta and Maltz, 2016) suggest that highly dense information exchange cross functional groups can lead to superior performance outcomes in firm cluster. A firm cluster needs a highly dense core with brokering activities. The structure of information exchange in network is also important, as strategically connecting participants can change their constraints and opportunities to access to information. Finally, this study suggests brokerage and network locations can be measured separately by measuring the density in the network, and then

synthesize together to predict firm performance. Based on above discussion, this study proposes the following hypothesis.

Hypothesis 2.1: Broker firm's degree, betweenness, closeness, and eigenvector centrality are positively associated with SMEs development outcomes.

6.4 Analysis procedure: Network brokerage

A complex SMEs network consists of a large number of firms from different knowledge areas. Researchers such as Podolny and Baron (1997) and Rodan and Galunic (2004) suggested that the brokers are critical in SMEs networks. And those broker roles are not static in SMEs development. Burt (2007 and 2015) suggested that the brokers are central in SMEs networks as bridging the gaps. These brokers roles in SMEs development can be analysed in networks. This analysis includes how those connections are developed in networks (Obsfield, 2005), how firms are connected each other in SMEs development (Ibarra 1993; Stolle, 1998; Stolle and Rochon, 1998; Starkey and Tempest, 2004), and the structure of network influence SMEs development outcomes (Chung and Gibbons, 1997; Podolny and Baron 1997; Song, et al., 2013; Hofman, et al., 2016). Network studies (Podolny and Baron, 1997) also suggested that there are a large number of connections between different professional groups in SMEs development, especially between design and engineering. Those

connections between professional groups rely on brokers placed at the intersection between them to transfer information across the groups.

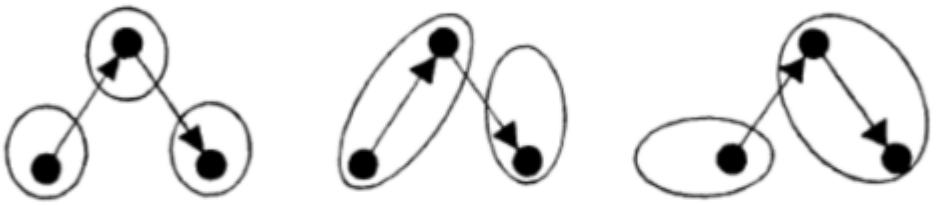
SMEs development across structural boundaries between different professional groups relies on brokers (Burt, 2014). When SMEs development progress, the collaborations between designers and engineers evolves to cross the structural boundary between them. Firms in different professional groups are connected by brokers in networks. Those brokers are firms placed in the middle between different professional groups. Each professional group is highly interdependent and work on concurrent activities in SMEs development and connected by the brokers. The professional groups in SMEs development are not organised in hierarchy structures which are led by some senior members of each professional group. Thus, a SMEs network is featured in multidisciplinary roles and non-hierarchical structure. Those multidisciplinary roles in non-hierarchical structure can be reflected from the roles of brokers at different stages of SMEs development. Broker roles identified by Burt (2007) showed that broker roles are associated with the stages of SMEs development. Therefore, this study proposes a model in the later theoretical framework to explain how broker roles can change at each stage of SMEs development. Broker roles are not only about bringing firms, but also, "liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator".

In network typology, Gould and Fernandez (1989) suggested five types of brokers,

"liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator" in networks. In Figure 6.1, the nodes represent firms in SMEs development. The lines between the nodes represent connections. The circles around the nodes represent the boundary between difference professional groups, for example, the boundary between design and engineering groups. The first type is the "liaison" broker, a third firm links two groups (see Figure 6.1). A liaison broker provides a connection between two distinct groups but does not belong to either group. For instance, design firms and engineering firms are two separate professional groups, and a technology advisor can act as a liaison broker to provide a link between them in the network. The second type of broker is "representative", a firm represents a group to connect with outsiders. Representative brokers act as delegates to provide connections between his or her own groups and other groups. For example, an engineering firm gathers information from design firms and distributes them to engineering firms. The next type is the "gatekeeper" broker, a firm offers access to its own group (see Figure 6.1). A gatekeeper broker provides connections between his or her own group and outsiders. Comparing to representative brokers, gatekeeper brokers grant access to information and representative brokers gain access to information. The fourth type is the "consultancy" broker, an outsider firm provides within-group brokerage (see Figure 6.1). A consultancy broker usually acts as expertise and provides links between members within a group. For example, designers usually require technology advisors to transmit information among them and provide technology supports to the design work. The last type is the "coordinator" broker. A coordinator provides connections

within his or her own group (see Figure 6.1). Those connections are completely internal brokerages. For instance, a management consultancy firm provides connections between the members of the management group to coordinate frims managing on different tasks. In network theory (Burt, 2007), connections between firms in SMEs development can be treated as networks. Networks can be analysed by using brokerage scores to measure each firm's broker activities.

Figure 6.1 Five types of brokers (adopted from Gould and Fernandez, 1989)



Brokers' roles are not clearly identified in SMEs networks. Each professional group in SMEs network has an interface and structural boundary. Podolny and Baron (1997) suggested that connections among professional groups in SMEs development appear as the interface of collaborations. Information can be transmitted at the interface with brokers where firms from different professional groups can be connected by a few brokers (Zou and Ingram, 2013). Also, there are other studies suggested that the

information brokerage process in the network is crucial since it can turn the collaboration paths between firms into short length (Coleman,1988 and 1990; Granovetter, 1992; Dyer, and Singh, 1998). This study proposes that brokers as the regular patterns of SMEs network are crucial to managing SMEs networks. These five types of brokers, "liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator" can be the key factors influencing SMEs development outcomes. Based on above discussion, this study proposes the following hypothesis.

Hypothesis 2.2: "Liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator" brokers are positively associated with SMEs development outcomes.

6.5 The influences of network centrality and brokerage

The previous sections discussed network centrality and brokerage. This section is to discuss how SMEs networks can influence SMEs development outcomes. It is clear that network centrality and brokerage can influence SMEs development outcomes.

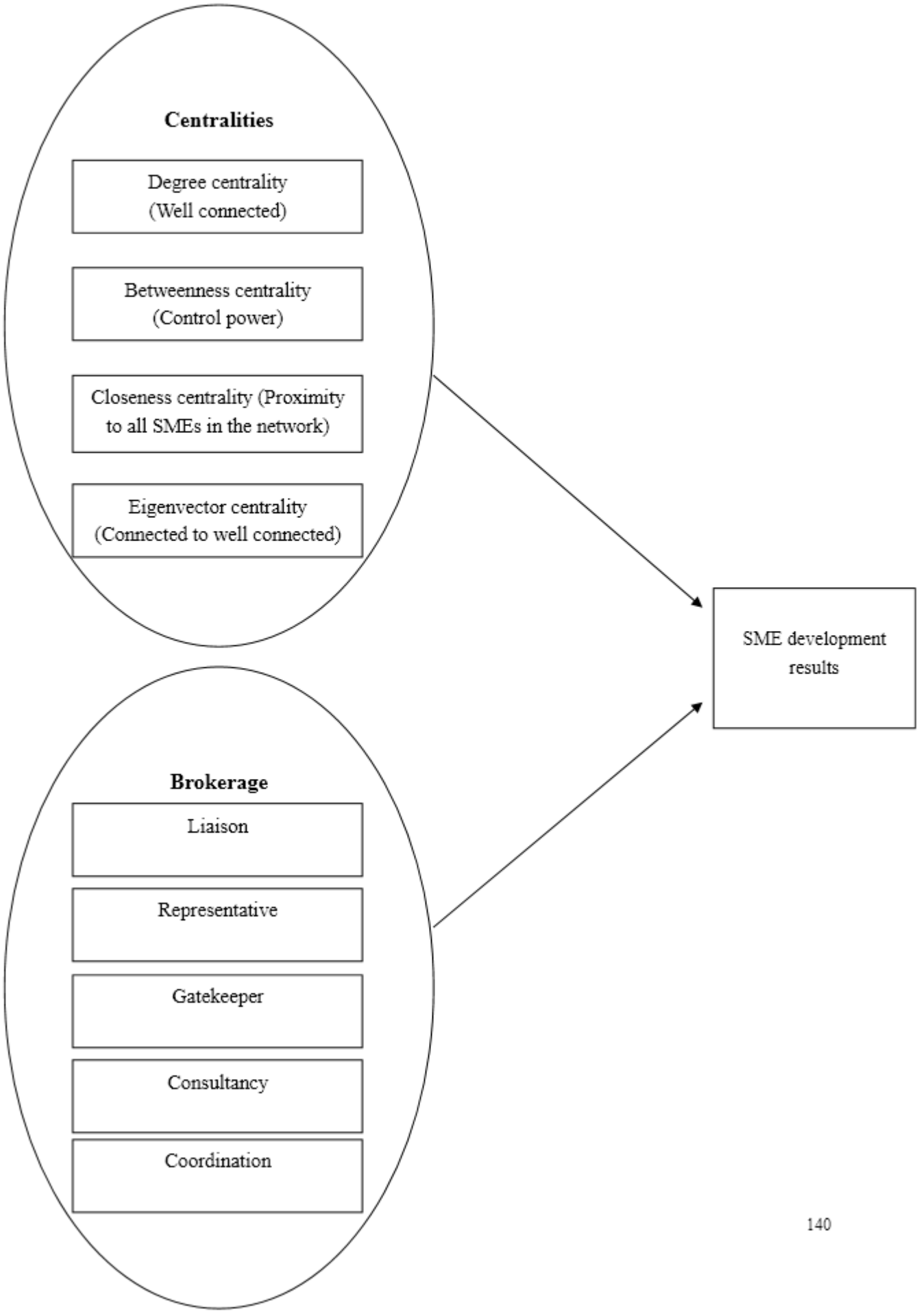
Tsai and Ghoshal (1998) modelled business diffusion between business units and presented this as a barter process, in which firms exchange different types of knowledge in SMEs development. They highlighted that brokers are located in a network and are directly connected with a larger number of specialists and a small number of other brokers. These brokers control the network as roughly 90 percent of connections are across business units. However, they did not explore what types of brokers in business clusters. Their study confirmed that SMEs network can provide an analysis of this broker phenomenon. Also, this study's hypotheses propose that these brokers can positively influence firm performance. The various forms of knowledge tend to form separated clusters in this case. Specialists across function groups are linked by a few brokers at the intersection between the groups. Walker et al. (1997) suggest that the number of specialists is not associated with high-impact SMEs development. This result showed the contradiction between theory and practice. The researchers suggested that a repository of knowledge between specialists, the effective integration of knowledge and the capabilities of organising versatile specialists within and outside the boundaries of the function group, lead to more significant SMEs development impacts.

The inter-organisational connection in collaboration across functions mostly relies on such "brokers". In other words, when the SMEs development collaboration evolves across disciplines, specialists are usually connected by the "brokers" who are centrally located (Granovetter, 1974 and Burt, 2004). This broker influence in SMEs

development across function can be analysed by adopting network analysis (Burt, 2004). Network structures such as brokerage (Fukuyama, 1995 and 1997; Burt, 2004) have been used to describe the general patterns of SMEs networks.

Based on above analysis, this study summarises the focus on network influences in SMEs development as 1) To what extent centrality can influence SMEs development outcomes, and 2) what are the roles of brokers and to what extent they can influence SMEs development outcomes? Brokerage and network locations are highlighted by the existing studies explored the relationship between SMEs network and performance outcomes (Holti, et al., 1997; Edelman, et al., 2004; Rodan and Galunic, 2004; Burt, 2007). However, they only suggested that firms which are central in a network are likely to have better performance. In other words, only a broker position is associated with higher performance in performance. Further, Burt (2007) suggests network analysis can provide a representative view for analysing SMEs development process, and focusing on inter-organisational level collaboration. Related to this, Fleming and Waguespack (2007) confirmed that this study area has been rarely explored. As the discussion above, analysing inter-orgnisational level SMEs networks can help to understand the SMEs development process. This study proposes that there are more types of brokers and also network locations can influence firm performance.

Figure 6.2 The theoretical framework of this study



6.6 Method

This study collected data from Firm-Level Micro-Data in OECD ORBIS Database. The data covers joint SMEs development bank loan between 2011 and 2015 in the region of Beijing and Shanghai. This study collected data for 1056 firms including 353 small firms, 371 medium firms, and 332 large firms. This study identified these firms by based in whether the firm has collaborations in the dataset. Thus, the data this study collected covers all firm financially declared collaborations. The data covers firm collaborations between 2011 and 2015 in the region of Beijing and Shanghai. The reason for using this dataset is that recent research (Potrafke, 2015) suggested they are the most active areas and time period in firm collaborations, in term of volume of co-production and number of firms. This study adopts randomized permutation regression to test the correlations between firm connection structures and their SMEs development results. Network data about organisational connections can have some outliers in distribution. Randomized permutation regression can provide better results of the model coefficients to resolve the issue of overly influencing outliers in network data (Wasserman and Faust; 1994; Hanneman and Riddle, 2005). Thus, this study's choice of analysis can provide a more robust model.

The independent variables are network structures including each firm's centrality and brokerage. SMEs development results are the dependent variables. This study uses revenue growth form new products or services as the measure of each firm's SMEs

development results. And non-network factors influencing SMEs development are used as the control variables. Especially, this study controls number of employees and revenue to rule out the effects of firm size on SMEs development. The independent variables are network structures including each firm's sparse connections and interlocked connections. Revenue growth results are the dependent variables. This study uses revenue growth form new products as the measure of each firm's SMEs development results.

Each firm's broker roles and centrality are calculated by using the Ego Network Structure Count function in UCinet. They are this study's proposed independent variables. Later on, they are tested against firm's revenue growth in regression modelling to show the effect of firm connections. Firm connections snapshots are generated by using the software Ucinet. Each snapshot represents a large firm cluster. These snapshots consist of firms as nodes and SMEs development collaborations as the ties. Centrality and brokerage scores are calculated by using the ego network structure count function in UCinet. These snapshots provide information about the overall structure of firm cluster as a whole and each firm's network structure.

6.7 Results

Figure 6.3 and 6.4 show the firm connections in information and communication technology (ICT) sector in Beijing and Shanghai. The nodes are firms. The lines between them are joint SMEs development loan from Bank of Communication, which represents SMEs development collaborations and partnerships in this study. The size of each node represents each firm's overall revenue growth 3 years after joint SMEs development loan approved. This is used to measure SMEs development results in this study.

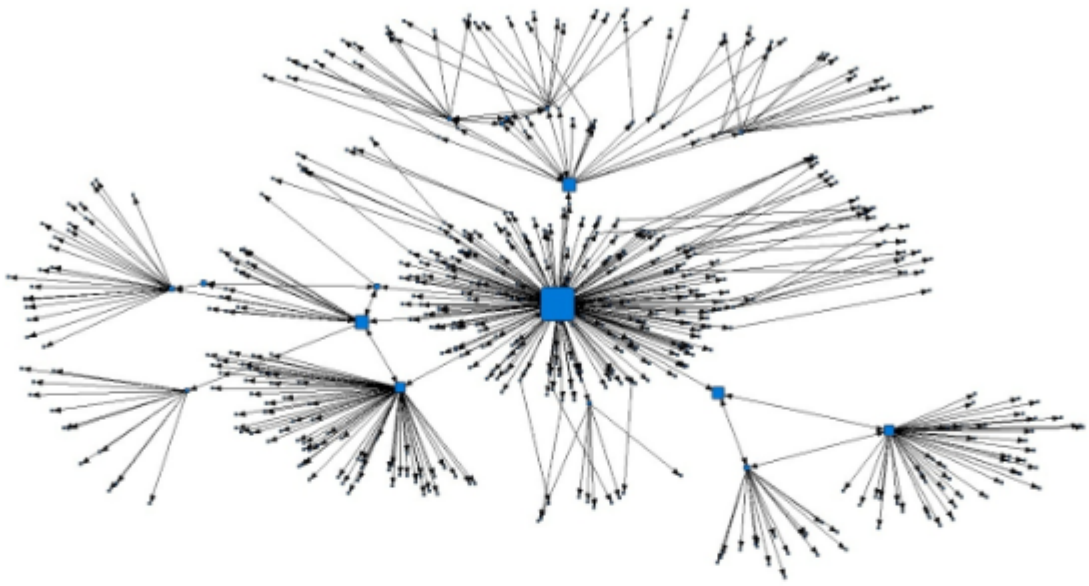


Figure 6.3 SMEs network in information and communication technology (ICT) sector in Beijing (Sample size: 511 firms, nodes are firms, lines are joint SMEs development loan from Bank of Communication, the size of the node represents each firm's overall revenue growth in 3 years after joint SMEs development loan approved)

Number of firms	Number of ties
511	527

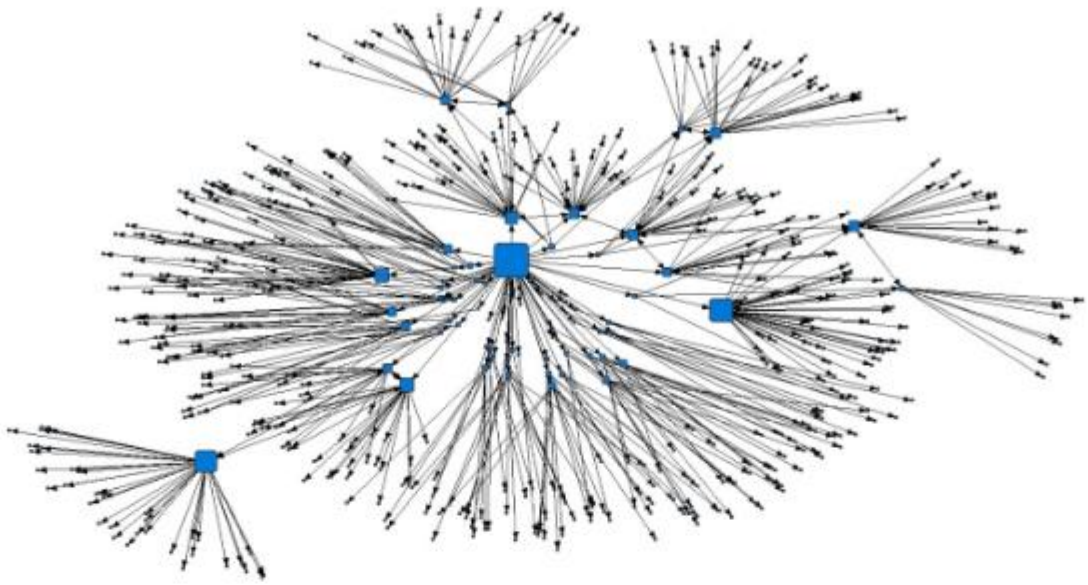


Figure 6.4 SMEs network in information and communication technology (ICT) sector in Shanghai (Sample size: 545 firms, nodes are firms, lines are joint SMEs development loan from Bank of Communication, the size of the node represents each firm's overall revenue growth in 3 years after joint SMEs development loan approved)

Number of firms	Number of ties
545	561

As discussed earlier, centrality and brokerage can influence SMEs development results. Table 6.1 shows the results of regression modelling. This study uses two separated sets of data to measure the SMEs development results. They are 3 years revenue growth and 5 years revenue growth. 3 years revenue growth is the dependent variable in Models 2, 3 and 4, while in Models 5, 6 and 7, 5 years revenue growth is the dependent variable. In Model 1, this study uses only the control variables to show the difference without the proposed independent variables.

Table 6.1 Multivariate regression models

	Model 1	Model 2	Model 3	Model 4	Model 5
	3 years revenue growth			5 years revenue growth	
Constant	−0.517	−0.457	−0.219	0.1197	0.0158
	(0.797)	(0.878)	(0.886)	(0.972)	(0.985)
Company age	−0.029**	−0.0287**	−0.0289*	−0.0207*	−0.0212**
	(0.011)	(0.016)	(0.015)	(0.017)	(0.019)
Number of employee	−0.0089	−0.0087†	0.0081*	0.0417	0.0479*
	(0.029)	(0.027)	(0.023)	(0.021)	(0.022)
Revenue	0.0657	0.1282*	0.1257	0.1689*	0.2898*
	(0.165)	(0.173)	(0.179)	(0.158)	(0.229)
Budget (SMEs development loan received)	0.067	0.0071	0.0215	0.1009	0.0523
	(0.19)	(0.109)	(0.136)	(0.168)	(0.147)
Group–IT Management	0.2009	0.2682	0.2137	−0.6589†	−0.6597†
	(0.37)	(0.306)	(0.307)	(0.309)	(0.386)
Group–IT Design	0.2278	0.0429	0.0792	−0.4937	−0.507
	(0.289)	(0.296)	(0.293)	(0.329)	(0.309)
Group–IT Engineering	0.2081	0.2026	0.907†	−0.6967	−0.2389
	(0.568)	(0.607)	(0.579)	(0.658)	(0.603)
Brokerage		0.2821**	0.3269**	0.2311**	0.2917**
		(0.18)	(0.139)	(0.179)	(0.168)
Network centrality			0.2712**		0.3961**
			(0.137)		(0.139)
R^2	0.4077	0.5726	0.6996	0.5267	0.7258

N = 1056; †$p \leq 0.1$; * $p < 0.05$; ** $p < 0.01$; Robust standard errors in parentheses.

This study's result suggests centrality and brokerage have significant influence on SMEs development results. In Model 2, this study's results show that brokerage are positively associated with SMEs development results ($\beta = 0.2821$, $p = 0.02$). This finding is consistent with previous research (Burt, 2015; Cross et al, 2015; Gargiulo and Sosa, 2016). This study's Model 3 shows that the correlation between centrality and 3 years revenue growth is positive and significant, meanwhile brokerage is also positively associated with the revenue growth (βcentrality = 0.2712, $p = 0.009$ and βbroker= 0.3269, $p = 0.004$). This finding adds a new point to the existing theories (Burt, 2015; Cross et al, 2015; Gargiulo and Sosa, 2016).

This study's model 4 and 5 show similar results about the correlations between these two structures of firm connections and firm's 5 years revenue growth. Model 4 suggests brokerage can contribute to SMEs development results ($\beta = 0.2311$, $p = 0.004$). This study's model 5 includes centrality, the influence on 5 years revenue growth is increased (βbrokerage = 0.2917, $p = 0.002$ and βcentrality = 0.3961, $p = 0.007$).

The R^2 increase indicates this study's hypotheses are supported and the model is robust. In this study's results, the R^2 increase shows the influence of firm connections on SMEs development results. For example, comparing to Model 1, R^2 in Model 2 is increased by adding brokerage. Adding centrality in Model 3, the results show

increased R^2 comparing to Model 2. Similar results are shown in Model 4 and 5 testing against 5 years revenue growth.

The results support this study's two hypotheses (see Table 6.2). While Model 1 shows firm's characteristics matters for SMEs development, the results show centrality and brokerage have more significant influences. Moreover, the influence of brokerage is even more significant when centrality is added in the model. This study's finding confirms Uzzi (1996 and 1999) and Burt's (2007) theories discussed in the theoretical framework. Brokering activities are about bridging the gaps between firms in the network. Moreover, brokerage and centrality have significant influences on firm performances.

Table 6.2. Summary of findings

	3 years revenue growth	5 years revenue growth
Centrality	Hypothesis 2.1 supported	Hypothesis 2.1 supported
Brokerage	Hypothesis 2.2 supported	Hypothesis 2.2 supported

6.8 Discussion and conclusion

Five types of brokers were defined by Gould and Fernandez (1989). However, there are still some questions about brokers remain either unknown or unclear. First of all, which types of brokers exist in SMEs networks? Seconds, who are the brokers? Third, what is the proportion of brokers in a network? Four, can a firm play different broker roles in a network? This section will discuss the findings from each of these four aspects and make a connection with the existing theories.

First, Gould and Fernandez (1989) suggested that there could be five types of brokers. They are "liaison", "representative", "gatekeeper", "consultancy" and "coordinator" brokers. However, they did not find out which types of broker exist in SMEs networks. The findings of this study suggest that all the five types of brokers defined by Gould and Fernandez (1989) exist in the SMEs network in this study's case. These five types of brokers almost exist equally in number. This suggests that the brokers of SMEs network could consist of these all five types of brokers. Previous, brokers are measured as just firms bridging the others. This study tested five types of them together.

Second, who are the brokers in SMEs development? Previous literature (Batjargal , 2003, 2006 and 2007; Svendsen and Svendsen, 2003; Kavanaugh , et al., 2005; Joshi, 2006; Kilduff, et al., 2006; Hinton, et al., 2012; Baker, et al., 2016) suggested that managers and firms with experiences and knowledges in SMEs development are brokers. This study's findings suggest a different answer to this. Brokers are a group

of firms with various positions in SMEs development rather than only management consultancy. In this study's finding, brokers are not only management consultancy firms, but also engineering and design firms. This finding suggests that brokers are a more complicated combination of different firms than previous literature suggested. This result suggests that all the five types of brokers identified in the theoretical framework appear in the same network. They are "liaison", "representative", "gatekeeper", "consultancy" and "coordinator" brokers.

Third, are there only a few of brokers or a lot of brokers in SMEs development? This study suggests that brokers are a large group of firms rather than a small group in network comparing to Burt's research (2004 and 2007). Around one third of the firms acted as brokers in the network and a broker group exists in each SMEs network. Burt's (2004 and 2007) suggests only a few based on structural holes theory. This study suggests brokers are a large group of firms rather than a few based on GF test. In this study's finding, an inter-connected broker group exists in each SMEs network. It should be noted that the network snapshot presents a large number of firms acting as SMEs development brokers located in the middle of the network. This find is against those existing studies (for example, Burt 1992 and 2004; Fernandez, et al., 2000; Fernandez, 2002; Becheikh, et al., 2005; Bernardi, et al., 2012; Cross, et al., 2015; Gargiulo and Sosa, 2016; Schleimer and Faems, 2016) found that brokers are only a few firms in the network. The findings show that SMEs development brokers are not only a few firms in the network, they are a large group of firms in the network.

Thus, this study suggests in the context of SMEs development, brokers are a large group of firms rather than a few.

Finally, Gould and Fernandez (1989) suggested that there could be five types of brokers, but an interesting question remains that can firms play multiple roles in SMEs development remains. It has been found in this study that most of the brokers do not only play one of those five broker roles but also play multiple roles of a broker. A broker, in this case, came up in the SMEs development process naturally to meet the needs of collaborations. As collaborations constantly happen between professional groups through SMEs development, most of the brokers have to play multiple broker roles.

In sum, this study demonstrated the importance of centralities and brokerage in SMEs development. This is due to the exchange and circulation of information between professional groups during SMEs development. Previous literature found the importance of exchange and circulation of information (Rogers, 1995; Kraatz, 1998; Beugelsdijk and Van Schaik, 2005; Boland, et al., 2007, Fu and Zhang, 2012). Also, some literature highlighted the value of network (Burt, 2004 and 2007). However, they have not explored the factor of firms' collaborations in SMEs development. This study's finding provided a better understanding about how brokers bridging collaborations between firms with different knowledge backgrounds and skills. Thus, this study's findings are complementary to the five types of broker model (Gould and

Fernandez, 1989) and technology broker concept (Burt, 2004 and 2007). This study's findings show that five types of brokerage and four types of centrality are more beneficial to SMEs development than either only bridging firms.This means having these five types of brokerage and four types of centrality can provide the positive effect of each on product SMEs development results. Also, this study's findings provide evidences and motivations for seeking more effective types of brokerage and four network locations. Firm connections are highly complex in SMEs development. In order to understand the complex structures of SMEs development, more effective structures need to be explored. This can improve the understanding about how firms can collaborate together in SMEs development more effectively.

Chapter 7 Finding 3: Further details about SME connection dynamics and structures

7.1 Introduction

This chapter's results are based on the same set of data to explore SME network dynamics. As motioned before, the data covers SME collaborations between 2011 and 2015 in the region of Beijing and Shanghai. The collected data includes 1041 SMEs. These SMEs were identified by whether the SME has collaborations in the dataset. Thus, the data collected covers all SMEs financially declared collaborations. The data covers SME collaborations between 2011 and 2015 in the region of Beijing and Shanghai. The reason for using this dataset is that recent research (Potrafke, 2015) suggested they are the most active areas and time period in SME collaborations, in term of number of SMEs.

The data covers every 6 month period between 2011 and 2015. Randomized permutation regression was adopted to test the correlations between the previous period and the later period of SME's connections. Network data about organisational connections can have some outliers in distribution. Randomized permutation regression can provide better results of the model coefficients to resolve the issue of

overly influencing outliers in network data (Wasserman and Faust; 1994; Hanneman and Riddle, 2005). Thus, this choice of analysis can provide a more robust model.

The independent variables are network structures including each SME's number of connections, number of inter-connections, and brokerage role in the previous period of 6 month. The dependent variables are SME's number of connections, number of inter-connections, and similarity of brokerage roles with connected SMEs in the later period of 6 month. Each SME's number of connections and inter-connections are calculated by Centrality function in UCinet. SME's brokerage role similarity is calculated by using the Ego Network Structure Count function in UCinet. This empirical chapter provides the results of network dynamics analysis. This includes:

- Present the findings in network dynamics.
- Argue the existing theories in network dynamics, and how it links to the analysis results.
- Suggest the network dynamics tendencies in SME connections.

Network theories suggested that the gaps between SMEs in their networks can be strategically bridged and contribute to SME development outcomes (Burt, 2007). Network theories have been adopted to explain the structures of SME connections.

However, the structures of SME connections are the results of SMEs connecting with each other. The dynamics happened before the structures are formed in SME networks. Thus, it is necessary to carry on analysis about network dynamics. This study provides an analysis of network dynamics of SME collaborations in SME development. Previous research suggested that SME networks dynamics has three tendencies. First, well-connected SMEs get more connected and extensive connections with increasing number of connections (Borgatti, 2011). Second, well-connected SMEs get more inter-connected so that SME networks get more clustered (Obstfeld, 2005). Third, SMEs with different types of open connections tend to connect with each other (Burt, 2015). Thus, this analysis focuses on testing three hypotheses which are derived from the previous literature review. These three hypotheses are:

Hypothesis 3.1: The well-connected SMEs get more connected with others in SME development.

Hypothesis 3.2: The well-connected SMEs get more interconnected with each other in SME development.

Hypothesis 3.3: SMEs with different roles of brokerage ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other.

The following sections are structured as presenting and discussing the findings in each hypothesis testing. Section 7.2 and 7.3 presents and discusses the first hypothesis

testing result about well-connected SMEs. The second hypothesis testing result about interconnected SMEs is presented and discussed in Section 7.4 and 7.5. Section 6.6 and 7.7 shows and discusses the third hypothesis testing result about connected brokerage roles.

7.2 Analysis result 1: Well-connected SMEs

Figure 7.1 and 7.2 shows the SME connections in Beijing and Shanghai. The nodes are SMEs. The lines between them are collaborations, which represents SME development collaborations and partnerships in this study.

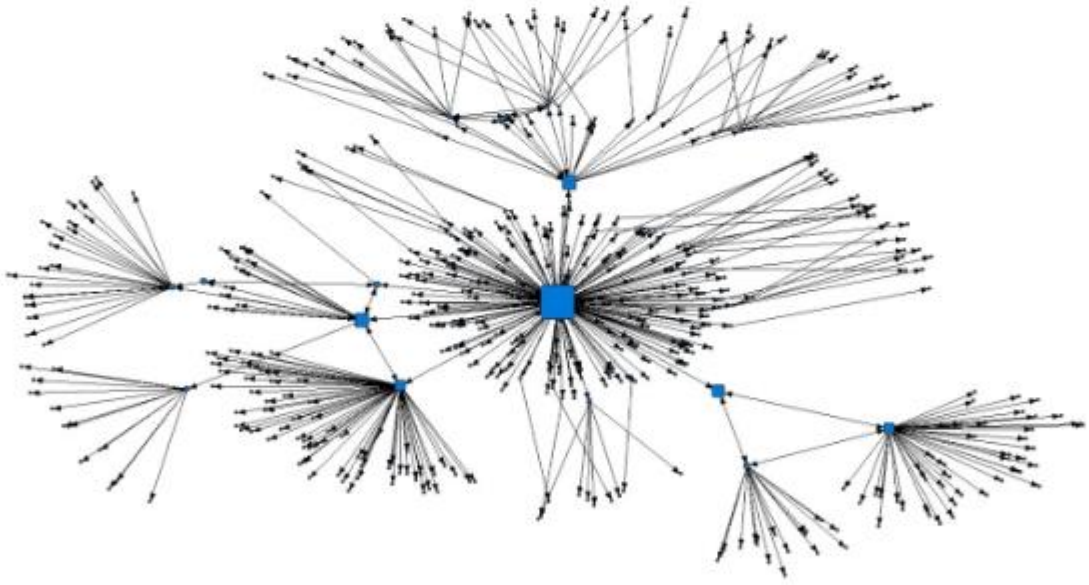


Figure 7.1 SMEs in Beijing and Shanghai (Sample size: 511 SMEs, nodes are SMEs, lines are collaborations)

In Figure 7.1, the snapshot of network analysis about the first SMEs cluster in Beijing

and Shanghai is presented. This snapshot includes a large number of 527 connections among 511 SMEs identified in the data. Each node represents a SME. And the lines are collaborations among those SMEs. These 527 connections formed 1172 sparse structures of SME connections and 123 interlocked structures of SME connections. This finding suggests that there is a larger number of connections among those SMEs and a larger of sparse and interlocked structures exist in SMEs network.

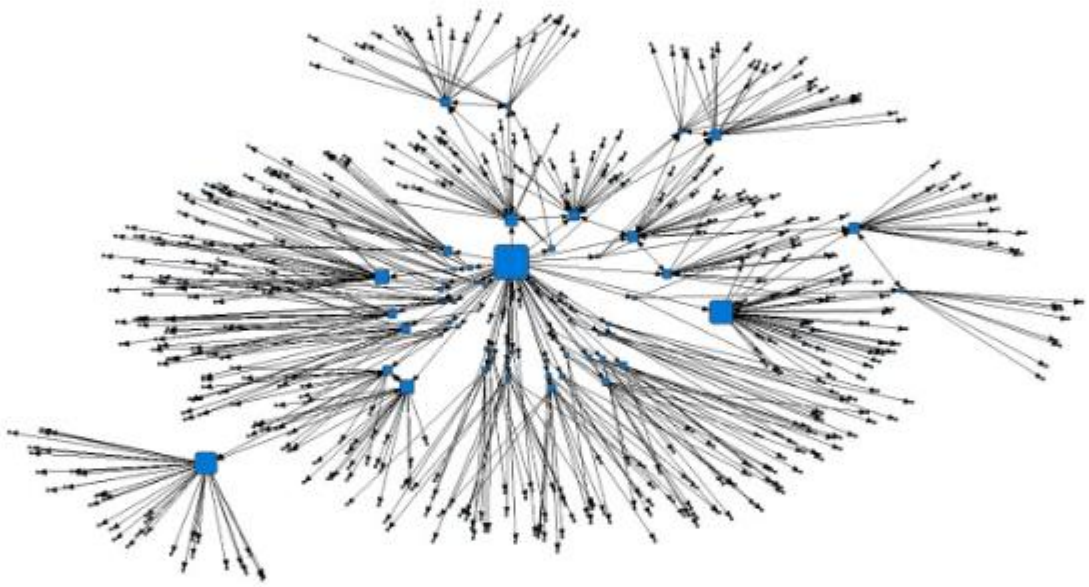


Figure 7.2 SMEs in Beijing and Shanghai (Sample size: 545 SMEs, nodes are SMEs, lines are collaborations)

In Figure 7.2, the snapshot of network analysis about second SMEs cluster in Beijing and Shanghai is presented. This snapshot includes a large number of 561 connections among 545 SMEs identified in the data. Similar to Figure 1, each node is a SME and the lines are collaborations among those SMEs. These 561 connections formed 1012 sparse structures of SME connections and 107 interlocked structures of SME

connections. This finding is consistent with Figure 1 and confirms that there is a larger number of connections among those SMEs and a larger of sparse and interlocked structures exist in SMEs network.

It is noticed that the number of connections is associated with the number of SMEs. Figure 7.1 has 527 connections among 511 SMEs, while Figure 7.2 has a bigger size with 561 connections and 545 SMEs. The more SMEs in a network, the more connections are among them. Also the number of sparse and interlocked structures is associated with the number of SMEs and the number of connections. In Figure 7.1, 527 connections among 511 SMEs formed 1172 sparse structures and 123 interlocked structures. In Figure 7.2, a smaller number of 561 connections among 545 SMEs formed a relatively smaller number of 1012 sparse structures and 107 interlocked structures. In general, the more SMEs and connections in a network, the more sparse and interlocked structures they can form. Although, there is argument about the number of connections, sparse and interlocked structures can decrease when the number of SMEs increases in a network (Burt, 2007). The reason is that each connection is collaboration and needs efforts to maintain it. SMEs usually has limited resources, thus limits the number of connections they can possibly spend on. However, it does not appear that connections, sparse and interlocked structures can decrease when the number of SMEs increases in this study's finding.

Table 7.1 SME clusters profile

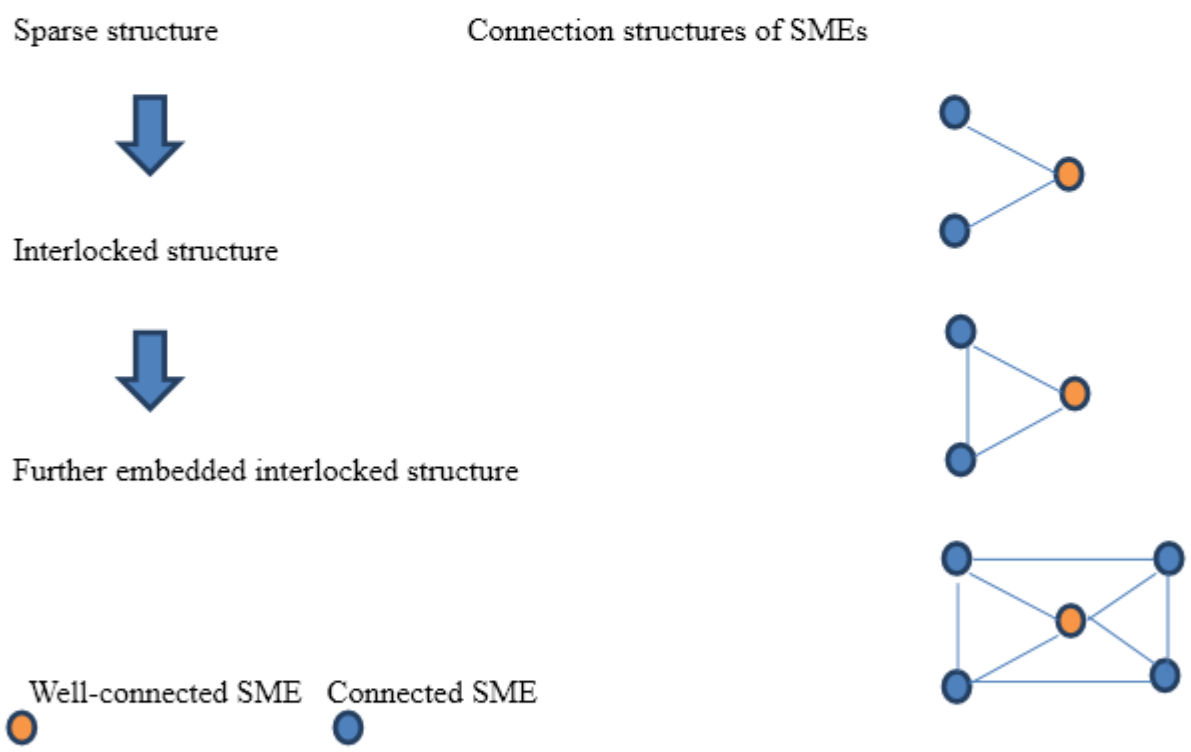
Number of SMEs	Number of ties	Number of open ties 	Number of closed ties 
1056	1188	2184	230

The overall profile of Figure 7.1 and Figure 7.2 is presented in Table 1. This result suggests that there are a large number of 1188 connections among 1056 SMEs identified in those two networks. These 1188 connections formed 2184 sparse structures of SME connections and 230 interlocked structures of SME connections.

This study's finding suggests some SMEs have large number of connections and some SMEs only have a few of them. For example, those SMEs have hundreds connections with others in the center of Figure 7.1 and Figure 7.2. And those SMEs have only one connection on the periphery of Figure 1 and Figure 2. The number of connections each SME can have is also a long time debate topic (Narula, 2004; Burt, 2007; van de Vrande et al., 2009; Zeng, et al., 2010; Rosenbusch et al., 2011; Fernandez-Olmos and Ramirez-Aleson, 2017). On one hand, SMEs cannot afford to have too many connections with the others (Burt, 2007; Zeng, et al., 2010; Fernandez-Olmos and Ramirez-Aleson, 2017). Especially in this study's data, each connection represents formal financial collaboration. On the other hand, SMEs cannot afford to have as many connections as they want, because each connection may give them financial returns (Narula, 2004; van de Vrande et al., 2009; Rosenbusch et al., 2011). This study suggests that SMEs have large number of connections and it does not appear any limit of it. The finding also suggests that well-connected SMEs exist in each network. As

discussed in the literature review, there is a tendency of being well-connected SMEs. There are debates in the existing literature about what proportion of well-connected SMEs during SME development. To resolve this issue, this study's findings provide evidence to support that there are a small proportion of SMEs becoming well-connected during the development process (see Figure 7.1 and 7.2). And this study suggests that these small number of well-connect SMEs form a large number sparse structures of SME connections and interlocked structures of SME connections.

Figure 7.3 Three types of well-connected SMEs



There are three types of well-connected SMEs in Figure 7.1 and Figure 7.2. They are well-connected SMEs with sparse structures, well-connected SMEs with interlocked structure, and well-connected SMEs with further embedded interlocked structures (see

Figure 7.3). Well-connected SMEs with sparse structures are SMEs connecting the others. These SMEs are like bridges between the others. Without them, some SMEs would lose their connections to the SMEs cluster. Well-connected SMEs with interlocked structure are inter-connected SMEs. Those SMEs are connected one to all others. Contrasting to sparse structures, those SMEs do have any third party acting as bridges. Well-connected SMEs with further embedded interlocked structures are SMEs with more than one interlocked structure. It is necessary to explain why SMEs have more than one interlocked structure is a different structure from SMEs with interlocked structure. The reason is that SMEs have more than one interlocked structure connect well-connected SMEs. In other words, these SMEs may not connect with many SMEs, but they are connected with those well-connected SMEs. Therefore, SMEs with further embedded interlocked structures may be benefited from those well-connected SMEs in their development without having to manage large number of connections.

Table 7.2 The number of three types of well-connected SMEs

	Sparse	Interlocked	Further embedded interlocked
Beijing SMEs network	39	12	6
Shanghai SMEs network	37	17	9
Total	79	29	15

While there are 1188 connections formed 2184 sparse structures of SME connections and 230 interlocked structures of SME connections (see Table 1), however, this large of number sparse structures and interlocked structures are formed by a small number of SMEs (see Table 2). 79 well-connected SMEs formed 2184 sparse structures of SME connections. And 29 well-connected SMEs formed 230 interlocked structures of

SME connections. This indicates that there are a small number of well-connected SMEs rather than just a lot. Although there are a large number of sparse and interlocked structures, they are formed by a small number SMEs.

Table 7.2 shows that there are 39 well-connected SMEs with sparse structures in Figure 1 and 37 well-connected SMEs with sparse structures in Figure 7.2. Again these numbers are consistent with how many SMEs and connections in each network. Those SMEs can be found in the central area of Figure 7.1 and Figure 7.2. Without them, the whole network will be disconnected. Table 7.2 also shows that there are 12 well-connected SMEs with interlocked structure in Figure 1 and 17 well-connected SMEs with interlocked structure in Figure 7.2. These numbers are not consistent with how many SMEs and connections in each network. Figure 7.1 has larger number of SMEs and connections than Figure 7.2 has, however, there are less well-connected SMEs with interlocked structure in Figure 7.1 than Figure 7.2 has. There is debate about why bigger SMEs cluster tend to have less well-connected SMEs with interlocked structure. The reason is that the probability of having 'common friends' is small in a 'big world', but much higher in a 'small village' (Burt, 2007). The bigger a network is, the smaller chance of SMEs collaborating with common third parties. This is supported in this study's findings. Table 7.2 also shows that there are 6 well-connected SMEs with further embedded interlocked structures in Figure 7.1 and Figure 7.2 well-connected SMEs with further embedded interlocked structures in Figure 7.2. Again, these numbers are not consistent with how many SMEs and connections in each network. The bigger network has less well-connected SMEs with further embedded interlocked structures. It is the similar reason as why bigger SMEs cluster tend to have less well-connected SMEs with interlocked structure.

Previous literature suggested that well-connected SMEs are SMEs have a large number of connections with the others. However, this study's finding suggests that there could be three types of well-connected SMEs, sparse, interlocked, and further embedded interlocked (see Figure 7.3), but an interesting question remains that whether being well-connected SMEs relies on the number of connections they have. This study's finding suggests that the answer is no. This study suggests whether a SME is well-connected relies on how it structurally bonded with the others. Also only few of SMEs are well-connected in one type, they can actually be well-connected in these three types at the same time. Table 7.3 shows that 20% of well-connected SMEs have all three types, sparse, interlocked and further embedded interlocked. 18% of well-connected SMEs have all three types, sparse and interlocked. 62% of well-connected SMEs have only one type. Thus, SMEs can be multiple types of well-connected at the same time. The findings show that 38% of SMEs are not just being well-connected in one type.

Table 7.3 Multiple types of well-connected SMEs (79 well-connected SMEs in total)

Being sparse, interlocked and further embedded interlocked	**Being sparse and interlocked**	**Being sparse**
12 out of 79 well-connected SMEs	15 out of 79 well-connected SMEs	52 out of 79 well-connected SMEs

Table 7.3 shows what connection structures those well-connected SMEs have. There are in total of 79 well-connected SMEs in those two networks presented in Figure 7.1 and Figure 7.2. The results show that most of those well-connected SMEs have only sparse structures of connections, which is 62%, 52 out of 79 SMEs. This confirms the

point of previous literature (Narula, 2004; Burt, 2007; van de Vrande et al., 2009; Zeng, et al., 2010; Rosenbusch et al., 2011; Fernandez-Olmos and Ramirez-Aleson, 2017) which well-connected SMEs have sparse structures of connections. Then those well-connected SMEs are like bridges to connect the other in the network. The results also show that there is a significant number of well-connected SMEs have both sparse and interlocked structures of connections, which is 16%, 12 out of 79 SMEs. This findings challenges the point of previous literature (Narula, 2004; Burt, 2007; van de Vrande et al., 2009; Zeng, et al., 2010; Rosenbusch et al., 2011; Fernandez-Olmos and Ramirez-Aleson, 2017) which well-connected SMEs only have either sparse or interlocked structures of connections. The results suggest that SMEs can have both sparse and interlocked structures of connections. Then those SMEs are not only bridging the others but also inter-connected with some of them in the network. In addition, the results show that there is also a significant number of well-connected SMEs have sparse structures of connections, interlocked structure of connections, and further embedded interlocked structures of connections which is 19%, 15 out of 79 SMEs. This findings adds a new point on previous literature (Narula, 2004; Burt, 2007; van de Vrande et al., 2009; Zeng, et al., 2010; Rosenbusch et al., 2011; Fernandez-Olmos and Ramirez-Aleson, 2017) which well-connected SMEs do not only have sparse and interlocked structures of connections. They can also have further embedded interlocked structures of connections, which is a new type of being well-connected SMEs not mentioned in previous literature.

In sum, the number of well-connected SMEs is small during their development. The existing literature suggests that well-connected SMEs have a large number of connections. This study's finding suggests that there are three types of being well-

connected, sparse, interlocked, and further embedded interlocked. Thus, this study's findings are complementary to how SMEs can be well-connected.

7.3 Discussion 1: Well-connected SMEs

This study added three new tendencies of connections to well-connected SMEs. Rather than only building connections through connected SMEs, this study suggests that these connections are more likely to be built as sparse structures, interlocked structures, and further interlocked structures. This is complementary to previous theories in network dynamics. According to Burt's (2007) theory, SME networks do not stay static in SME development. Obstfeld (2005) suggested that changing network dynamics is a process of creating new connections between SMEs. Network dynamics is about introducing disconnected SMEs and facilitating connections between connected SMEs. In network dynamics, brokerages are ongoing activities rather than just static network structures. For example, there is a gap between SME B and C connected by A at the first stage. SME A acts as a broker between B and C (stage 2) and a new tie is built up between B and C (stage 3). Such brokerages (stage 2) connect the gaps between SMEs in the network. Then B can also become a broker to connect A and a new SME D (stage 4).

A similar dynamics in SME development is also suggested by Rogers (1995). Connections among SMEs over time are to combine different knowledge and skills. Such dynamics in SME development is described as a SME that has the relevant

knowledge or skills, another SME that does not yet have relevant knowledge or skills, and setting up a tie connecting the two. In a large network, this dynamics can apply to between one and several SMEs (Ostrom, 1994 and 1998; Gabbay and Zuckerman, 1998; Afuah, 2013; Garud, Tuertscher, and Van de Ven, 2013).

This study suggests that SME connection dynamics is not only about bridging the gaps between disconnected SMEs in different professional groups, but also building sparse, interlocked, and further embedded interlocked structures. During this process, the network can facilitate new coordination and information exchange between otherwise disconnected SMEs. Thus, SME connection dynamics are important in SME development. The positive influence of inter-firm connections in SME development activities is widely accepted in previous literatures (Burt, 1992 and 2007; Cross, et al., 2015; Schleimer and Faems, 2016). These literatures suggested inter-firm connections are among SMEs that invest in SME development to gain external knowledge and business resources. Furthermore, these studies recognized that knowledge and resource exchange among SMEs is the key determinant of SME development results. In response to the surge of inter-firm connections in SME development, some studies have analyzed inter-firm connections as networks by applying the network theory (Gulati, 1999; Rodan and Galunic, 2004; Gilsing and Nooteboom, 2005). They suggested that the positioning of SMEs and the structures of networks significantly affect their SME development results. However, the positioning of SMEs and network structures that is in place also influences how new connections are formed between SMEs. The existing empirical studies have not addressed this dynamics aspect of inter-firm networks. Therefore, this study suggests that previous inter-firm connections more likely influence the later connections.

7.4 Analysis result 2: Interconnected SMEs

This section presents the analysis result about interconnected SMEs. Interconnected SMEs are measured by the number of connections (degree centrality), network control power (betweenness centrality), network distance (closeness centrality), and connections with well-connected (eigenvector centrality). The following sections below will present these findings respectively.

Degree centrality shows to what extent a SME in the network is well-connected. Table 7.4 shows each SME's centrality in the network. As discussed in the methodology part, centrality measures can be used to describe the network structure. The result in Table 7.4 shows that inter-connected SMEs have large number of connections, which can be seen in the degree centrality.

Table 7.4 Average centrality

	Degree	Closeness	Betweenness	Eigenvector
Interconnected SMEs	96	3	93	95
Non-interconnected SMEs	1	7	2	2

The results show degree centrality for both interconnected SMEs and non-interconnected SMEs. Inter-connected SMEs have averagely 95 more connections than non- interconnected SMEs. Thus, this study suggests that the network is in a form of that most of interconnected SMEs have large number of connections. This

new finding will challenge the existing literature about the network is either loosely (Burt, 2004) or fully connected (Uzzi, 1996). This study suggests neither loosely (Burt, 2004) nor fully connected (Uzzi, 1996) fits the context of SME development in this case. In the context of SME development, this study suggests that the network appears as those interconnected SMEs have most of the connections.

Betweenness centrality shows the power of network control. SMEs have a high power of network control which can be seen in the betweenness centrality. The result in Table 7.4 indicates that there is big difference between inter-connected and non-interconnected SMEs. Although there are lots of SMEs in the network, but only a few of them can control the network. They are the well-connected SMEs. Also, it is noticed their network control power is absolutely high. Averagely, each interconnected SME control 93 connections between non-interconnected SMEs by providing connections between them. This finding is against the existing literature about SME development is a free and independent process.

Table 4 also shows that SMEs are very close to each other in the network, which can be seen from the closeness centrality. The longest distance to connect to a SME in the network is through no more than 7 SMEs in the middle. The result in Table 7.4 shows that SMEs are very close to each other in the network and toward to be closer to each other in the network during their development, which can be seen from the closeness centrality. Due to a large number of SMEs in the network, this network is a very dense network with short network distant between SMEs. More important, this study suggested that SME network is a "small world" network characterised by short path lengths. This study applied the network perceptive to analysing SME connections in

their development. The result suggested the "seven degrees of separation" in network that any two SMEs may be linked by no more than seven SMEs in the middle. For those interconnected SMEs, the network distance is even shorter by no more than three SMEs in the middle.

Table 4 indicates well-connected SMEs are connected to each other in the network. This can be seen in which can be seen in the eigenvector centrality. Well-connected SMEs have much higher eigenvector centrality value than non-well-connected SMEs. Well-connected SMEs are inter-connected like a cluster. In the context of SME development, this study suggests that the network appears well-connected SMEs are inter-connected. All well-connected SMEs tend to have high eigenvector centrality scores. Also, well-connected SMEs are not only bridging other SMEs otherwise disconnected, well-connected SMEs are also inter-connected like a cluster. This new finding will fill the gap in the literature about the relationships between well-connected SMEs in SME development.

In summary, the findings of interconnected SMEs are:

1) Most of connections in the network belong to interconnected SMEs.
2) Interconnected SMEs have a high power of network control.
3) SMEs are very close to each other in the network.
4) Well-connected SMEs are inter-connected.

7.5 Discussion 2: Interconnected SMEs

SME connections among interconnected SMEs are crucial to SME development. Previous literature suggests connections are more likely to be built between SMEs during their development (Burt, 2007). However, this study's finding suggests that those connections are more like to be built between well-connected SMEs to form interconnected clusters. In SME development, there are a great amount of connections between well-connected and non-well-connected (Bayat, Schøtt, and Zali, 2014). These connections between SMEs in the integration of knowledge and skills and create new SMEs (Shazi, et al., 2015). However, this study's finding suggests that most of connections in the network belong to interconnected SMEs.

Interconnected SMEs have a high power of network control by providing connections between non-well-connected SMEs. When SME development requires connections with the others, connection building is usually a free and independent process between two SMEs (Adler, 2001; Adler and Kwon, 2002; Oh, et al., 2006; Bayat, Schøtt, and Zali, 2014). However, this study's finding is against this point. The network control power is from those interconnected SMEs. Those interconnected SMEs are mutual third parties bridging the gaps between disconnected SMEs. Although this regularity of network dynamics has been proposed, the challenge is how to bridge disconnected SMEs in larger and complex networks. A large and complex network consists of a large number of SMEs. SME connections rely on interconnected SMEs (Burt, 2007). Burt (2007) showed that inter-connections are associated with SME development. Most of not well-connected SMEs are connected by those interconnected SMEs in

networks. SME networks are not organised in hierarchy structures which are led by some firms. However, interconnected SMEs are placed in the middle between most of firms in networks. Although each SME is highly interdependent and work on concurrent activities, connections are still controlled by those interconnected SMEs. Thus, SME networks are featured in non-hierarchical structure but centralised network control power. This can be reflected from the betweenness centrality.

SMEs are very close to each other in their network. Walker et al. (1997) analysed how resource endowments contribute to SME's network position. They found that initial resource endowments do not significantly affect those SME development outcomes but significantly affect SME's network position. A similar finding was also suggested by Burt (2007), who found that the tendency of connecting SMEs in close SME's network positions during their development. Complementary to this point, this study's finding suggests SMEs can be connected to each other through no more than seven SMEs in the middle.

Well-connected SMEs are becoming inter-connected during SME development. The major barrier to analysing SME clustering activities is how to conceptualise dynamics (Newell, et al., 2004; Burt, 2007; Aalbers, et al., 2013). In networks, this dynamics is highly complex and unclear. SMEs are connecting to each other concurrently. Thus, the tendency of which SMEs are connecting to which is the key pattern of dynamics (Nebus, 2006; Burt, 2007). It is important to find out how to the tendency of which types of SMEs are more likely to be connected. Thus, the analysis of network dynamics focuses on the tendency of SME connections. Researchers such as Podolny and Baron (1997) and Rodan and Galunic (2004) suggested that those well-connected

firms are critical in connecting the others in networks. However, this study's finding suggests that those well-connected SMEs are more likely to connect to each other. And those interconnections are not static in SME development. Burt (2007 and 2015) suggested that the firms are central in networks are more likely to connect to each other. This study's finding is against this point. Those firms are central in networks since they are well-connected. This finding is also against the previous literature about how those connections are developed in networks (Obsfield, 2005), how SMEs are connected each other (Ibarra 1993; Stolle, 1998; Stolle and Rochon, 1998; Starkey and Tempest, 2004), and how the structures of network influence the future structures (Chung and Gibbons, 1997; Podolny and Baron 1997). Network studies (Podolny and Baron, 1997) also suggested that there are a large number of connections between SMEs in the center of network. These connections are not between SMEs in the center of network. They are between those well-connected SMEs placed at the intersection between the others.

This study makes contribution to the literature on inter-firm connections in SME development by analysing the formation of new SME connections. The results demonstrate the impact of previous inter-firm connection structures on the formation of new connections. And this study explained how SME networks emerge in SME development. Although previous research have analysed inter-firm connection structures that can influence SME development, there was lack of explanations about how SME networks are connected and structured. The results suggest that SMEs search for new inter-connections through SMEs from previous collaborations. The results also suggest that well-connected SMEs attempt to form dense networks.

7.6 Analysis result 3: Connected brokerage roles

Table 7.5 shows the results of regression modelling. The data were separated into every 6 month period between 2011 to 2015. As discussed earlier, the previous each SME's number of connections, number of inter-connections, and brokerage role can influence their connections in the later period of 6 month.

Table 7.5 Regression results

Constant	-11.692
	(0.512)
Number of connections	0.592**
	(0.216)
Closeness of inter-connections	
Through one SME in the middle	2.6923**
	(0.317)
Through two SMEs in the middle	2.2688**
	(0.295)
Through three SMEs in the middle	1.8235**
	(0.192)
Through four SMEs in the middle	1.197**
	(0.112)
Through five SMEs in the middle	1.1992**
	(0.107)
Through six SMEs in the middle	1.1985**
	(0.102)
Brokerage role similarity	-2.5918**
	(1.265)

$N = 1056$; $\dagger p \leq 0.1$; $^{*}\ p < 0.05$; $^{**}\ p < 0.01$; Robust standard errors in parentheses

The results in Table 7.5 show that the number of connections in previous 6 month period is positively influence the number of connections in later 6 month period. This means the more SMEs connections in previous 6 month period the more SMEs connections in the later 6 month period. This finding is consistent with previous

research about consistency of SMEs connections in time periods (Burt, 2007; Cross et al, 2015; Gargiulo and Sosa, 2016). The results also show that the number of connections can positively influence the number of interconnections. This means the more SMEs connections the more interconnections among them. In other words, well-connected SMEs are likely to be interconnected with each other. This finding adds a new point to the previous literature (Burt, 2007; Cross et al, 2015; Gargiulo and Sosa, 2016) which did not mention the relationship between well-connected SMEs and interconnected SMEs. Also, the results show that brokerage role similarity in the previous period can negatively influence the number of connections in the later period. This means connections between SMEs with similar brokerage roles are unlikely to happen. SMEs with similar brokerage roles are unlikely to be connected. On the other hand, SMEs with different brokerage roles are more likely to be connected. This finding adds a new point to the previous literature (Burt, 2007; Cross et al, 2015; Gargiulo and Sosa, 2016) which did not mention how SMEs' brokerage roles can influence SMEs connections.

In the model, the results show that the number of connections in previous period is positively associated with the number of connections in later period ($\beta = 0.592$, $p = 0.001$). This finding is consistent with previous research (Burt, 2007; Cross et al, 2015; Gargiulo and Sosa, 2016). The model also shows that the correlation between number of connections and interconnections is positive and significant, meanwhile brokerage role similarity in the previous period is negatively associated with connections in the later period ($\beta centrality = -2.5918$, $p = 0.001$). This finding adds a new point to the existing theories (Burt, 2007; Cross et al, 2015; Gargiulo and Sosa, 2016).

The results support the three hypotheses (see Table 7.6). While the model shows 1) well-connected SMEs get more connected, 2) well-connected SMEs get more interconnected, and 3) SMEs with different brokerage roles tend to connect together. This study's finding confirms Uzzi (1996 and 1999) and Burt's (2007) theories discussed in the theoretical framework. Brokering activities are about bridging the gaps between SMEs in the network. Moreover, this study adds a new point about SMEs with different brokerage roles tend to be connected together.

Table 7.6. Summary of findings

Well-connected SMEs get more connected	Hypothesis 3.1 supported
Well-connected SMEs get more interconnected	Hypothesis 3.2 supported
Differences in brokerage roles	Hypothesis 3.3 supported

Table 7.6 summaries the results of hypothesis testing. First, well-connected SMEs get more connected. This is supported by the positive correlation between the number of connections in previous period and the number of connections in later period in Table 7.5. This means the more number of connections a SME had in the previous time the more number of connections it will have in the later time. Thus, this supports well-connected SMEs get more connected. Second, well-connected SMEs get more interconnected with each other. This is supported by the positive correlation between

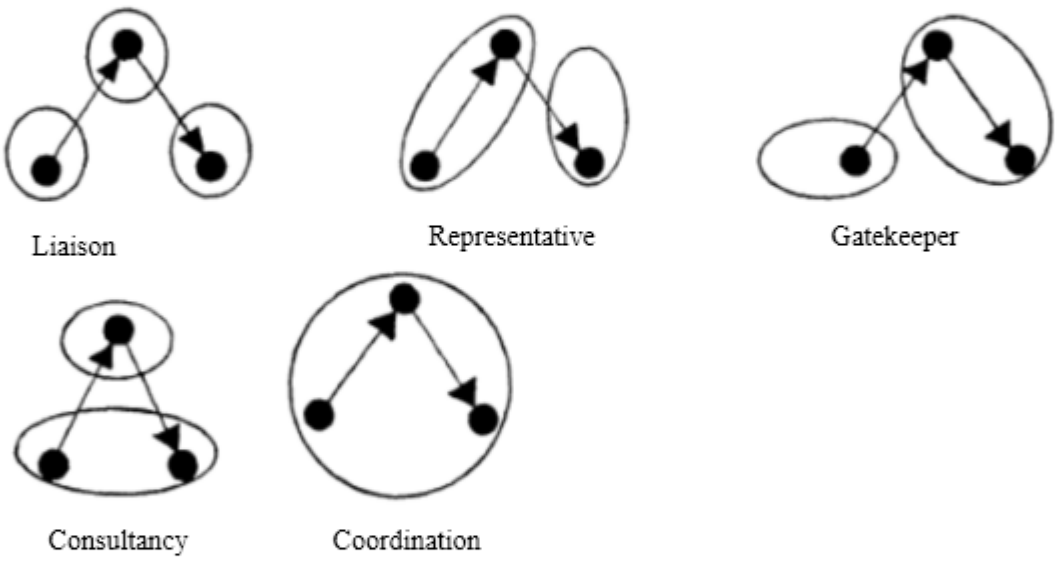
the number of connections in previous period and the number of inter-connections in later period in Table 7.5. This means the more number of connections a SME had in the previous time the more number of inter-connections it will have in the later time. Thus, this supports well-connected SMEs get more interconnected with each other. Third, SMEs with differences in their brokerage roles are more likely to be connected with each other. This is supported by the negative correlation between the brokerage similarity and the number of connections in Table 7.5. This means SMEs with similar brokerage roles are unlikely to be connected with each other, on the other hand, SMEs with different brokerage role are more likely to be connected with each other.

7.7 Discussion 3: Connected brokerage roles

As mentioned in the previous literature review, five types of brokers were defined by Gould and Fernandez (1989). They are "liaison", "representative", "gatekeeper", "consultancy" and "coordinator" brokers. However, it is not clear that how they are connected with each other during network dynamics. The findings of this study suggest that SMEs with different broker roles tend to connect together see (Figure 5 and 6).

In network typology, Gould and Fernandez (1989) suggested five independent types of brokers in the networks. In Figure 7.4, the nodes represent SMEs. The lines between the nodes represent SME connections. The circles around the nodes represent the boundary between different types of firms, for example, the boundary between design and engineering groups. In network theory (Burt, 2007), networks can be analysed by using brokerage scores to measure each firm's broker activities.

Figure 7.4 Five types of brokers (adopted from Burt, 2015)



However, brokers' roles are not clearly identified in networks. Each brokerage role is identified independently. The relations among them are not clear. Thus, this study argues that the combinations of these brokerage roles need to be clarified. Each professional group in network has brokers as an interface and structural boundary. Podolny and Baron (1997) suggested that connections among SMEs between professional groups appear as the interface. Connections at the interface are brokers and SMEs from different professional groups can be connected by a few brokers (Zou

and Ingram, 2013). Also, there are other studies suggested that the brokerage process in SME network is crucial since it can turn the information exchange paths between SMEs into short length (Coleman, 1988; Granovetter, 1992; Dyer and Singh, 1998). Therefore, this study focuses on SME connection dynamics between different firm brokerage roles.

Figure 7.5 shows that there are very weak connections between SMEs with similar brokerage roles. The probability to have a connection between two liaison SMEs is 0.1%. This means there is only 1 connections between two SMEs with liaison roles in the data which covering 1056 SMEs with 1188 connections. There are similar results in connections between SMEs with gatekeeper roles and also coordination roles. For SMEs with representative roles and also consultancy roles, the probability is 0.1% and 0.2%. This means there is only 1 or 2 connections between two SMEs with representative roles or consultancy roles in the data. Overall, this suggests that it is very unlikely to have connections between SMEs with similar brokerage roles.

Figure 7.5 Connected brokerage roles: Probabilities of connections between similar roles

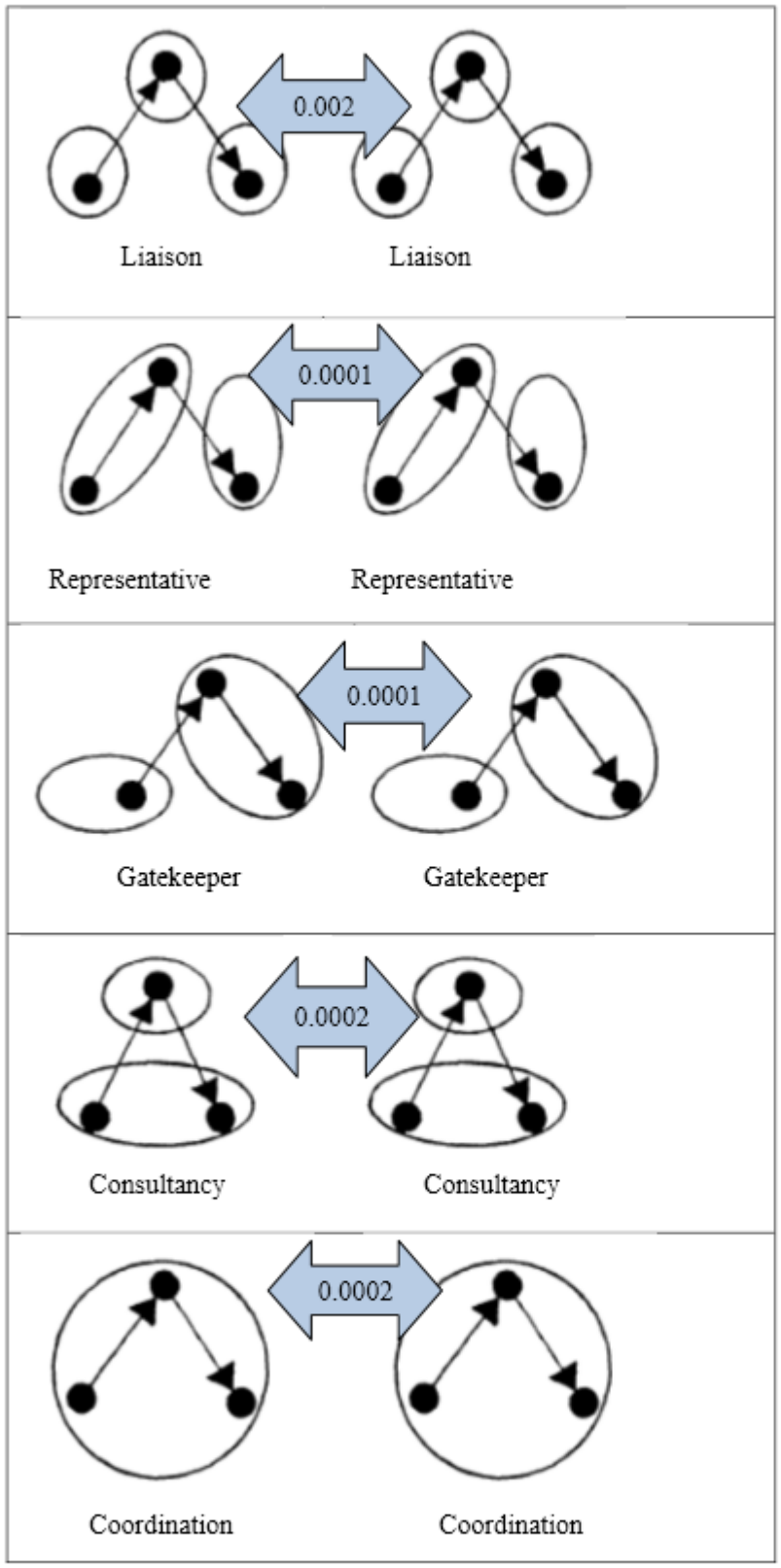


Figure 7.5 shows the probabilities of SMEs with similar brokerage roles to be connected with each other. If two SMEs both have liaison roles in a network, the chance they can be connected is 0.2%. This means they are very unlikely to be connected with each other in a network. If two SMEs both have representative roles in a network, the chance they can be connected is 0.1%. Again, this means they are also very unlikely to be connected with each other in a network. If two SMEs both have gatekeeper roles in a network, the chance they can be connected is 0.1%. Then chance they can be connected with each other is very unlikely. If two SMEs both have consultancy roles in a network, the chance they can be connected is 0.2%. They are also very unlikely to be connected with each other. If two SMEs both have coordination roles in a network, the chance they can be connected is 0.2%. This also suggests they are very unlikely to be connected with each other. Overall, the results in Figure 5 suggest that SMEs with similar brokerage roles are very unlikely to be connected with each other. This adds a new point on previous literature (Narula, 2004; Burt, 2007; van de Vrande et al., 2009; Zeng, et al., 2010; Rosenbusch et al., 2011; Fernandez-Olmos and Ramirez-Aleson, 2017) which did not mention how brokerage roles can influence the chance of SMEs to be connected.

On the other hand, there is much bigger chance to have connections between SMEs with different brokerage roles (see Figure 7.6). For example, there is 23% chances to have connections between liaison and representative SMEs, consultancy and

representative SMEs, and also consultancy and gatekeeper SMEs. The chance to pair consultancy and coordination, coordination and gatekeeper, liaison and gate keeper is 25%. There is 22% chances to have liaison and coordination connections as well as representative and gatekeeper connections. Also, the probability to have liaison and consultancy connections or representative and coordination connections is 21%. These are much higher than having connections between SMEs with similar brokerage roles which is no more than 0.2%. Therefore, this study's finding suggest that SMEs with different brokerage roles are more likely to connect to each other, and that SMEs with similar brokerage roles are unlikely to connect to each other.

Figure 7.6 Connected brokerage roles: Probabilities of connections between different roles

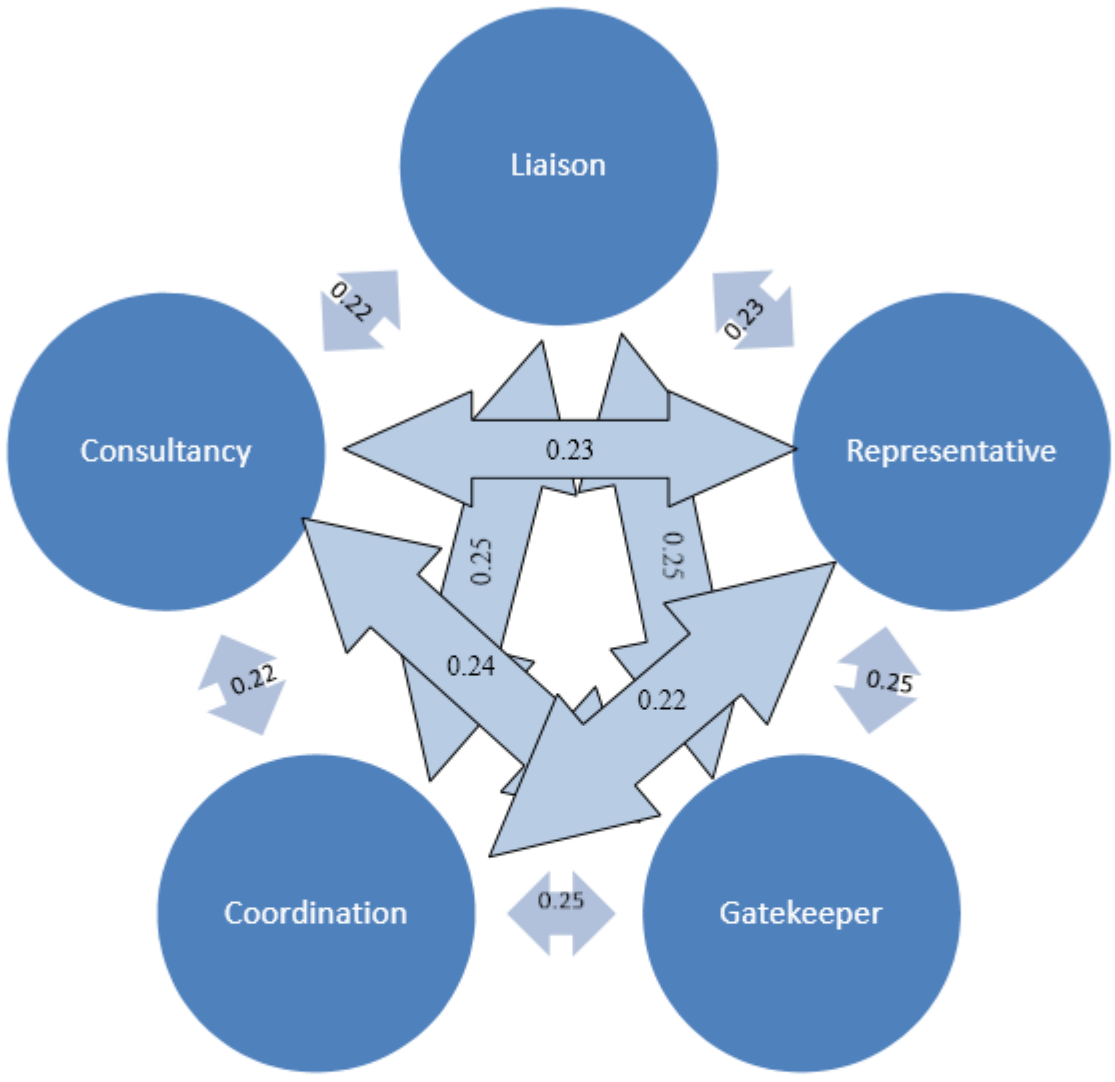


Figure 7.6 shows the probabilities of SMEs with different brokerage roles to be connected with each other. The results suggest that a SME with liaison role and a SME with representative SMEs are likely to be connected with 23% of chance. Also, a SME with consultancy role and a SME with representative role can be likely connected with each other with 24% of chance. In addition, a SME with consultancy

role and a SME with gatekeeper role have 22% of chance to be connected with each other. The chance for a pair of SMEs with consultancy and coordination role, coordination and gatekeeper role, or liaison and gatekeeper role is 21%. This means they are likely to be connected with each other in a network. There is also 25% chance for a pair of SMEs with liaison and coordination role or representative and gatekeeper role to be connected with each other. The chance to have a pair of SMEs with liaison and consultancy role or representative and coordination role to be connected with each other is 23%. Overall, the results in Figure 6 suggest that SMEs with different brokerage roles are likely to be connected with each other. This adds a new point on previous literature (Narula, 2004; Burt, 2007; van de Vrande et al., 2009; Zeng, et al., 2010; Rosenbusch et al., 2011; Fernandez-Olmos and Ramirez-Aleson, 2017) which did not mention how different brokerage roles can increase the chance of SMEs to be connected.

7.8 Summary

Overall, this study discovered how the number of connections, being well-connected, and brokerage roles can influence SMEs network dynamics. The results suggest SMEs networks evolve during time in three ways. First, those SMEs with large number of connection get more and more connections with the others in the network. Second, those well-connected SMEs with large number of connection get to be

connected with each other. Third, more importantly, those SMEs with similar brokerage roles do not tend to connect with each other in a network. Instead, those SMEs with different brokerage roles tend to connect with each other in a network. These three findings can help to understand how SME network evolve during time and predict the structures of SMEs networks in future. Obviously, SMEs networks do not evolve in a random way. Those connections are strategic choices. For example, those well-connected SMEs with sparse structures, they are benefited from bridging the other otherwise disconnected SMEs in their growth. This will be showed in the later findings about the influence of SMEs networks. Also, those well-connected SMEs tend to be interconnected with each other. It looks like they are forming a winners club together in their growth. This will also be showed in the later findings about the influence of SMEs networks. In addition, SMEs' brokerage roles can be used to predict the chance of that a pair of SMEs are connected or not. The findings show that SMEs tend to be connected with SMEs with different brokerage roles. This suggests SMEs are looking for complimentary partners rather than similar partners. Difference means good here, similarity means unnecessary more likely. Again, this may shed a light on SMEs connections are strategic choices rather than random pairing. SMEs are looking for what are valuable to them in their networks. It is worthy to mention again about the cost of SME connections. Each connection is a financial commitment. In this case, SMEs will tend to get the most out of it. Thus, the value of each connection to them is the driven force of their strategic choices.

Theory wise, this study suggests SME network dynamics are following three rules: first, the well-connected SMEs get more and more connections, second, well-connected SMEs tend to be connected with each other, third, SMEs with similar brokerage roles are unlikely to be connected with each other, instead, SMEs with different brokerage roles are more likely to be connected with each other. These three new points can help to improve the theories (Narula, 2004; Burt, 2007; van de Vrande et al., 2009; Zeng, et al., 2010; Rosenbusch et al., 2011; Fernandez-Olmos and Ramirez-Aleson, 2017) in the dynamics of SME networks and connections. If a moment of a SME network is just a frame of picture in a series of motion pictures, then the next moment can be predicted by these three rules. Although these three rules are not able to get a prediction totally right, but they can still help a prediction to be less wrong.

Network theories suggested that the gaps between SMEs in their networks can be strategically bridged and contribute to SME development outcomes. Network theories have been adopted to explain the structures of SME connections. However, the structures of SME connections are the results of SMEs connecting with each other. The dynamics happened before the structures are formed in SME networks. Thus, it is necessary to carry on analysis about network dynamics. This study provides an analysis of network dynamics of SME collaborations in SME development. The findings suggest that SME networks dynamics has three tendencies. First, well-connected SMEs get more connected and extensive connections with increasing

number of connections. Second, well-connected SMEs get more inter-connected so that SME networks get more clustered. Third, SMEs with different brokerage roles tend to connect with each other.

In summary, tendencies of SME connections are as follows.

- First, SME networks are densely connected and inter-connected. This can be seen in the results about the average number of each firm's connections and inter-connections.

- Second, well-connected firms tend to be inter-connected. This means firms tend to be clustered in less number of larger groups.

- Third, the analysis considered brokerage role similarity as a variable in network dynamics. The results suggest firms with different brokerage roles are more likely to connection with each other.

Theorising SME networks is not only about collaborative connections, but also influences, structures and dynamics. This study focuses on these three new parts of network theory. The results of this study show that SME networks have regular influences, structures, and dynamics. In this study's conclusion, these regular influences, structures, and dynamics are presented in regression modelling and network pictures.

Chapter 8 Conclusion and implications

8.1 Introduction

This chapter discusses the final conclusions of this study, including the implications of this study's findings, limitations, the differences between this study and previous research, and recommendations for future work. The main findings and discussion of this study have already presented in earlier chapters. This conclusion chapter is drawn from the results of each of earlier chapter to show the significance of this study for knowledge and practice.

Section 8.2, 8.3 and 8.4 are to identify and demonstrate the implications of this study. They are to answer the question what this study's findings mean to theory, research method, and practice. Section 8.5 discusses the limitations of this study. While presenting confidence regarding to this study, this section discusses methodological restrictions and issues in practical realities. Section 8.6 summarises the distinguish features of this study from previous research. This section does not only point out what this study adds to theory, but also the arguments this study made. Finally, section 8.7 offers some recommendations for future research in this area.

8.2 Contributions to theories

This section provides a summary of the three finding chapters about sparse and interlocked connections (see Chapter 5), brokerage and centrality (see Chapter 6), and network dynamics and structures (see Chapter 7). And then this section discusses this study's implications to theory. Most of the theories in SME management focus on cause and effect. The process of SME development has been ignored. The process here means a movement, action, or event can recur and create various and complicated results. Most of the theories separate the cause from the process. In those theories, scholars usually explain SMEs development outcomes in a way of cause-process-effect. Thus, this study suggests that networks as complex processes rather than causality. From this network perspective, this study adds knowledge to complex processes in SMEs development rather than causality only.

SMEs development is defined as increasing the supply of products and services, providing sustainable quality of life and structure of economy, adopting sustainable ways of production, finding new sources of supply, and even exploring new markets (Stiglitz, 2016). SMEs development is also defined as a transformation process of turning market opportunities into available products and services (Badaracco, 1991; Krishnan, Ulrich, and Karl, 2001), achieving sustainable and competitive success

(Drucker, 1985), and improving productivity in business (Rao, et al. 2001). In general terms, SMEs development is a process which leads to SMEs growth. However, this study argues that SMEs usually do not develop alone. They work with other organisations together. Thus, this study focuses on the relations between SMEs co-development and their revenue growth. In relation to SMEs co-development, previous research often argued that SMEs can benefit from inter-firm connections in their development (Burt, 2015; Baker, et al., 2016). In an environment where knowledge is difficult to access, inter-firm connections enable SMEs to combine their knowledge and skills to achieve SMEs development. This study shows that what are the structures, dynamics, and influences of inter-firm connections in SMEs development. Thus, the findings of this study can improve the understanding of inter-firm connection structures, dynamics, and influences in SMEs development.

The links between the finding chapters (see Chapter 5, 6 and 7) are SME inter-firm connection influences, structures, and dynamics. Chapter 5 tested what the relations between SME connections and revenue growth are. As a result of SME connection influences, the network structures are very complex in the network snapshots. Therefore, the SME connection structures were further explored in Chapter 6 to find out how SMEs are connected with each other in their co-development. One regular pattern in the SMEs networks is centrality due to the increase of connectivity. In terms of centralities, SMEs are more inter-connected together. The other regular pattern in the SMEs networks is brokerage. Chapter 6 provided the details of sparse (five types

of brokerage) and interlocked (four types of centrality) structures of SME connections. Then, Chapter 7 explored how a network evolves from few connections to a large number of highly complex sparse and interlocked connections during the progress of SMEs co-development. In these three finding chapters, this study provided further understanding about the relations between the inter-firm connections and SMEs development results. And, this study added knowledge to the influences, structures, and dynamics of SME connections. Therefore, this study's contributions to SME connections are: SME connection influences, structures, and dynamics.

8.3 Contributions to research methods

This section discusses this study's implications to research methods. This study's findings are the results of network analysis. Network analysis has been adopted to analyse SME activities in regards to how networks influence performances (Burt and Minor, 1983; Law and Callon, 1992; Portes, 1998; Burt, 1992, 2004 and 2007). This study adopts network analysis to analyse how SMEs are connected together in their development by focusing on the influences, structures, and dynamics of SME connections in their co-development. First, network regression modeling is used to test the relations between inter-firm connections and SMEs development results. Second, network structures wise, network analysis is used to find out the regular

connection structures among SMEs. Third, network dynamics is interpreted by the tendencies of connections to show which SMEs tend to connected with together in networks.

The analysis conducted in this study is a possible way of predicting network dynamics and structures in SMEs development. This study suggests that SMEs co-development can be investigated from a network perspective. Network analysis can be used to predict and elaborate SMEs development outcomes and the structures of SME connections. This study has provided evidence to prove that how SMEs development outcomes are related to their networks and how latter network structures are related to the previous network structures in time. Thus, this study suggests that network could be an important indicator of SMEs progress.

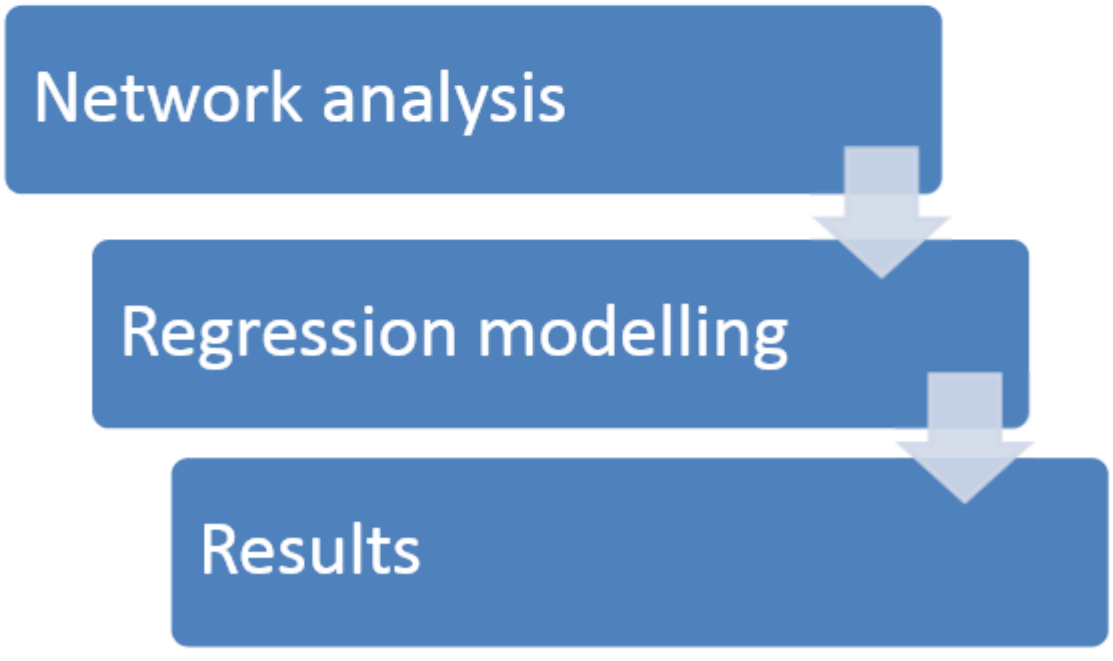


Figure 8.1 'Three-layer' analysis

This study adopted a 'three-layer' analysis. The advantage of this 'three-layer' analysis is similar to the idea of big data. Big data as a data analysis tendency has become very popular in the recent years. The fundamental advantage of big data is not the amount of data. It is the analysis of data generated by data. In this study, data generated by data is the network data generated by the collected data. For prediction purposes, it has been proven that results from big data are usually more accurate and contain more information. This 'three-layer' analysis approach also transfers the focus from cause-effect to network as process and links the SMEs networks with their development outcomes. Thus, this study contributes to research method by combining network analysis and hypothesis testing.

8.4 Contributions to practices

This section discusses this study's general implications to practice in SME management. This study provided information about how SME networks influence their development outcomes. This study also suggests that sparse and interlocked connections are important to SMEs development. Sparse and interlocked connections show how to organise collaborations in SMEs clusters. Thus, this study's results improve the understanding of managing SME collaborations in practices.

Here, it is necessary to point out two features of using this study's network model in practice. First, the network is not only a way of presenting the data but also a perspective. SMEs development process should be re-considered, moving away from a sequence of events to a complex but manageable structure of inter-firm level interactions. Studies treating network as a new perspective (Tasi, 2001; Perry-Smith and Shalley. 2003; Brass et al., 2004; Kilduff and Brass, 2010) emphasised relations in networks, the interaction in social relations, dyadic relations, complex structure of connectivity, and network connections as firm development outcomes' indicators. The results of this study's analysis presented the processes of SMEs development and suggested network as indicators to performance. Second, the network is not just about structure, because the processes of SMEs development. SME networks certainly exist in a dynamic way rather than a static image. The findings about network dynamics suggested the changes in SME networks are not random. The useful details of SME network dynamics can be captured in the network and applied in future practice. Previous studies (Podolny and Page, 1998; Podolny, 2001) argued that a new form of organisation can be studied through networks. This network form of organisation could not be classified as static or hierarchy. This study's results showed that SMEs as a network form of organisations can improve performance by having sparse and interlocked connections with others.

8.5 Limitations

This section discusses the strength and limitations of this study, the advantages of network and what networks are incapable. This study conceptualised complex SME activities in collaborations into connections in networks. However, the content of SME connection is not the same. For example, each information exchange between two firms adds new information to the connection between them. This is related to the individual level of interactions between people in SMEs development. The networks in this study are incapable of explaining such interactions. Also, SME failure could be caused by competition, policy change, or simply just some accidents. In these situations, it might still need qualitative research to be carried out.

Network data has a fundamental issue has been mentioned. The structure of the network is represented by numbers. Network data usually are binary data, contain only 0 and 1. 0 means no tie between firms. 1 means a tie between two firms. 0 and 1 here are also probabilities in modeling. The issue about network data is that the probability about an active tie or no tie implies that SME connections sometimes can simultaneously exist and not exist. For instance, 0.75 means there is 75 percent chance of a tie between two SMEs. However, this also indicates that SME connections are simultaneously exist and not exist. This is because integers will be broken into decimals after several rounds of analysis. When interpreting the analysis

results, this makes networks simultaneously exist and disappear, since these numbers are probabilities of SME connections. Trying to round the numbers will lose accuracy. Thus, further research is required to find out how to interpret or avoid this.

8.6 Differentiating this study from previous research

This study makes contribution to network theories (Burt, 1992, 1997, 2004, 2007, 2014 and 2015; Uzzi, 1996 and 1999) by finding out how networks can influence SMEs development outcomes. The importance of networks in firm development has been recognised by scholars (Burt, 1992 and 2004; Podolny et al., 1996; Reagans and Zuckerman, 2001; Tasi, 2001; Leven, et al., 2014). A gap in the theories is what kind of firm connections in networks can influence firm development outcomes.

Consistent with these previous studies, this study's method is based on network analysis. Comparing the previous studies focusing on some specific moments of networks, this study's results cover a time period to reveal SME network dynamics, structures and influence. The results of this study showed the evolvement of collaborations between SMEs step by step. Firstly, this study provided findings of network dynamics. It is recognised that network analysis is particularly useful in the early stages of "new exploratory investigations (Borgatti, 2011). The findings of

network dynamics demonstrated the regular patterns of the network. Secondly, the findings of network structures provided the details of SMEs networks. Network analysis has advantages in providing greater opportunities for in-depth observation of inter-firm level activities. Finally, this study provided results about network influences. Table 8.1 summarises related research and their research questions and findings.

Table 8.1 Related research and their research questions and findings

Previous literature	**Research questions and findings**
Research about the structure of connections in firm development: Walker, et al., (1997); Tsai and Ghoshal, (1998); Tsai, (2000); Gilsing and Nooteboom, (2005); Ibarra, et al., (2005); Burt, (2015); Cross et al., (2015); Gargiulo and Sosa, (2016)	Research question: What are the effective structures of inter-firm connections? Findings: Sparse and interlocked connections are effective structures in firm development, however, firms have to balance their connection structures between sparse and interlocked. This study suggests that firms do not need to balance their connection structures between sparse and interlocked. They can have sparse and interlocked with different firms.
Research about the dynamics of connections in firm development: Granovetter, (1985); Krackhardt, (1992); Nohria and Eccles, (1992); Uzzi, (1996 and 1999); Reagans and Zukerman, (2001); Pittaway, et al., (2004)	Research question: How do networks evolve in firm development? Findings: Networks evolve as 'bridging firms' disconnected firms. This study suggests that network dynamics is not only about bridging firms but also being interlocked together in the network.
The influence of firm connections are highlighted by Borgatti, and Everett, (1999), Borgatt (2011), and Burt (1997 and 2007)	Research question: Do sparse and interlocked connections positively influence on SMEs growth? Findings: Sparse and interlocked connections can positively influence on SMEs growth. This study suggests that sparse and interlocked connections can positively

	influence on SMEs growth, and jointly, they can provide extra positive effect.

Different from previous research, this study identified the weaknesses in the existing network theory and provided a conceptual contribution. This study suggests that the existing network theory has weaknesses in explaining network dynamics, structures, and influences. And this study demonstrated that network dynamics is not only about bridging firms but also being interlocked together in the network. This study also suggests that the existing network theory has weaknesses in explaining network structures. And this study demonstrated that network structures is not only about brokerage but also a group of centrally located firms as five types of brokerage and four types of centrality. Thus, SME networks in this study provided more details of SMEs activities.

8.7 Implications to stakeholders

This study presents three results which have implications to stakeholders, including business managers, policy makers and investors. The first one is SME network dynamics, which shows how SMEs are connecting with others during their development. It suggests that the collaborations between SMEs from different industrial sectors are important throughout the whole development process. The

second one is SME network structures. It shows that how SMEs play the roles of brokers connecting others and work together. There are five types of brokers can placed in sparse connections to improve SMEs development outcomes. They are liaison, consultancy, coordination, representative, and gatekeeper brokers. The third one is SME network influence. The finding shows that sparse and interlocked connections can contribute to SMEs development outcomes significantly. This highlights the importance of SME connections to practices.

This study's implication to SME management practices is a network model showing how to manage SME collaborations. In practice, SMEs can use the network model to manage the large-scale of collaborations across organisational boundaries. In practice, this model shows how effective connecting to networks and the influences on financial outcomes. SME network structures can be various in the processes of collaborations. This study suggests sparse and interlocked connections as efficient connections. Also, this study's network model highlights five types of brokerage in sparse connections and four types of centralities in interlocked connections can influence financial outcomes. Thus, the results of this study can be used as a guide on how to organise collaborations between SMEs.

8.8 Future research

Further research can improve this study's model with more data cross different sections and context. This study's results show the importance of combining various inter-firm connection structures in the context of SMEs. These results can be more generalised with similar data from different business contexts. This study began with the idea using network analysis to investigate SMEs development process to fill the gap in the previous research. Although network theory has been suggested by Borgatti (2011), this study suggests that network should not only be treated as a theory but also as a method. Further research in this area has two promising directions, outlined below.

The first future research direction is about the nature of SME connections in networks. For example, the financial contribution ties can also be classified by the sources of finance. Similarly, information exchange ties can be considered as another type of connections. The second future research direction is the simulation of network dynamics with a large data set. This can offer a prediction of the sequence of SME activities. This study used data based on OECD database. A large data set with more time points in the data can enable more detailed research. This will provide more detailed information about how SME networks evolve. Network dynamics has been a

cutting-edge issue in network research. A large data set can be used for analysis of network dynamics to find out more regular patterns of SME network evolution.

8.9 Summary

This study provided three findings. These three findings are 1) the influence of sparse and interlocked connections, 2) five types of brokerage as sparse connections and four types of centrality as interlocked connections, and 3) the structures and dynamics of SME connections.

Finding 1: The influence of sparse and interlocked connections

First, this study provided answers to the question how SME connections influence their development outcomes. SME networks have a significant influence on their development outcomes. After adding the network variables in the model, the model can explain about 70 percent of outcomes which can be considered as a robust model. Especially, sparse and interlocked connections alone can influence about 30 percent of SME development outcomes.

Finding 2 Five types of brokerage and four types of centrality

Second, this study identified the regular patterns in sparse and interlocked connections. This study suggests they are a combination of five types of brokerage and four types of centrality. This finding has a contribution to the theories about network location advantages.

Finding 3 The structures and dynamics of SME connections

Third, this study identified the regular structural patterns in SME connections. This study suggests the regular patterns in SME network dynamics are not only bridging firms but also tendency to be interlocked and connecting to different brokerage firms. This adds new theory in the area of network dynamics.

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