SMEs, Growth, and Networks:

Understanding the Missing Links

Content

Abstract

This study examines the relationship between SME connections and their growth. Small and medium enterprise (SME) growth usually requires collaborations, since SMEs often do not have the knowledge and business resources to grow individually. Existing research shows that SMEs can benefit from inter-organisation connections to access external knowledge and business resources, thus these connections among SMEs are crucial to their growth. However, it is not clear what the influences, structures, and dynamics are of SME connections. This study explores SME connections through three research questions: 1) What is the relationship between SME connections and SME growth? 2) How do SMEs connect with each other? 3) How do SME connections evolve through growth?

The data covers SME connections in Beijing and Shanghai. They are the most active areas and the time period in SME collaborations, in terms of the number of SMEs. The chosen SME networks have overall positive revenue growth in the time period 2011 to 2015 and has 1041 active SMEs with 1187 collaborations. Successful network development results and active SME connections in these areas provide two representative SME networks.

This study adopts network theory and network analysis to explore the effects of SMEs networks on SMEs growth. To answer the research questions, this study uses network

analysis as the method to generate network snapshots and test the relationship between SMEs network connections and their growth, determined through increase in revenue. In addition, this study shows the SME connection structures and dynamics to provide details about how SMEs are connected with each other and how connections change during their growth.

This study's results provide further developments in network theory. First, this study suggests that open and closed SME connections can influence revenue growth, since they are strategic choices to get network positions which other firms rely on their connections. Second, this study demonstrated that open and closed SME connections are not caused by the context of the information technology industry, in which this study's data is based. They are effective structures in inter-firm collaborations. Third, this study added three tendencies to explain how existing connections influence new connections formed between SMEs.

The contribution of this study is to improve the understanding of SME growth and networks. Existing literature shows that SME growth can benefit from inter-organisation connections. However, there remains a lack of understanding of the extent of SME connection influences, the SME connection structure details, and the evolving dynamics of SME connections. To improve these, this study explores SME connection influences, structures and dynamics. Consistent with prior research, this study confirms that SMEs revenue growth can benefit from having open and closed

connections in their networks. In addition, this study emphasizes the importance of not only the SME connection influences, but also the structures and dynamics. This study shows that SMEs have five types of open connections and four types of closed connections. And there are three tendencies about which SMEs are more likely to be connected through growth. Thus, there are implications in how SMEs connect into networks to achieve growth.

This study has implications in SME management practices, especially, in how to manage the collaborative connections among SMEs. This study's findings show that, in order to achieve growth, SMEs need to 1) connect with the well-connected SMEs, 2) be interconnected with other SMEs, and 3) connect with SMEs with different types of network roles. At the micro level, these results can be used as a guideline for SME managers to improve their inter-firm collaborations. Also, at the macro level, the results can be used by policymakers to improve SMEs performances as clusters.

Chapter 1 Introduction

1.1 Introduction

The aim of this study is to investigate the relations between inter-firm connections and small and medium enterprises (SMEs) growth. SME growth 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 growth requires new theories on the complex structures of SMEs collaborations and how these collaborations can influence SMEs growth.

SMEs growth can be influenced by their connections in collaborations (Vos, 2005). SMEs can be benefited from rapid response and flexibility through collaborative connections with others. Thus, SMEs connections can influence their growth (Dagnino, *et al.*, 2016). However, it is not clear that the structures of SMEs connections and SMEs growth results. Thus, in the context of SME growth, this study aims to provide more knowledge about how SMEs can grow through their connections.

This study uses network analysis to investigate how SME collaborations via the establishment of networks influence their growth. The analysis in this study focuses on networks at the inter-firm level. First, this study examines the relationship between

SMEs networks and their revenue growth. Second, this study analyses SMEs network patterns, including how SMEs are connected in the network 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 growth.

1.2 Context for this study

SMEs are considered as a source of economic development, since they are more flexible and sensitive to changes in the business environment and technologies than large companies (Thorpe *et al.*, 2005). SME growth often requires joint work with other firms. Thus, SME connections play an important role in SME growth (Oparaocha, 2016). Previous literature (Burt, 1997) argued that SMEs can be strategically connected and contribute to SMEs growth outcomes. However, how SMEs are connected with each other, how these connections change as SMEs grow, and to what extent SME connections can influence SME growth remain unclear. Thus, this study explores SME connections in the context of SME growth.

1.3 Significance of the study and contributions to knowledge

Previous research (Fernandez-Olmos and Ramirez-Aleson, 2017) 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. SME growth emphasizes gaining access to resources and knowledge through connections with external parties (Weiblen and Chesbrough, 2015). Thus, 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 growth among firms (Lynch, O'Toole, and Biemans, 2016). Therefore, this study can improve the understanding of how the process of collaborative SMEs activities influences their growth results.

Also, this study compares the different structures of inter-firm connections. By doing this, this study can provide a guide to SME management practices and policies. This study has implications on how SMEs can improve their external connections to achieve better revenue growth. To guide future practices of managing SMEs collaborations, this study's findings provide interpretations of the evidence about SME network structures. For business managers, building particular structures of inter-firm

connections can improve their revenue growth. For policymakers, encouraging SME collaborations through inter-firm connections can enhance SMEs growth results.

In business practice, an SME invests in its own network structure and position, and then it usually expects financial returns. The connections among SMEs enabling information and business resource exchange, meanwhile, have costs for maintaining them. Once SMEs are connected, these connections require financial returns to maintain them. Maintaining SMEs connections requires working time and resources, so that SMEs can only have a limited number of connections. Thus, this study seeks an efficient way of managing SME connections. The contribution of this study is to find out those SME connection influence, structure, and dynamics positively associated with SME growth.

1.4 Theoretical gap

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 1.1). 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 1.1.

Figure 1.1 Theory map for SMEs growth and networks

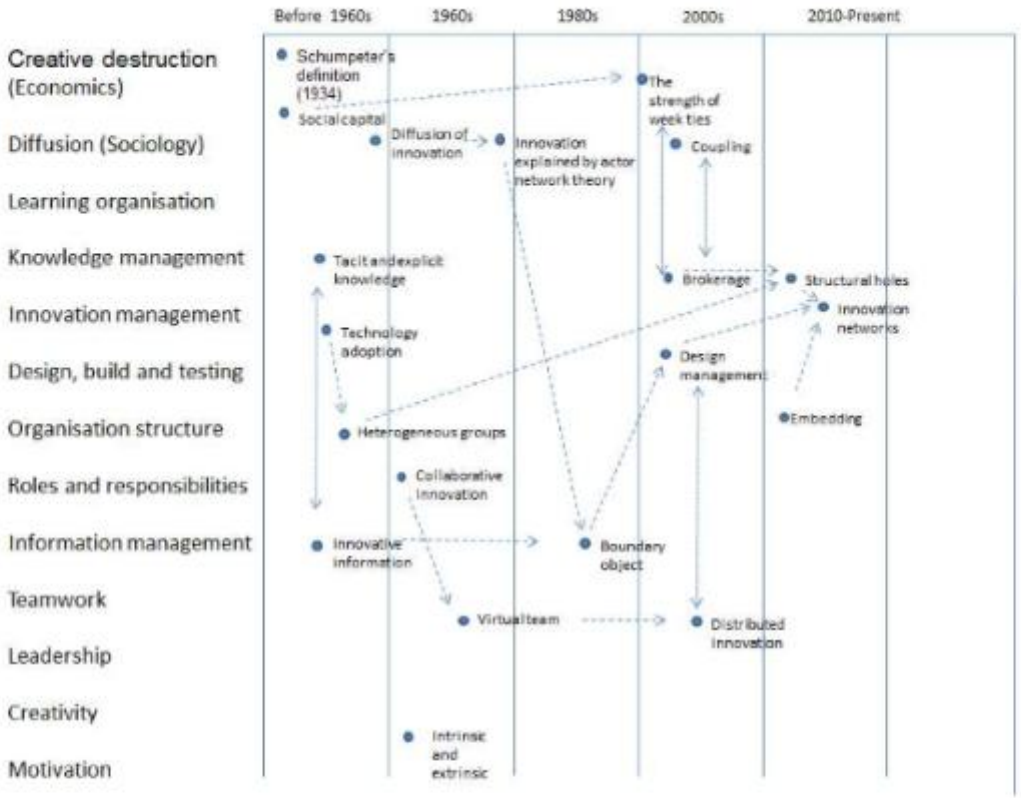


Figure 1.1 begins with Schumpeter's definition of operational collaborations. Operational collaborations among SMEs result in business growth by the integration of

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 1.1 shows another important theory in SMEs development, which 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; Huggins *et al.*, 2016 and 2020), sharing innovative information (Roger, 1995; Reagans and Zuckerman, 2001; Huggins and Prokop, 2017), 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.

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 SME growth (Burt, 2004 and 2007). According to Burt's (2007) theory, complex connections do not stay static in SME growth. Obstfeld (2005) suggested that changing network dynamics is a process of creating new structures between firms. Ibert and Müller (2015) suggested a theoretical gap, how various structures of inter-firm connections influence SMEs growth. Further, it is not clear that what are the structures, dynamics, and influences of inter-firm connections in SMEs growth (Guan *et al*., 2015). Thus, this study can improve the understanding of inter-firm connections in SMEs growth by exploring the structures, dynamics, and influences of inter-firm connections.

This study fills the gap in how SMEs networks have impacts on SMEs revenue growth. At the inter-firm level, it is unclear what the network patterns are and how networks affect SMEs growth outcomes (Borgatti, 2012). Thus, in SME growth, managing the collaborations between SMEs becomes a challenging task (Aalbers, *et al*., 2016). In the context of this study, SMEs need to work together to achieve growth. Thus, it is necessary to find out how SMEs can be connected efficiently with each other to achieve their growth.

Research has suggested that SMEs can financially benefit from inter-organisation connections in SMEs growth (Burt, 1997; Zaheer *et al*., 1998; Watson and Papamarcos, 2002). 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 inter-firm connection influences, over-looking the structures and dynamics of inter-firm connections. Consistent with prior research, this study focuses on the influences of inter-firm connections on SMEs growth results. In contrast to prior research, this study emphasizes the importance of inter-firm connection structures and dynamics. Thus, this study proposes that SMEs growth can be affected by a combination of various structures of inter-firm connections. This can provide a further understanding of the variety of inter-firm connections in the context of SME growth.

1.5 Aim of the study

This study aims to explore the influences of SME networks on SMEs growth. In SME growth, an individual firm's internal resources and knowledge, albeit necessary, are not enough to enhance development results significantly (Thorpe, *et al*., 2005; Burt, 2014). The inter-firm connections among SMEs can facilitate the integration and

sharing of diverse resources and knowledge in their progress. Therefore, it is important to investigate the influences of SME networks on SMEs growth.

Under this study's aim, there are three objectives. The first objective is to find out the structures of inter-firm connections frequently appearing in SMEs growth. The second objective is to test the relations between the structures of inter-firm connections and SMEs growth results. The third objective is to explain how networks evolve during SMEs growth and result in certain structures.

1.6 Structure of thesis

This study includes a literature review that provides a discussion about the relevant theories in the area of SME growth and its relationships with the structures of inter-organisational connections. This literature review starts with the context of SMEs growth 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, 7 and 8. Finally, Chapter 9 provides a conclusion.

In more details, the structure of thesis is organised as follows. Chapter One reports the

background, the significance of inter-firm connections and SME growth, an overview of the underlying theories, and the overall purpose of the study. Chapter Two provides a detailed overview of the relevant background literature, focused on the characteristics of SMEs growth. Chapter Three provides a theoretical framework as a link between the literature review and the empirical chapters, focused on how inter-firm connections have an impact on SMEs growth outcomes. The theoretical framework outlines the theoretical position of this study. It consists of theories about network dynamics, structure and influences. Chapter Four provides the methodological approach and discusses why this study adopts network analysis. Chapter Four also covers the research design, data collection, the selection of measurements and data analysis, and discusses the methodological issues in the data collection and analysis. The research findings will be shown in Chapter Five, Six, Seven and Eight. These chapters present and analyze the empirical findings, the network snapshots and results of network analysis and provide a discussion comparing the findings with the previous theories. Finally, Chapter Nine summarises the study and provides the implications, limitations and future research directions.

Chapter 2 The context of SME growth

2.1 SMEs in economic development

This section begins with the definition of SMEs. SMEs are defined as independent firms that employ fewer than 250 employees and turnovers lower than 50 million euros (OECD, 2016). However, the definition of SMEs is not unified. The definition of SMEs has a few components. This includes the number of employees, revenue level, legal status, and method of production (Storey, 1994; Jones, 2005). 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 most firms are small in some sectors, for example, creative design, whilst few firms are small in some sectors, for example, automotive (Storey, 1994). Thus, academics have formulated an "economic" and "statistical" definition of SMEs (Weston and Copeland, 1998).

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. SMEs are considered as a

bigger force than big companies in economy development, in terms of job creation and contribution to GDP (Stiglitz, 2000). 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, SME growth 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, the structure of the 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 a 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, connectivity among organisations is crucial to economic development.

Rogers (1995) suggested that economic development is driven by the sustainable diffusion of technologies and information among SMEs. This process is described as the information exchange through which one firm communicates a new idea to one or several others. Thus, maintaining this process among SMEs 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 social processes whose importance is in diffusing 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 exchanges and collaborations in a social system. Thus, it is important to understand the mechanisms about how economic development activities are organised.

Economic development is important because it creates wealth and 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 exchanges over a period of time among the members of a social system. Thus, this study suggests that the importance of economic development is its capacity to provide 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 SMEs growth are.

2.2 SMEs growth

There is a difference between SMEs development and growth. The last section discussed the importance of SMEs in economic development. SMEs development is not only about increasing the supply of products or services, but also providing sustainable quality of life, the structure of the 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 a positive direction and result of SMEs development (Penrose, 1959). The definition of business growth was proposed as two aspects (Cooke *et al.*, 2005): 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. 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 (Penrose, 1959). Oh *et al*. (2016) argued the definition of SMEs growth is a "flawed analogy" due to lack of academic rigor. SME growth as a process or outcome is an increasingly popular academic debate. SME growth as process emphasizes the processes of making strategic choices, getting access to information and resources, collaborations, and interactions. On the other hand, SME growth as outcomes emphasizes the results of the above processes. SMEs growth is considered as a result of their strategic choices (Vos, 2005). SME growth is usually determined by its strategy, which aims to achieve competitive advantages of rapid response and flexibility (Knack and Keefer, 1995). Evidence from quantitative analysis (Fernandez-Olmos and Ramirez-Aleson, 2017) suggested three factors that can influence SMEs growth. They are the economic conditions (macro-level), the business life cycle (industry-level), and the history and experiences of SME (firm-level). In addition, evidence from qualitative analysis (Solomon and Linton, 2016; van Weele *et al*., 2017) shows how SME managers perceive valuable resource and useful information (individual-level) can also influence the success of SMEs.

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 a 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 SMEs to consider forming a network as a strategy (Starkey and Tempest, 2004). Therefore, it is important to examine and clarify inter-organisational connections as part of the SME growth process.

The last section discussed the importance of SMEs in 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, these processes in SME growth can hardly happen (Landsperger *et al*., 2012). 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, 1993 and 1999; Levin and Cross, 2004; Platonov and Bergman, 2012), and (3) high risk in adopting new technologies (Burt, 2007 and 2014). These characteristics of SMEs growth are discussed below.

First, SMEs growth involves heterogeneous firms and diverse information sources (Colman *et al* 1966; 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 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 that increasing the flexibility in their team structure can enhance their quality of work and capacity. However, such an increase in flexibility results in that SMEs growth is a lack of control in time and expenses (Tymon and Stumpf, 2003; Qumer and Henderson-Sellers, 2008). Burt (2007 and 2015) 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 connection structures among SMEs during their growth, especially, how SMEs grow together as clusters (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 the 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 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.

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. It requires a new way of managing SMEs growth to fit this context (Davidsson and Honig, 2003; Funk, 2012). Thus, the next section is going to discuss inclusiveness as a solution for SMEs growth.

2.3 Inclusiveness

This section discusses why inclusive growth is important for SMEs. This discussion also provides a link between SME growth and inclusive growth. Empirical evidence on SME growth shows formal SME clusters can significantly increase the net asset and add value to SME growth (Rogers, 2004; Watson, 2007; Park *et al*., 2010). A large data set of SMEs over the time period from 1992 to2008 suggests that participation in government-supported SME clusters program can improve SME

growth (Schoonjans, *et al*., 2011). 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. Thus, SMEs can benefit from including other and being included in clusters.

Inclusiveness includes three aspects: 1) getting access to resources, 2) collaborations and 3) interactions. First, inclusiveness involves getting access to scarce resources and information. Varying knowledge and skills are needed to identify needs. Also, various technologies are adopted to meet their 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 growth. 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, collaborations can help to clarify opportunities and reduce risks in business development (Pittaway, 2004). Collaboration between firms from different knowledge backgrounds in SME growth 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, and 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 previous experiences but also direct or indirect collaborations. These collaborations can be considered as a complement to SMEs' experience and knowledge, compensating for their internal limitations by acquiring external expertise.

Third, inclusiveness also involves interactions with partners and customers. New business development is a complex task of understanding and anticipating customer needs. The interactions with customers happen concurrently with other activities in company development. Interactions with customers have a positive effect on firm growth (Matthing *et al.*, 2004). Firms can gain a better understanding of business development directions with those interactions.

Based on the above discussion, inclusiveness is complex, in terms of 1) getting access to external knowledge and resources, 2) collaborations, and 3) interactions. It involves SMEs as highly complex networks. These SME networks consist of a large number of inter-firm relations, which requires an analysis of network dynamics and structures.

To further clarify what inclusiveness is, this section will discuss inclusiveness from two aspects: 1) what inclusiveness is not about and 2) what inclusiveness is about. Inclusiveness is considered as an external competitive advantage (Leana and Van Buren, 1999; Leana and Pil, 2006). From the resource-based view, competitive advantages can be either internal or external. For example, low cost, better quality, and rapid delivery as an internal competitive advantage usually can put SMEs at a

favorable business position. This research argues that an SME's competitive advantage may span across organizational boundaries and may involve abilities to access external resources and routines. Thus, inclusiveness is an increasingly important concept for understanding external competitive advantages. These external competitive advantages are the relationships among organisations. Previous research (Dyer, 1998; Burt, 2015) 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 (1998) and Burt (2015) 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 (2015) perspective, inclusiveness means 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 attention, time, and resources on information exchange with other firms. 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 inclusiveness. However, the structure of information exchange between SMEs has rarely been explored.

Inclusiveness also means brokerage between SMEs. There are highly frequent information exchanges among firms in inclusiveness (Galison, 1997, Rodan and Galunic, 2004). Also, there are intensive information exchanges between firms with different skills and knowledge backgrounds in inclusiveness (Boland *et al*., 2007). Boland *et al*. (2007) suggested firms as information brokerage roles. They called this phenomenon as information brokerage, it means that information exchange during SMEs growth is central to some firms located at the intersection between different professional groups. It appears as some firms are frequently and densely placed at the intersection between professional groups in the networks. Therefore, these SMEs with brokerage roles are crucial to connecting SMEs together during their growth. The following section will discuss inclusive growth as an approach to SMEs growth.

2.4 SMEs inclusive growth

SMEs inclusive growth is defined as co-development among SMEs and related parties (Stiglitz, 2016). Amoah-Mensah (2011) suggested that SMEs with insufficient resources and ineffective information can still be successful in unstructured and irregular pathways. Such unstructured and irregular pathways suggest: 1) SMEs, in general, cannot be simply classified as suppliers or customers, and 2) the competitors and alliances are not clear to SMEs. In addition, the majority of small business managers do not engage in these theory frameworks mentioned, due to lack of training, budget, or time (Amoah-Mensah, 2011). Therefore, the inter-dependency among SMEs sharing resources and information is crucial to their success (Gupta, 2014).

The early research in this area focused on the factors of SMEs themselves (Zaheer *et al.*, 1998; Watson and Papamarcos, 2002). However, recent theories tend to focus on the connections among SMEs during their growth (Abosede, Obasan, and Alese, 2016). The inter-dependency among SMEs can be analysed through connections amongst them. These connections include operational collaborations and knowledge sharing (Burt, 2015). Relevant theories in this area have moved from analysing SMEs as individual firms to SMEs as clusters (Burt, 2007 and 2015). This change shows that the inter-dependency among SMEs is getting more important in theories. Therefore, theories explaining SMEs success have moved from the organisational level to

inter-organisational level.

Collaborations among SMEs result in business growth by the integration of products, services, knowledge and skills (Schumpeter, 1934). In SME growth, there is a large number 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 involved in the diffusing processes to achieve their growth (Burt, 2004 and 2007). In order to resolve this, the diffusion processes have two features in the theory and connected with other theories below (Bresson *et al.*, 2015). First, operational collaborations between different SMEs professional groups are important to their growth. Such operational collaborations provide opportunities for SMEs to combine their abilities to develop and grow together. Operational collaborations in SME growth 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, SME growth can be seen as collaborative activities. When SME growth requires

transactions and information across SMEs borders, different SMEs can work as a 'team' (Brass, *et al*., 2004). Such a 'team' consists of SMEs as team members to achieve their development goals, such as developing new products and services, discovering a new market, and finding new suppliers. These SMEs as a team together can combine SMEs' abilities and SMEs' common interests (Tsai and Ghoshal, 1998; Tsai, 2000). These SMEs' abilities include negotiation powers and skills, creating creative ideas about new products and services, and managing customers and suppliers (Tsai and Ghoshal, 1998; Gelfand *et al*., 2005). SMEs' common interests motivate them to combine their abilities. These common interests include financial returns, business expansion, and gaining competitive advantages (Tsai, 2000). Thus, SMEs are motivated to work together during their growth progress.

The importance of inter-firm connections was highlighted by Granovetter (1973). Then, network analysis was introduced to analyse inter-firm connections at the inter-organisational level. Brokerage (Uzzi, 1996) and structural holes (Burt, 2004) were proposed as two effective network structures in firm development. Further, 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 SME growth 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
Network theory (Burt, 2007)	Highlighted the importance of inter-firm connection structures

SMEs usually connected in networks (see Figure 2.1). The network theory suggests that SMEs can strategically connect with each other as networks to achieve success during their growth, by sharing their resource and information effectively (Burt, 1984; Adler, 2001). Walker *et al*. (1997) suggested that the initial resource and information endowments do not influence their growth significantly. These resources and information endowments can be effective on SMEs growth, when SMEs are connected as networks (For example, see Figure 2.1). 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 to 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 SME growth.

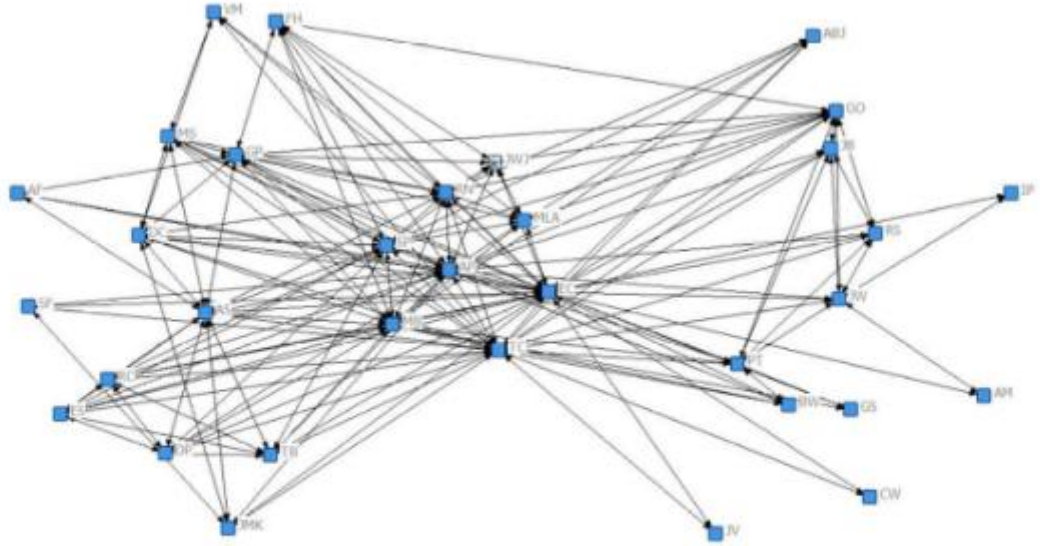


Figure 2.1 A SME network example

Network theories suggested that SME growth is significantly affected by the structures of their networks (Burt, 2015; Suryanarayana, 2015), especially, in the structural holes in their networks. Structural holes are loosely connected SMEs with unique connections among them (Burt, 2015). Burt (2015) suggested the structural hole theory as a more unified theory in the area of firm networks. His theory suggested that

not only the connections are important, but also the unique connections link otherwise isolated organisations are important. The structural hole theory suggests that SMEs network positions can affect their growth. 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 SME growth are.

2.5 SMEs clusters in inclusive growth

Before discussing SMEs networks, it is necessary to clarify that network is a cause of SME growth or a result. Either network causes SME growth or SME growth 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 the firm's performance differences afterward.

As discussed previously, SMEs in inclusive development can be benefited from strategically connecting others. Interest in understanding how inter-organisation connections influencing business growth has recently increased (Borgatti, 2011). However, these efforts have almost exclusively focused on the variety of inter-organisation connection structures that influence SME growth, over-looking one of the interaction effects between them. Thus, this study investigates how the

combination of different structures of inter-organisation connections can influence SMEs inclusive growth.

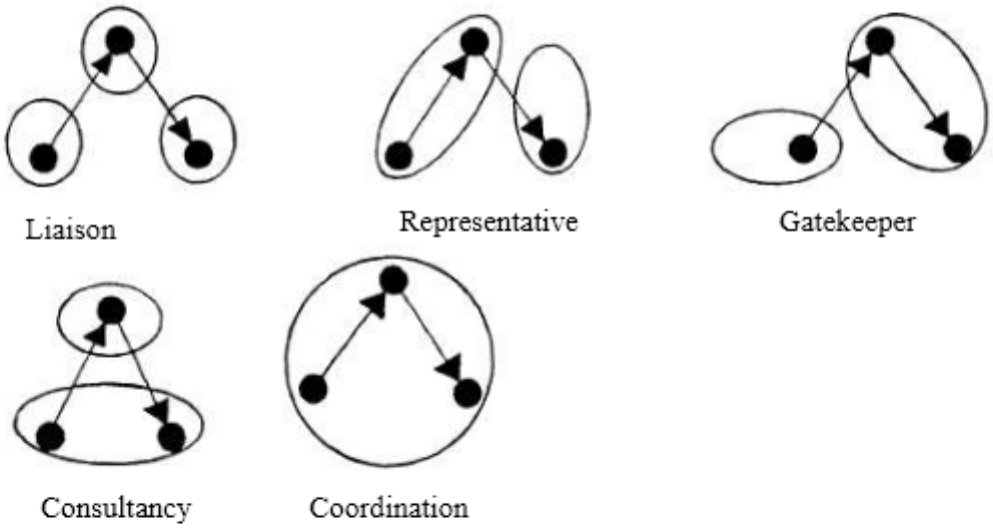
Network was suggested as a cause of SME growth (Burt's 1997 and 2007). SME's knowledge and business resources can be complementary to each other, thus collaborations between them can improve their ability and competence. Kilduff and Tsai (2003) suggest that a firm's knowledge and business resource differences cause them to form networks. SME growth usually consists of collaborative work to combine formerly separated knowledge into new knowledge and ideas (Lee and Berente, 2012; Zaina and Álvaro, 2015; Aalbers, *et al*., 2016; Leenders and Dolfsma, 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). These literatures suggest that network is a cause rather than a result of SME growth. 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 (Cross, *et al*., 2015). The work of Uzzi (1996) and Burt (1992

and 2015) suggest that efficient network structures of firms are either closed featuring dense clusters of firms or open 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 open networks are usually taken by centrally located firms that aggregate knowledge and resources from the others (Baker, *et al*., 2016; Lynch, O'toole, and Biemans, 2016).

On the other hand, closed networks have short connection (or path) lengths that 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 closed networks may not have the same intellectual reach as firms in open networks, but have higher levels of efficiency. Thus, both open and closed network structures are related to a firm's growth, however, the extent of their influences on SME growth results is not clear. SMEs can be benefited from connections in either open or closed network structures. SMEs are usually connected together in these complex structures to achieve growth (Yli-Renko *et al*., 2001). However, prior research suggested that a gap in the current theories is whether firms can take advantage of the combination of both open and closed network structures in SME growth (Bayat *et al*., 2014). Thus, it is important to find out if the combined open and closed structures of SMEs connections are valuable to growth.

Figure 2.3 Five network roles of SMEs



According to Burt's (2015) theory, SMEs can act as different roles in networks (see Figure 2.3). And they do not stay identical in SME growth. Burt (2015) suggests that SME growth over time is a process of developing these five types of roles. Such dynamics in SME growth can be seen as setting up connections to combine knowledge and skills in networks (Yan and Fang, 2014). Especially, in a large SMEs network, some SMEs act as 'brokers' connect the gaps between the others (Xiao and Tsui, 2007). And some SMEs actively connect to these 'broker' SMEs to achieve their growth (Guan *et al*., 2015). From this perspective, SMEs can achieve growth by connecting disconnected SMEs. In SME growth, 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). However, these five types of SMEs roles have not been fully studied and understood in research (Burt, 2015), especially, how they influence SME growth and how other SMEs in the network can be benefited from them.

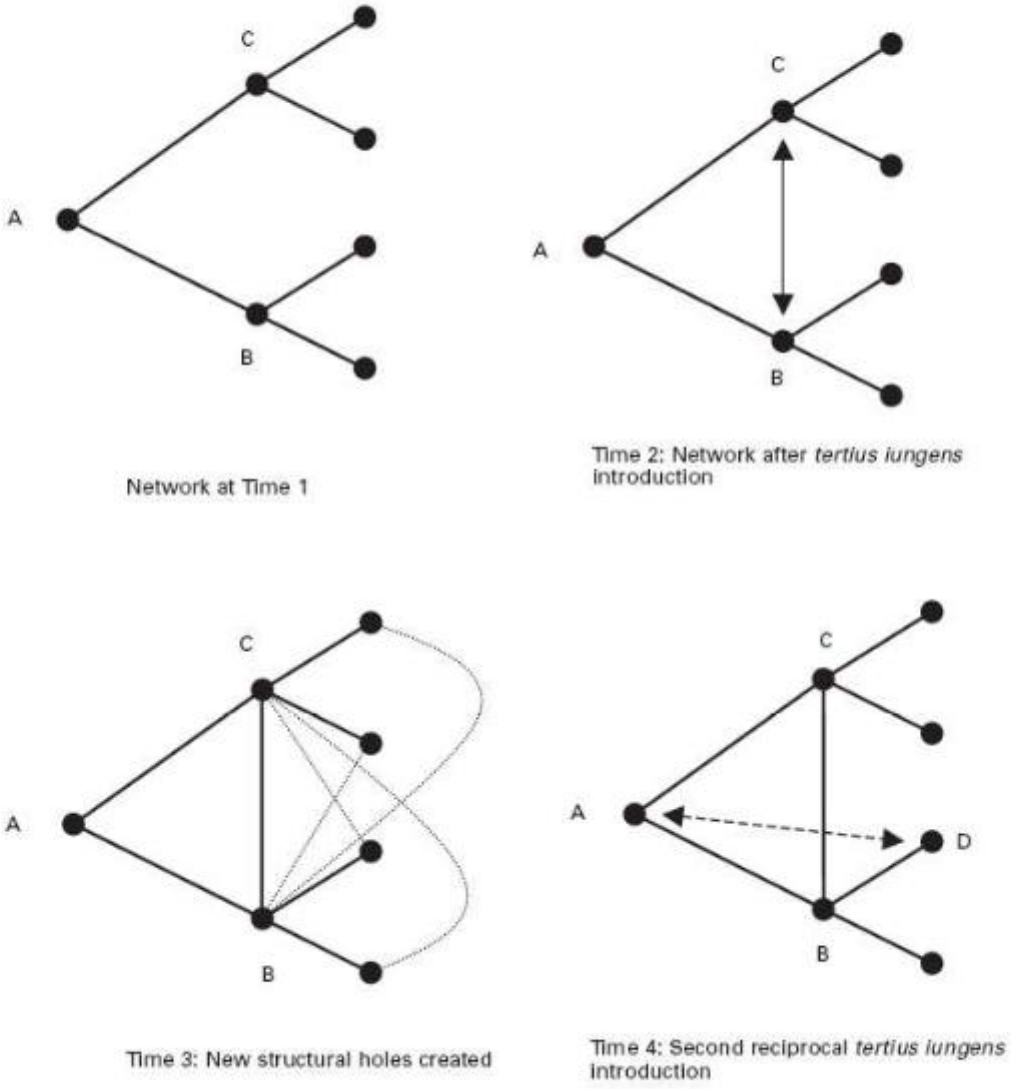
Theories are moving from SMEs as units to SMEs as clusters. This change requires new theories and analysis approaches. Prior theories focused on the characteristics and behaviors of SMEs and SME managers. In contrast, this study focuses on how those connections among SMEs are developed, how SMEs connect to each other, and the influence of those connection structures.

2.6 Complexity in SME inclusive growth

According to Burt's (2007) structural hole theory, the complex connections do not stay static in SME growth. Obstfeld (2005) suggested that changing network dynamics is a process of creating both new open and closed structures between firms. Network dynamics is about introducing disconnected firms and facilitating information exchange between connected firms (Dell'Era *et al*., 2013). In network dynamics, brokerages are ongoing activities rather than just static network structures

(Fang *et al*., 2015). 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, open and closed structures are created at the same time.

Figure 2.4 Network dynamics in SME growth



Source: Obstfeld (2005)

A similar dynamic in business growth is also suggested by Rogers (1995). Information exchange among the firms in business growth over time combines 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

(Coleman, 1988 and 1990). In a firm network, this dynamic can apply to between one and several firms (Garud, Tuertscher, and Van de Ven, 2013). Following this process to draw a network, the result is similar to Figure 2.4. Thus, business network dynamics are about bridging the gaps between disconnected SMEs. During this process, both open and closed 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 the influences of networks in SME inclusive growth.

Chapter 3 Theoretical framework

3.1 SME connections and network structures

This theoretical framework focuses on network theories about the relations between the structures of inter-organisation connections and inclusive SMEs growth results. These theories explain how SMEs can be benefited from the inter-organisation connections in collaborations (Lovejoy and Sinha, 2010; Burt, 2015; Baker, *et al.*, 2016). This chapter begins with a discussion about what SME connections are.

Firm connection is defined as operational or financial collaboration between firms (Burt, 2015). A connection between organisations is 'a purposeful social unit connecting business information and resources' (Levin and Cross, 2004, P23). The connections among organisations can facilitate the integration of diverse resources and knowledge in SME growth. Particularly in the case of SMEs growth, accessing diverse resources and knowledge in other SMEs through collaboration, albeit necessary, is not enough to enhance growth results significantly (Thorpe, *et al.*, 2005). SMEs also need closed connections and to be embedded in a cluster. Those closed connections help SMEs to confirm and corroborate the view that the firm is developing in a promising area and the technological expertise attained is generating profits (Nahapiet and Ghoshal, 1998). For instance, SMEs share and recombine of diverse resources and knowledge into innovative outcomes, a new product or service

(Becheikh *et al*., 2005). At the same time, they work against the difficulties associated with the uncertainties in their market, substitutes and technological evolutions (Hatchuel, 2005). In fact, 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, connections among SMEs can be a driven force for SME growth.

Network structure is defined as how organisations are placed in a network (Cohen and Havlin, 2010). Networks structure can reflect the synthesis process of business growth and innovation (Burt, 2007 and 2015). 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 SME to be fast grow and 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). Successful innovation is usually initially unknown or unfamiliar to most SMEs in their networks. It is assembled by combining a series of information and resources from connected SMEs. Thus, SMEs' growth can be influenced by their network structures.

Building up connections between SMEs is usually time consuming and therefore have an opportunity cost (Afuah, 2013). This is because SMEs only have finite or limited capacity for collaborations with each other (Zaheer *et al*., 1998). Collaborations take time and labour cost and SMEs usually have a small number of employees with limited working hours in a day (Horton *et al*., 2012). 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 (Watson and Papamarcos, 2002). Once SMEs are connected, their connections constrain their ability to building new connections. In the short term, an SME sticks to its direct connections – or ego network - once its connections are built up (Gabbay and Zuckerman, 1998). Thus, this research seeks efficient SME network structures, those that can lead to SME success.

In the later sections, open and closed connections are identified as important network structure to SME growth. Open connections are defined as ties centrally to an organisation (Burt, 2007). Closed connections are defined as inter-connected ties among organizations (Burt, 2007). Although prior empirical evidence (Ostrom, 1994 and 1998) 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

(Shazi *et al*., 2015). The literature on organisational connections in SME management has recognized the open ties are positively associated with getting access to external knowledge and resources (Ellis, 2000). Also, closed connections provide SMEs a number of equivalent communication channels that can monitor and confirm the directions of growth (Maula *et al*., 2003). SME growth is considered as behavioral consequences of SMEs with both open and closed connections (Song *et al*, 2013). Thus, it is important to find out how open and closed connections influence firm growth results (Inkpen and Tsang, 2005; Galaskiewicz, 2007).

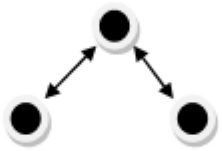
3.2 The open structures of SME connections

The previous studies in firm network structure can be classified into two groups: (1) the previous studies that encourage open structures and (2) the previous studies that encourage closed structures (Burt, 2007). This section discusses the open structures of SME connections, and the closed structures of SME connections are discussed in the next section.

Open connections are concerned as ties centrally to an organisation (Burt, 2007). In this case, an organisation has the advantage of recombining business resources and knowledge from 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 open 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 (Hatzakis *et al*., 2005). Thus, SMEs with open connections are more likely to be successful than those without.

Figure 3.1 Open connections



Open 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 SME's open connections is positively associated with the diversity of accessible external resources and knowledge (Burt, 2015). Open connections are beneficial to firms' capabilities in growth. Open connections reaching outside an organisation are significantly related to firm revenue growth (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 can be effective through open connections

across organisational boundaries. Thus, SMEs with open connections can effectively gather the required business resources and information to achieve their growth.

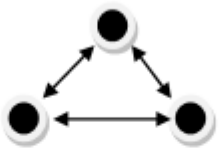
SMEs inclusive growth relies on collaborations between SMEs. These collaborations are through the brokerage. Open connections are the brokerage processes in an SME network. Open connections are the regular patterns of SMEs clusters in their development. Loosely connected SMEs with unique connections in their clusters can be more efficient in development. Thus, open structures of connections can be positively associated with SMEs' growth results.

3.3 The closed structures of SME connections

Closed connections refer to inter-connected ties among organisations (Granovetter, 1985; Nohria and Eccles, 1992). Closed connections are usually considered as structural redundancy in networks (Kavanaugh *et al.*, 2005). In this case, each organisation in closed connections is not considered as a unique bridge to connect any others. Prior research has shown some specific advantages associated with closed 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 closed

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 a lack of comparison and advice (Nebus, 2006). Closed connections are better than open 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 closed connections are positively associated with the results of knowledge transfer. And other prior research showed the advantages of closed connections in identifying valuable resources and knowledge in inter-organisational collaborations (Krackhardt, 1992; Uzzi, 1996; Pittaway, *et al*., 2004). In the specific case of SME growth, closed connections can facilitate mutual understanding and help to build a common basis for implementing new ideas. Therefore, closed connections can support the transfer and implementation of diverse business resources and complex information.

Figure 3.2 Closed connections



The features of closed connections among SMEs could help to overcome those

limitations of open connections. Although open 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), open connections may lack the necessary common base to integrate them (Granovetter, 1973 and 1985; Krackhardt, 1992; Sydow and Windeler, 1998; Joshi, 2006). Moreover, business resources and knowledge are hard to mobilized and transferred across organisational boundaries (Hassard, 1991), because of the lack of a common business language and shared approach (Podolny and Baron, 1997).

Another limit to SMEs growth through open connections is that having new business resources and ideas is fundamentally far away from turning them into business products or services. As Obstfeld (2005) and Burt (2015) 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 open connections might be an obstacle to the implementation of them (Kristensen, 1999). 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 (Nijssen, *et al.*, 2005). Thus, SMEs growth through open connections often loses control and lacks coordination.

However, open connections as brokerage processes in SMEs network can also slow down SME growth progress. In contrast, closed connections can progress faster than open connections, since most of the information exchanges are through direct contacts. SMEs with closed connections in their clusters can be more efficient in development. Thus, closed structures of connections are positively associated with SMEs' growth.

3.4 The influences of SME connections

The previous sections discussed complex network structures in SME growth. This section is to discuss how networks can influence SME growth in theories and practices. Burt (2015) suggested that structural holes in the network can influence SME growth in theories. In addition, firms as 'brokers' in the network can influence SME growth (Cross *et al*., 2015). 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 (Woolcock, 1998; Woolcock and Narayan, 2000). 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.

Based on the above analysis, this research summarises the network influences as 1) to what extent networks with structural holes can influence SME growth, and 2) what are the roles of brokers and to what extent they can influence SME growth? Further, Burt (2007 and 2015) suggests network analysis can provide a representative view for analysing SME growth processes, and focusing on inter-firm level collaborations. Related to this, Fleming and Waguespack (2007; 2014) confirmed that this research

area has been rarely explored. As the discussion above, analysing the inter-firm level networks can help to understand the SME growth process.

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

Are open and closed connections are caused by the context of this study? McDermott and Corredoira (2009) suggested similar structures in firm networks in the wine industry in Argentina (see Figure 3.3). They argued that the ability of a firm to access knowledge and upgrade its products does not depend on the number of connections, instead, it depends on their strategic positions as bridges between otherwise isolated firms. Their findings confirm this study's suggestion about SME connections as strategic choices. Also, the network in their research has similar structures with this study's, which have open and closed connections. This suggests open and closed connections are not caused by context.

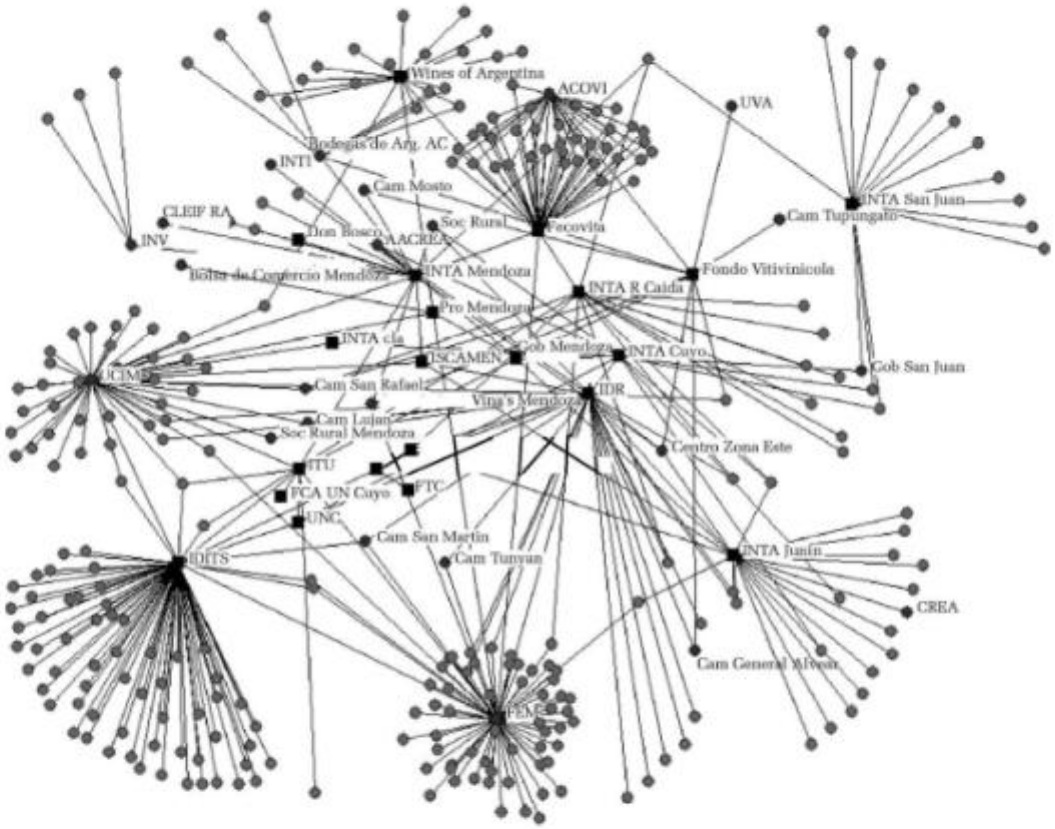


Figure 3.3 Similar structures in firm network in the wine industry in Argentina (McDermott and Corredoira, 2009).

Also, in another industry context, similar inter-firm connection structures in the defence industry are shown in a study conducted by Deloitte (2017). According to this study (see Figure 3.4), the eight most advanced weapon manufacturing companies (red nodes) established between 2012 and 2016 have contract-based collaboration connections among 1,200 firms (dark blue nodes), universities (yellow nodes) and government agencies (light blue nodes). Figure 3.4 shows that the eight most advanced weapon manufacturing companies (red nodes) have similar network positions with the nine SMEs with high revenue growth. Each of them connects a part

of the network can be isolated without its connections. Also, this network has similar structures with this study, which have open and closed connections. This also suggests open and closed connections are not caused by the context.

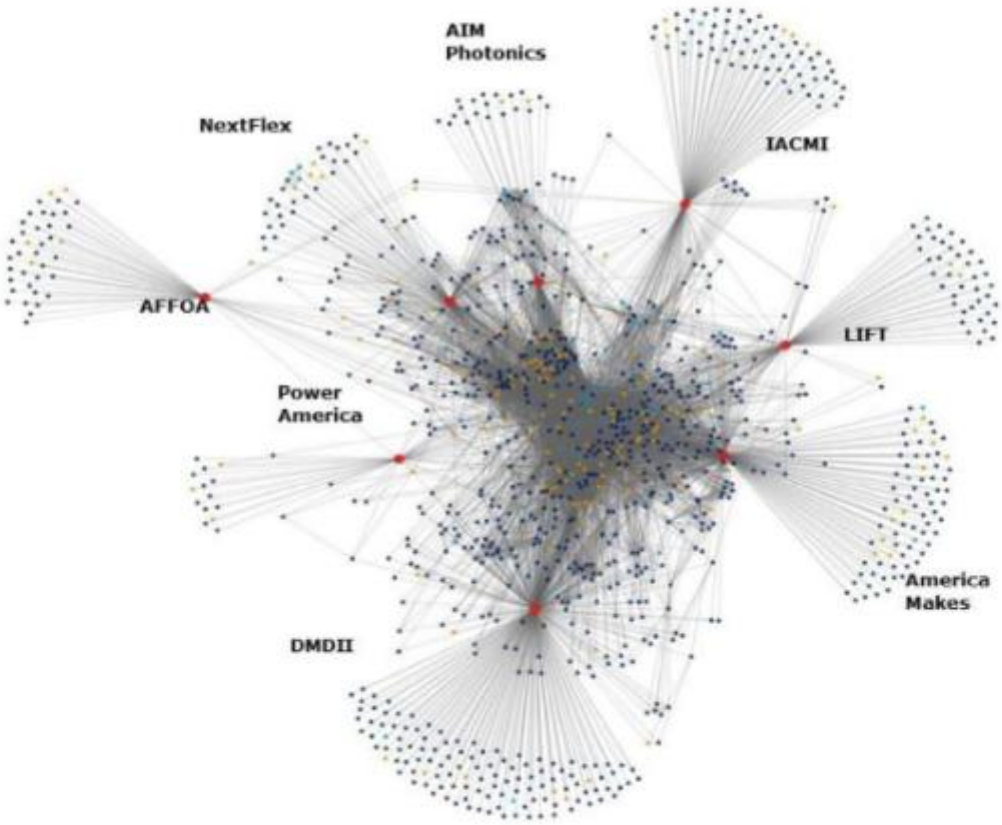


Figure 3.4 Similar structures in firm networks in the defence industry in the US (Deloitte, 2017)

In another different industry context, similar inter-firm connection structures in the green technology industry (environmental sustainability) are showed in a study conducted by Innovation Ecosystems Network Center at Stanford University (2019). The purpose of this study is to monitor the current emerging green technology industry and provide insights about firm connections during their growth. According to this study (see Figure 3.5), the current players in the industry are 7,396 firms (green

nodes). They have contract-based collaboration connections among 15,683 research institutes and universities (red nodes) and 12,591 government agencies (blue nodes). Their findings are also similar to this study. First, firms with high revenue growth (see larger green nodes in Figure 3.5) have open and closed connections, which are similar to the network positions of those nine SMEs with high revenue growth. Each of them also connects a part of the network can be isolated without its connections. This suggests open and closed connections are unlikely caused by the context of this study, and open and closed connections can be strategic choices.

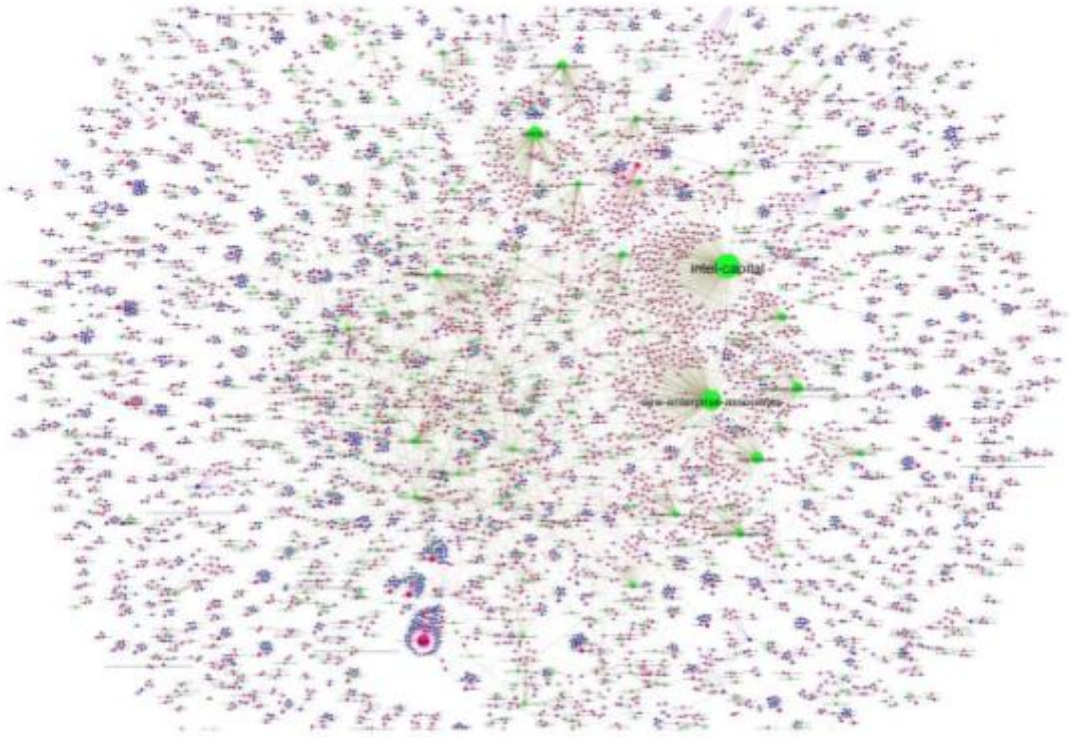


Figure 3.5 Similar structures in firm networks in the green technology industry in the US (Innovation Ecosystems Network Center at Stanford University, 2019)

This discussion shows that:

- Open and closed connection structures are not caused by the context, since they are found in different industries.
- Open and closed connection structures are strategic choices, since these studies also found those firms with open and closed connections outperform the others.
- Open and closed connection structures as strategic choices are to occupy a network position, which connects a part of the network isolated without them.

Base on the discussion above, the next section is to highlight the key points in this study's theoretical framework.

3.5 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) the previous studies that encourage an open structure with structural holes and brokerage, and (2) the previous studies that encourage the opposite of an open structure, a closed structure with

embedding and closure. The empirical findings encouraging open structure focuses on structural holes. Structural holes are the gaps between firms with different backgrounds and skills. The empirical findings encouraging the open structure network found that diverse information from firms with different backgrounds and skills can increase SMEs growth (Burt, 2007 and 2015). Also, there are empirical findings encouraging the opposite of an open structure network, closed structure network with embedding and closure (Uzzi, 1996 and 1999). Embedding is the opposite of structural holes. Structural holes treat the gaps between firms as an asset. Quite the contrary, embedding as the strong ties between firms are also an asset in SME growth.

Previous studies suggest that both open (Grootaert, 2001; Burt, 2007 and 2015) and closed (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 the loosely connected network structure. Loosely connected network structure can combine diverse knowledge and skills from different professional groups (Willem and Scarborough, 2002; Wang *et al*., 2013). 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 (Damanpour, 1996). However, SME

growth 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 the 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 with a fully connected network are usually direct contacts. Thus, SME growth 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 (2007 and 2015) 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 growth progress. The structure of network seems like a double blade sword. SME growth 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 growth 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, 2007 and 2015; Hanaki, Nakajima and Ogura, 2010) and a fully

connected network is usually efficient (Friedkin, 1981 and1982; Dasgupta, 2000; Davidsson and Honig, 2003; Burt, 2007 and 2015).

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 the loosely connected structure. In other words, how can an SME network be efficient and creative? Based on the above discussion, this study proposes the research questions in the next section.

3.6 Research questions

This literature review highlights the gap in the theories of SMEs growth. A theoretical gap is how a combination of various structures of inter-organisation connections influences SMEs growth results. The inter-dependency among SMEs is crucial in their development and has rarely been explored. SMEs can be benefited from the inter-organisation connections in collaborations (Burt, 2015; Baker, *et al*., 2016). Thus, this study aims to exam the relations between the structures of inter-organisation connections and inclusive SMEs growth results. Thus, the regular patterns of SMEs cluster dynamics, structures, and their influences need to be explored. This literature review proposes three research questions. Table 3.1 summarises these research

questions.

Table 3.1 The identified research questions

Previous literature	**Research questions and hypotheses**	**Analysis required**
Although, the influence of firm connections is highlighted by Borgatti (2011) and Burt (2007 and 2015). However, not all kinds of firm connections have influences on revenue growth. Thus, this study is to find out what types of firm connections are influential on revenue growth.	Research question 1: What is the relation between SME connections and revenue growth?	To answer the first research question, three hypotheses need to be tested as below: • Hypothesis 1: Open connections positively influence SMEs growth. • Hypothesis 2: Closed connections positively influence SMEs growth. • Hypothesis 3: Open and closed connections jointly and positively influence SMEs growth.
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*.,	Research question 2: How SMEs are connected with each other in SME growth? .	To answer the second research question, descriptive statistics about network structures are provided and there is no hypothesis testing

(2015); Gargiulo and Sosa, (2016)		
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 3: How do SME connections evolve towards to open and closed structures?	To answer the third research question, three hypotheses need to be tested as below: • Hypothesis 1: The well-connected SMEs get more connected with others in SME growth. • Hypothesis 2: The well-connected SMEs get more interconnected with each other in SME growth. • Hypothesis 3: SMEs with different roles of brokerage ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other.

The first research question is to test the relations between SME connections and the results of growth. To answer the first research question, three hypotheses need

to be tested. Hypothesis 1 tests whether open connections positively influence SMEs growth. Hypothesis 2 tests whether closed connections positively influence SMEs growth. And Hypothesis 3 tests whether open and closed connections jointly and positively influence SMEs growth. According to the network theory, there are two structure patterns in SMEs clusters can influence SME growth: 1) SMEs with open connections can be more efficient in development, and 2) SMEs with closed connections can be more efficient in development. SMEs inclusive growth relies on collaborations between SMEs. These collaborations are through the brokerage. Open connections are the brokerage processes in a SMEs network. However, open connections as brokerage processes in the SMEs network can also slow down SME growth progress. In contrast, closed connections can progress faster than open connections, since most of the information exchanges are through direct contacts. The literature review suggests that the regular structure patterns of SMEs cluster and their influences are crucial and can be explored by using network theories. Thus, the first research question is to test what the relations between SME connections and revenue growth are.

The second research question is to further explore the details of closed and open structures of SME connections. As a result of SME connection influences, the network structures are very complex. Therefore, the SME connection structures need further exploration the find out the details about how SMEs are connected with each other in their co-development, which is the reason for proposing the

second research question.

Then, the third research question is to explore why SME networks evolve from a few connections to a large number of open and closed connections in SMEs growth. To answer the third research question, three hypotheses need to be tested. Hypothesis 1 tests whether the well-connected SMEs get more connected with others in SME growth. Hypothesis 2 tests whether the well-connected SMEs get more interconnected with each other in SME growth. And Hypothesis 3 tests whether SMEs with different roles of brokerage ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other.

By answering these research questions, this research can find out how inter-firm connections evolve in inclusive growth. Thus, this research aims to answer these three questions about the influences, structures, and dynamics of SME connections in SMEs growth. The focuses of these three research questions are: influences (Research question 1: what), structures (Research question 2: how), and dynamics (Research question 3: why) in SMEs growth. In order to answer these three research questions, the next chapter discusses the methodology.

Chapter 4 Methodology

4.1 Introduction

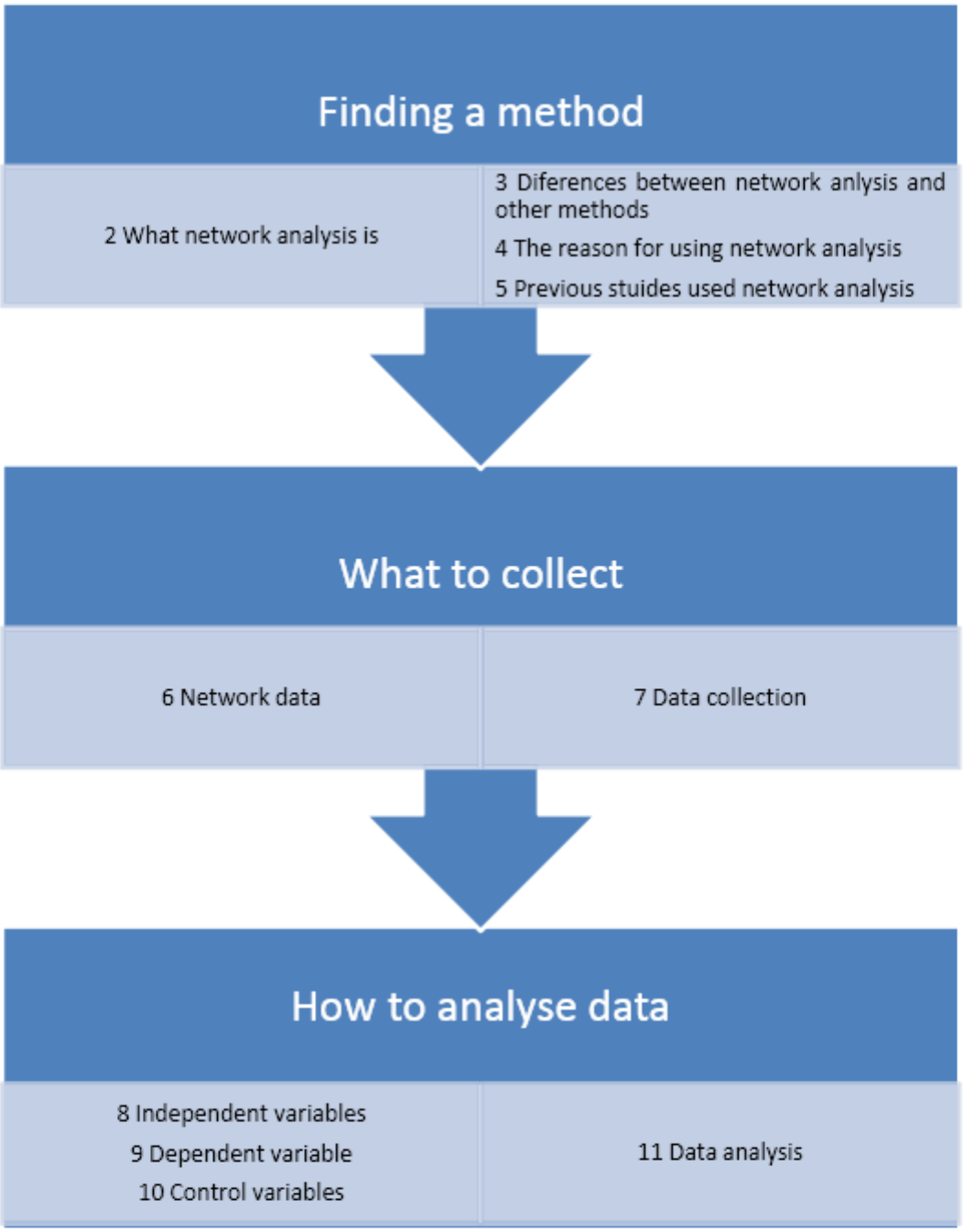
This chapter discusses:

1. what network analysis is,
2. the differences between network analysis and other methods,
3. the reason for using network analysis,
4. previous studies used network analysis,
5. network data and data collection,
6. the variables,
7. analysis approach adopted in the study,
8. methodological issues and philosophical basis.

This chapter is structured into three main parts (see Figure 4.1). These three parts are finding a method, collecting data, and analysing network data. First, this chapter discusses what method is used and the reasons. Second, how the data about networks are collected. Third, this chapter discusses how to use network regression modeling with the results from network analysis as variables to explore the network influence. And this chapter also discusses how to generate snapshots about the dynamics and structures of networks. After the data analysis section, this chapter also outlines the

methodological issues and philosophical discussion about network analysis.

Figure 4.1 The structure of this chapter



4.2 What is network analysis

Network analysis 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 are in open and closed connections. Network analysis takes account of three elements in networks, actors, ties, and mechanism (Conway and Steward, 2009).

Actors: In this research, actors are the SMEs in each network. Collaboration activities (Rogers, 1995) are relationships between SMEs. The nature of inter-firm collaboration is that firms working together to achieve competitive (Togar and Sridharan, 2002). Thus, an SME network represents collaboration activities between SMEs in their development (Burt, 2007 and 2015).

Ties (or links): In this research, the ties represent collaboration relationships among SMEs. Collaborations are not concerned as directed relational ties among SMEs (Burt, 2007 and 2015). Collaboration ties do not distinguish between 'collaborating with' and

'being collaborated with'. The content of each collaboration tie is related to SME growth, which is discussed in the network data and data collection section later.

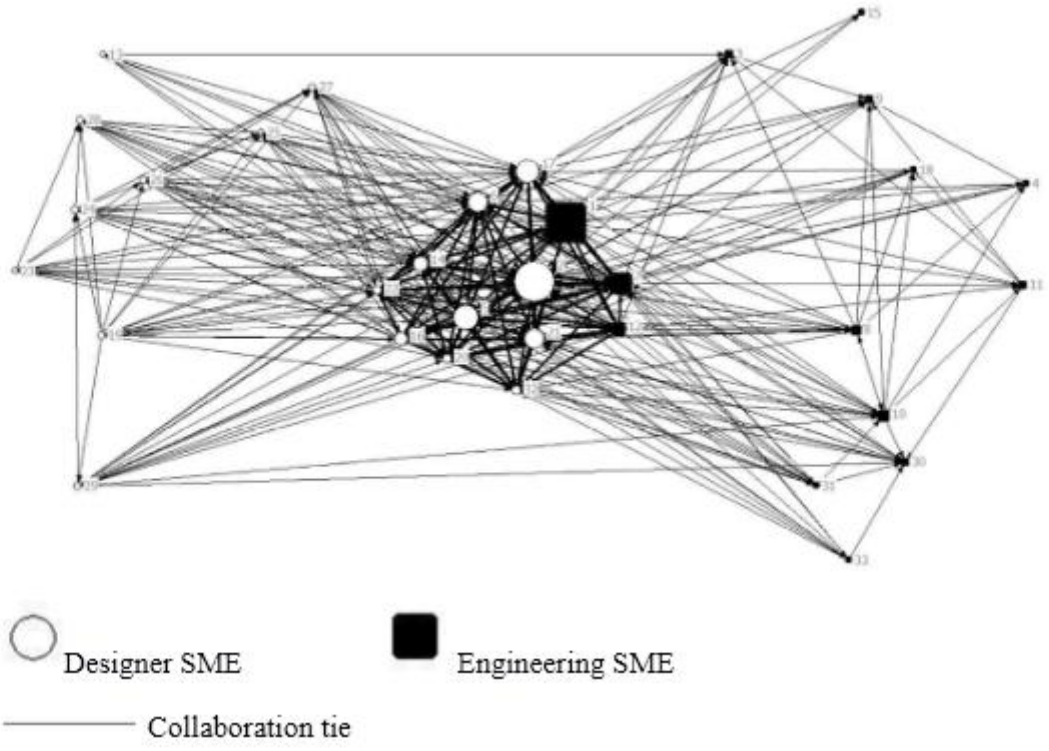
Mechanism: In this research, the mechanism is open and closed structures in the SMEs network. This network mechanism is based on network theory (Lin, 1999; Burt, 2007 and 2015). This network mechanism can help to find out the patterns in each SMEs network. For example, some types of open and closed structures can be found as frequently appearing 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 research adopts network analysis to analyse how SMEs co-develop together. Especially, how SMEs are connected. Network analysis can provide the visualisation of connection structure among SMEs. Each network visualisation is presented as a network snapshot. A network snapshot represents the collaboration relationships among the SMEs. In this research, network analysis is used to visualise the structure of the SMEs network.

Figure 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 4.2). Also, each type of firm can be also represented in a different shade of colour. The ties among them show the collaboration relations that occurred in development. The size of each node

represents the SME's revenue growth, which measures to what extent the SME is well developed (the details about measures are discussed in the later section). The SMEs in the center of the network are connected with both open and closed structures. This can also be measured by brokerage and centralities (the details about measuring open and closed structures are discussed in the later section).

Figure 4.2 A network example



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 SME growth. 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 open and closed structures. For example, brokerage score can specify that to what extent an SME is connected to open structures or not. Centrality values can quantify SME's closed connections in terms of the SME's connections in the network (the details about open structures measured by brokerage score and closed structures measured by centrality are discussed in the later section). Eventually, network influence can be found out from these quantified network patterns. These quantified network patterns can be tested against SMEs performance using network regression modeling. Therefore, network analysis is to represent, analyse and theorise about activities and systematic characteristics in networks (Freeman, 1979; Borgatti and Everett, 1999). Such activities and characteristics are, for example, network influences, open and closed structures, and network dynamics. The details about these are discussed in the independent variable section.

4.3 The differences between network analysis and other methods

Difference 1: Comparing to qualitative method

First, the qualitative approach can be adopted to analyse network dynamics. The

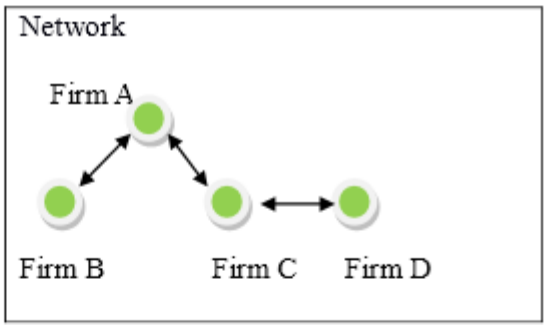
complex interactions between participants can be drawn as network snapshots through the analysis of interview data (Bogartti, 2011). These network snapshots can present how networks evolve. Then regular patterns of network dynamics can be revealed (Johnston and Peters, 2006). Comparing to the qualitative approach such as case study, network analysis can quantify network dynamics patterns then enable actor-based modeling (Burt, 2007). The network modeling 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 that can be used in regression modeling to test network influence.

Difference 2: Comparing to quantitative method

The statistics method is not able to represent networks. For example, Firm A connects both Firm B and C (see Figure 4.3). In network data, this network is coded as a matrix with Firm A, B, C and D as both column and row. If there is a connection between the two of them, there is 1 at the intersection. If not, there is 0 at intersections. The network can be drawn based on the numbers in the matrix. In statistics data, this network is coded as a table with Firm A, B, C, D as the row, and the number of connections as the column. However, the network cannot be drawn based on the numbers in statistics data. The reason is that the network cannot be drawn based on how many connections each firm has (Wasserman and Faust; 1994; Hanneman and Riddle, 2005). Statistics data does not contain information about who is connected to

whom. There are many different networks can have the same number of connections for each firm but have different structures.

Figure 4.3 Comparison of network data and statistics data



Network data representing the network above

	Firm A	Firm B	Firm C	Firm D
Firm A	0	1	1	0
Firm B	1	0	0	0
Firm C	1	0	0	1
Firm D	0	0	1	0

Statistics data representing the network above

	Number of connections
Firm A	2
Firm B	1
Firm C	1
Firm D	1

Also, statistic regression modeling focuses on the relationships between variables. However, the details of these variables are usually missing. Regression modeling can provide analysis in network influence, but have a very limited contribution to the understanding of the details about network dynamics and structure (Wasserman and Faust; 1994). Comparing to regression modeling, network analysis provides more details about SME network structures (Hanneman and Riddle, 2005). The differences between network regression modeling and statistic regression modeling are discussed in the later data analysis section.

Difference 3: Comparing to both qualitative and quantitative methods

Qualitative designs are usually more descriptive in details than quantitative designs (Glaser and Strauss, 1967), such as case studies. 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, 1999 and 2003). However, it is difficult to provide accurate modeling or prediction of network influence by using qualitative approaches. Comparing to both qualitative and quantitative methods, the results of network analysis can provide quantitative modeling of network influence and qualitative details about network structures and dynamics.

The advantages of network analysis are 1) abstraction and 2) theory building (Borgatti, 2012). First, network analysis research usually abstracts SME connections into networks and focuses on 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 performance. However, the position of each firm in a network is difficult to be defined and measured. For example, who are in the center of the network, e.g. well-connected firms or gatekeepers. Pre-defined findings and concepts in research may restrict research to develop new findings and concepts. To overcome this issue, network analysis provides a way to measure the position of each firm in a network. Thus, network analysis is used to explore the regular patterns of SME network structure rather than confirm pre-defined findings and concepts.

Based on above discussion, this study suggests that 1) network analysis can provide analysis in network influences, structures, and 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 research chooses

them as analysis approaches.

4.4 The reasons for using network analysis

The research questions proposed in this study have required the analysis of network influences (research question 1), network structures (research question 2), and network dynamics (research question 3). This study suggests using network analysis to answer these research questions. There are four reasons for using network analysis in this research, 1) for analysing the network influences of SME collaborations, 2) for analysing network structures, 3) for analysing network dynamics, and 4) qualification for testing network influences.

Reason 1: Analysing network influences

This research aims to investigate the relations between the structures of inter-organisation connections and SMEs growth. SMEs inclusive growth is defined as a process of co-development among SMEs and related parties (Stiglitz, 2016). This process relies on effective collaborations among them as networks. SME networks do not only represent the individual firm's work but also how those work together. In

SMEs growth, firms usually work as a cluster concurrently with each other rather than as individual firms on separate tasks (Rogers, 1962 and 1996). To analyse these activities, this research requires a method that is able to explore the relations among SMEs. The method chosen for this study is to analyse the network in SMEs growth. The purpose of this research design is to analyse the cause-effect relations in SME networks. Due to this purpose, this research has the need for conducting network analysis. Therefore, this study uses network analysis to explore the complex structures of SMEs collaborations and how these collaborations can influence SMEs growth.

Reason 2: Analysing network structures

This research 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 of the complexity of SME growth (Lounsbury and Ventresca, 2003). Case study and equation modeling can only deal with 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 three) and centralities (relations between one to the others in a network). Also, there are arguments about case studies that 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 research requires a method to analyse the network structure.

Reason 3: Analysing network dynamics

Network dynamics in SME growth requires reconfiguration of analysis approaches (Burt, 2012 and 2015). These new network positions cannot be readily dealt with by case study or structural equation modeling. These new network positions do not emerge with formal titles. 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 growth may still be its specialty rather than a broker. To explore the new network positions in dynamics, this research requires an analysis to be able to analyse firm connections at the inter-firm level. 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 growth. The analysis of those network snapshots needs to be able to show the changes in relationships across different stages of SME growth. For example, those network snapshots can be used to compare the changes in relationships among firms at different stages of SME growth. Thus, this research requires an analysis to provide network snapshots about the connectivity and interdependence between firms across different stages of SME growth.

Reason 4: Quantification

The complex connections among firms usually need quantification in the analysis (Burt, 2013). Quantitative results of network patterns can provide a comparison. This research 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 modeling. This can help to find out the network influences on SME performance. To explore the SME network influence, this study requires a method to provide quantification of SME networks.

Overall, to answer the research questions, the results of network analysis can present the influences, structures, and dynamics of SME connections. This can help to understand the inter-firm level interactions by conceptualising firms as the actors (or nodes) and collaborations between them as the ties (or links). Complex networks usually have regular patterns in structures and dynamics, these patterns can be observed from the network snapshots generated by network analysis. In network snapshots, general patterns of inter-firm level interactions and their evolvement can be observed and analysed. Also, network analysis can provide the depictions and

quantification of these connections among firms. Thus, it is necessary to analyse inter-firm level connections by using network analysis.

4.5 Previous studies used network analysis

The previous studies in business management used network analysis includes the areas of individual level teamwork, manager employment changes, firm alliances, policies for firm clusters, and functional units within companies. This section will discuss these uses of network analysis.

At the individual level, a number of studies explored the relationship between teamwork structures as networks and team performance by using network analysis. These studies collected data by various methods such as questionnaire survey, interview, and mixed method of both. Their findings suggest that team performance is not necessarily associated with individual creativity (Tilson *et al*., 2010; Yoo *et al*., 2010; Svahn *et al*., 2017). Also, some studies tried to add motivation in their models, to test if creativity and motivation together can influence team performance. They provided similar results by using a longitudinal study with large data sets. These studies found that neither individual creativity nor motivation has a strong influence on team

performance. Instead, they suggest there are relationships between team structures as networks (who work with whom) and performance (Nan, 2011; Svahn *et al*., 2017). Those studies provided implications on how teamwork structures can influence team performance for both academics and managers. Especially, the results of network analysis provided implications on how individual level activities as networks influence performance.

In terms of the organisational level, Dougherty and Dunne (2014) and Yoo *et al*. (2010) suggest that firm performances rely on managing information exchange networks, which allows employees to get access the information for their particular needs. Brhel *et al*. (2015) and Lyytinen *et al*. (2016) provided similar findings by using network analysis and qualitative analysis with data collected from 173 European and US firms. Network analysis was used in this area to show how to access business information through networks.

At the industry level, some scholars studied the effects of firm alliance networks (Lyytinen and Rose, 2003; Colombo *et al*., 2014). These existing studies have found that the impact of teamwork and information exchange as a network on firm performance is always significant (Hanseth and Lyytinen, 2010; Iansiti and Lakhani, 2014). Orlikowski (1996) used network analysis to find out what is effective in form collaboration activities. It has been proved that teamwork relations can bring positive returns to the firm alliance (Colombo *et al*., 2014). And it will also bring advantages to

the firms by facilitating trust and reciprocity. Network analysis was used in this area to demonstrate that teamwork and information exchange is critical in firm collaborations.

At the policy level, the existing studies (Greenstein *et al*., 2013; Bhatt *et al*., 2016; Munir *et al*., 2016) explored the relationships between firm cluster policy and firm performance outcomes. These existing studies investigated how policies for forming firm clusters have effects on performance outcomes. These studies suggested that firm cluster policies can encourage and support business activities. However, they cannot explain the variance in firm performance outcomes from organisations under some policy. Organisations can have different performances under the same policy (Boudreau, 2010; Munir *et al*., 2016). Overall, these existing studies used network analysis to reflect the policy influences on firm networks.

At the management level, Boudreau (2010) analyses company's functional units as networks. Organisations are usually multiunit organisation. Each unit needs information from each other to complete their tasks. The results suggest that these units can benefit from new information developed by other units. And such information exchange networks among organisational units provide opportunities for firm development. The structure of information exchange networks between cross function was also explored. Network analysis helped to gain useful information about how functional units work with each other to enhance firm performance.

Also, previous studies used network analysis to explore brokerage activities. Network analysis helped to understand that information exchange in business is central to some people located at the intersection between different professional groups. Also, Boudreau (2010) suggested those people as information brokerage roles. It appears as some people are frequently and densely placed at the intersection between professional groups in business activities (Majchrzak and Malhotra, 2013; Bresnahan and Greenstein, 2014). Therefore, network analysis was used to explore networks between professional groups.

4.6 Network data

Data requirements

The data requirements for this research are based on the existing network research and with modification for this research's purpose. This research'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 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, 2, and 3
• Evaluation of SMEs growth from financial reports	Research question 1
• SMEs profile	Research question 1 and 2
• When did this particular collaboration happen (specify the date for analysing network dynamics)	Research question 3

In sum, the data items consist of four major parts: (1) connections among SMEs, (2) SMEs financial report, (3) SME profile and (4) collaboration time details. The data about the SMEs networks can be collected from Orbis OECD database. And the data about each SME's performance can also be collected from the financial reports in the

database. Each SME has two development outcome measures (one is the short term and one is the middle term from the financial reports). The details about the development outcome data are discussed in the dependent variable section.

Dataset and source

This research 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 research collected data for 1041 firms. All the firms are from information and communication technology (ICT) including information technology design firms, engineering firms, and information technology management consultancy firms, as this sector is one of the most innovative and interconnected (Potrafke, 2015). This research identified each firm based on whether the firm has expenditure in the dataset. This study's data does not cover collaborations in the form of sharing information and business resources, making joint decisions, sharing profits, or 'verbally' agreed collaborations. Thus, the data collected covers all firms that declared collaborations financially in their development.

The data covers SME growth between 2011 and 2015 in the region of Beijing and

Shanghai. The reason for using this dataset is that recent research (Potrafke, 2015) has suggested that they are the most active areas and the time period in SME growth, in terms of volume of products and number of firms. The data contains detailed firm-specific information including company profiles, collaboration partners, investment, sales, number of employees, and revenue. The data regarding collaboration partners provide information about the name list and connections in SME growth, which is then used to generate the independent variables. The dataset includes 1041 firms and 1187 collaborations amongst them. Firms' profiles, such as the number of employee and revenue, are used to generate the control variables to distinguish the effects of firm size from the effects of firm connections.

SMEs concept in the data

The definition of SMEs has a few components. This includes the 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). There is no doubt that SMEs are distinguished from large firms by size. In SME growth, SMEs as organisations have less research and development power than large firms (Thorpe *et al*., 2005). Thus, the original purpose of introducing this concept was for taxation (Mulhern, 1995; Berger and Udell, 2006). This is because SMEs need support and protection policies.

However, it has been argued that the size of firm is not related to the results in development (Pittaway *et al*. 2004). SME growth is more like to be based on increment changes in firm size rather than radical and fundamental changes (Thorpe *et al*., 2005). Thus, the firm size matters even less in SME growth. In this research, SMEs are treated as firms with less than 50 workers and 50 million euros turnovers.

Firm connections in the data

The nature of firm connections in financial collaborations 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 SME growth. 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 SME growth. In SME growth, the 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 is collaborations. 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 recommended for analysing big datasets (Burt, 2012 and 2015). Thus, this study uses joint SMEs development loans as the firm connections.

4.7 Data collection

The data are collected from Firm-Level Micro-Data in the OECD ORBIS Database which covers SME connections in the region of Beijing and Shanghai between 2011 and 2015. The data includes 1041 SMEs. They were identified by whether the SME has financially declared collaborations in the dataset. Each SME in the networks contributes financially to their connections. Thus, the data collected covers all financially declared SMEs collaborations. Inter-firm collaboration is defined as two or more firms working together to achieve competitive advantages through joint investment, sharing information and business resources, making joint decisions, and sharing profits (Togar and Sridharan, 2002). As discussed in the methodology, formal networks are more likely to be influential on revenue growth than informal networks in firm development (Burt, 2015). The reason is that informal networks are usually overlapped with formal networks (such as formal financial collaborations) and they cannot represent of the overall network structures (Borgatti, 2011). Thus, this study focuses on formal networks rather than informal networks.

The data covers SME connections in Beijing and Shanghai. They are two separate clusters. The reason for analysing two separate networks is to make sure the consistency of the findings and avoid extreme cases and outliers. Recent research (Potrafke, 2015) suggested they are the most active areas and the time period in SME collaborations, in terms of the number of SMEs. In order to present representative SME networks, network analysis research needs to choose networks with 1) a large number of connections (ideally bigger than 250), 2) successful network development results, and 3) active connections. To meet these requirements, the chosen dataset is SME networks with overall positive revenue growth in the time period and has 1041 active SMEs with 1187 collaborations. Therefore, this study chooses this dataset which covers SME growth in the active areas and time period.

In order to provide the results of network analysis, a careful strategy of sample selection is required. 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 research, 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 research, each connection between two

firms is confirmed from both of their data items.

Firms 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 research 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 complementary to each other. In order to collect the data about the entire network, this research combines both '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 research 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 next few sections are to discuss the variables and data analysis in this study's network modeling.

4.8 Independent variables: measuring network patterns

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

Independent variable 1: open structures

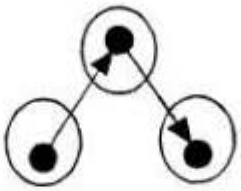
This research's first independent variable is about open structures in networks. As discussed in the theoretical framework, the brokerage can reflect the broker roles in a given network. Thus, this research uses brokerage as measures. A brokerage is a firm who connects other firms in a network (Burt, 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 measure 1), representative (as measure 2), gatekeeper (as measure 3), consultant (as measure 4) and coordination (as measure 5). 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 (measure 1, 2, 3, and 4) or within (measure 5) these three groups.

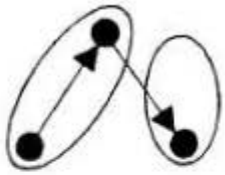
The first measure is the "liaison" broker, a third firm links two groups (see Figure 4.4). A liaison broker provides a connection between two distinct groups but does not belong to either group. For instance, design firms and engineering firms are two separate professional groups, and a technology advisor can act as a liaison broker to provide a link between them in the network. The second measure of open structures 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 measure is the "gatekeeper" broker, a firm offers access to its own group (see Figure 4.4). 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 measure is the "consultancy" broker, an outsider firm provides within-group brokerage (see Figure 4.4). 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 measure is the "coordinator" broker. A coordinator provides connections within his or her own group (see Figure 4.4). Those

connections are completely internal brokerages. For instance, a management consultancy firm provides connections between the members of the management group to coordinate firms managing on different tasks. In network theory (Burt, 2007), connections between firms can be treated as networks. Networks can be analysed by using overall brokerage scores (the sum of measure 1, 2, 3, 4 and 5) to measure each firm's open structures of connections.

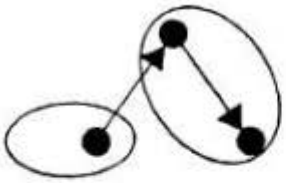
Figure 4.4 Five measures of open structures



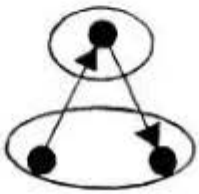
Measure 1: Liaison



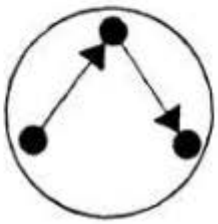
Measure 2: Representative



Measure 3: Gatekeeper



Measure 4: Consultancy



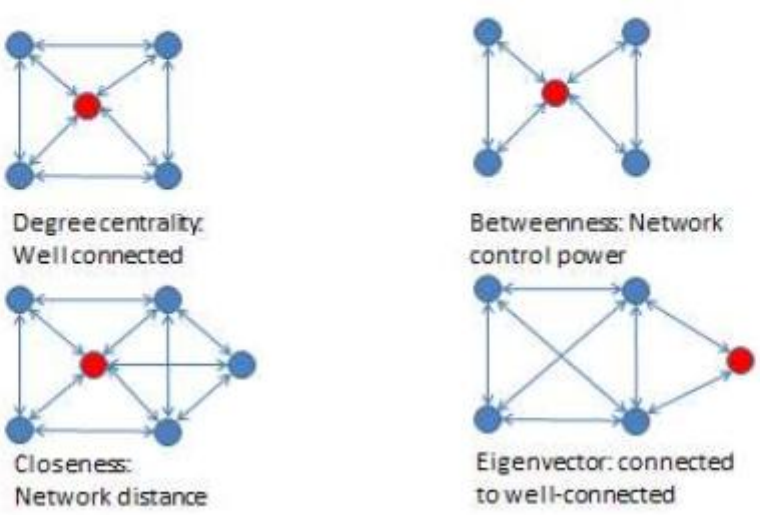
Measure 5: Coordination

Independent variable 2: Closed structures

This research's second independent variable is about SMEs' closed structures, 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 research uses centralities as the measure for closed structures. There are four centrality measures (see Figure 4.5), degree, betweenness, closeness, and eigenvector centrality (Freeman, 1979; Borgatti, 2011). Each of them provides a distinct measure of how an SME centrally located in a given network. An SME can be centrally located in a network and have different influences in four ways as below.

Figure 4.5 Four measures of closed structures



Measure 1: Degree centrality (Well connected)

Degree centrality measures how many connections an actor has in a given network (Freeman, 1979; Borgatti, 2011). This measure can reflect the SME's direct influence on 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 important roles in a network (Borgatti, 2011). Thus, the other three centrality measures are introduced to provide more systematic measures about network structure.

Measure 2: Betweenness centrality (Information control)

Betweenness centrality measures how many times 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. An SME's betweenness centrality is expressed by the number of shortest paths in the network passing through that SME. Thus, this research uses betweenness centrality to reflect SMEs' network location advantages in closed structures.

Measure 3: 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 an SME's information passing through how many firms to arrive at the others. It is regarded as an indicator of the expected time-until-arrival for an SME to spread information to all others in a network.

Closeness centrality measures the optimal paths an SME has. Thus, this research uses closeness centrality to reflect the proximity of SMEs in a given network.

Measure 4: 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 an 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 research uses eigenvector centrality as a measure for closed structures.

4.9 Dependent variable: measuring SMEs growth outcomes

This research uses each SME's revenue growth as the dependent variable. In the theoretical framework, this research defined the dependent variable as SMEs growth

outcomes following the previous research (Burt, 2007 and 2015). The proposed research questions require analysis of the relationships between SMEs network patterns and growth outcomes. In order to test the relationships, this research needs to measure both network patterns and growth outcomes at the firm level. Thus, this section is to discuss the reason for using SME's revenue growth as the dependent variable.

Previous research (Burt, 2007 and 2015) suggested SMEs growth outcomes at the firm level can be measured as revenue growth. The reason is that a firm's growth from other perspectives including branch expansion, customer increase, and competitive advantages are usually correlated with revenue growth (Rodan and Galanic, 2004; Liao and Welsch, 2005; Cross, *et al.*, 2015). Thus, revenue growth is considered representative of SMEs growth outcomes.

Previous research (Burt, 2007 and 2015) suggested there are three aspects of SMEs growth results at the firm level, short, middle, and long term. The long term development results can be influenced by many unpredictable changes in the business environment and technologies, 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 a research focus. Previous research (Rodan and Galanic, 2004; Liao and Welsch, 2005; Cross, *et al.*, 2015) applied this approach to evaluate SME growth. The middle term development results tend to focus on a firm's progress, especially the progress of financial growth. The short term development

results tend to focus on the effectiveness of growth, for example, profit increase. Also, previous research suggested financial returns are more representative than other measures, for example, staff increase, firm expansion, and competitive advantages (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 growth results.

This research measures each SME's revenue growth 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 growth. The middle term outcomes about growth outcomes tend to focus on a firm's progress, especially the progress of growth. The short term financial aspects of growth outcomes tend to focus on the effectiveness of the results. To avoid this bias, this research includes both short and middle financial reports. The same regression modeling procedure is run on these two dependent variables. This is to make sure the robustness and consistency of the analysis results. The regression modeling results of these two dependent variables are presented separately in the findings.

4.10 Control variables

Control variables are the other potential influences on the dependent variables. Those influences should be taken into account alongside the independent variables. This research uses the control variables to rule out those alternative influences on SMEs performance. As discussed below, the control variables used in this research are drawn from the literature. The control variables are 1) age of the firm, 2) the 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 SME growth (McEvily and Zaheer, 1999; Reagans and Zuckerman, 2001; Rodan and Galunic, 2004; Gilsing and Nooteboom, 2005) Therefore, this research 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; Youndt and Snell, 2004; Thorpe *et al*., 2005). Also, number of employees can represent the size of the business. Thus, this research 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 growth outcomes (Reagans and Zuckerman, 2001; Wellman, *et al*., 2001; Green and Brock, 2005; Lissoni, 2010). Thus, this research includes revenue as a control variable. It is collected directly from the OECD database for each SME by using data export function.

4 Turnover

Turnover means the available amount of money can be used by each SME (Hacket and Dilts, 2004). It includes the SME growth task related cost, for example, purchasing software and hardware, employing advisors, travel expenses and so on. Financial inputs

can be positively associated with SMEs growth 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). Therefore this research includes turnover as a control variable. It is collected directly from the OECD database for each SME by using data export function.

This research includes four control variables: 1) firm age, 2) number of employees, 3) revenue, and 4) turnover. These four variables are chosen from those have been used and recommended in the related previous research about SMEs growth. The reason is that these four variables have significant influences on SMEs growth, so that they can be used to compare to SMEs connection influences (Burt, 2007 and 2015). This helps to show the extent of SMEs connection influences. In general, these four variables are the elements that can have impacts on SMEs growth results, yet they are not network impacts. Thus, these control variables are set up to distinguish and compare network and non-network impacts on SMEs growth results.

4.11 Data analysis

The data analysis starts with three tests to check if the data is suitable for the analysis.

These tests include: 1) multicollinearity check, 2) heteroscedasticity check, and 3) descriptive statistics. Multicollinearity check and heteroscedasticity check are to decide whether the data can be used for regression modeling and what kind of regression modeling can be used. Descriptive statistics provide an overview of the data.

If the data passes the requirements in multicollinearity check and heteroscedasticity check, the regression modeling can be carried out. The robustness of regression modeling can be examined by 1) ADjR2 increases, 2) P value, and 3) consistency between different samples (Wasserman and Faust; 1994; Hanneman and Riddle, 2005). $ADjR^2$ indicates how robust and accurate the overall model is. The higher $ADjR^2$ increases, the more robust and accurate the overall model is. The $ADjR^2$ increase has been presented in the last section, which suggests the model has good robustness with about 30 percent of $ADjR^2$ increase. This also suggests that open and closed connections can be used to predict SME revenue growth in both 3 and 5 years term. In contrast to $ADjR^2$ increase, the value of P indicates how robust each variable in the model is rather than the overall model. A more strict definition, the value of P is to determine whether each variable in the model can be supported by the data. The lower P value, the more significant influence a variable has. If open and closed structures in all models have P value lower than 0.05, then the result suggests the model is robust and the influences of open and closed are significant. This also means that the chance for an SME to have open or/and closed structures which do not influence its revenue growth is lower than 5 percent. In other words, if an SME has open or/and closed

structures, there is more than a 95 percent chance to influence its performance. Again, the P value in the model also confirms the robustness. To avoid the data are from extremely outlier cases and make sure the consistency, this study separates the data into two parts and runs the same analysis on each part of the data separately.

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

Analysis for answering research question 1: Network influences on SMEs growth

This research adopts randomised permutation regression to test the correlations between firms' connection structures and the SMEs growth outcomes. Network data about organisational connections can have some outliers in distribution. Randomised 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.

This study chooses randomised permutation regression to test the relationships between SMEs network and growth 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 that usually have some outliers in the data (Hanneman, R.A., & Riddle). 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 a robust model.

Non-network factors influencing SME growth 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 firm development. The independent variables are network structures including each firm's open connections and closed connections. SME growth results are the dependent variables. This research uses revenue growth as the measure of each firm's development results.

Analysis for answering research question 2: Network structures

This research uses network visualisation by using Netdraw function in software Ucinet. Firms are analysed as nodes in the network snapshots, joint SMEs development loan is lines between firms representing their collaborations, 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 open connections and the number of each firm's closed connections by using the Netdraw function. The numbers of each firm's open and closed connections are calculated using the Ego Network Structure Count function in UCinet. They are the proposed independent variables. Later on, they are tested against the firm's revenue growth in regression modeling to show the effect of firm connections. The snapshots provide information about the overall structure of the firm cluster as a whole and each firm's network structure of open and closed connections.

Analysis for answering research question 3: Network dynamics

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)

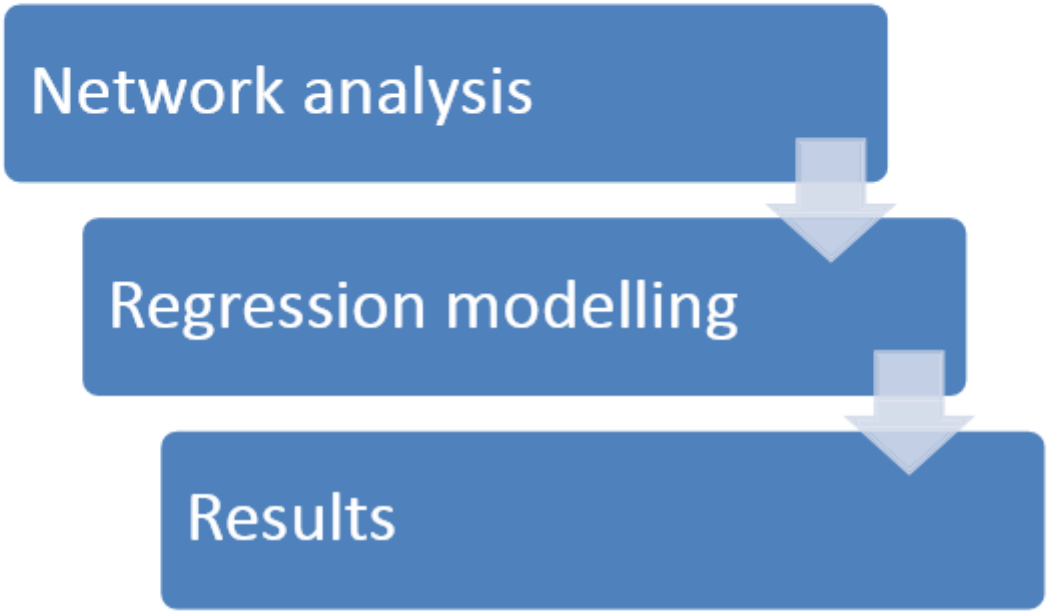
interactions between firms as the ties (or links). Complex networks usually have regular patterns in structures and dynamics, these patterns can be observed from the network snapshots. In a network snapshot, Network has general patterns in its evolvement which can be observed and analysed at the inter-firm level. Network snapshots provide the depictions of network patterns. It is important to analyse networks from snapshots, for example, by stages and structures. 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 a 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).

Overall analysis

This research 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 (see Figure 4.6). This study used network analysis as an extra 'layer' of analysis. Most of the research only analyse the collected data. This study not only analysed 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.

Figure 4.6 Data analysis



	Research Question 1	**Research Question 2**	**Research Question 3**
Data analysis	Network regression modeling	Gould and Fernandez test (G&F test)	Network snapshots
Expected test	Network influences	Network structures	Network dynamics

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 recent years (Borgatti, 2011). 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 (Borgatti, 2011). This 'three-layer'

analysis approach also transfers the focus from cause-effect to network as process and links the SMEs networks with their performance. Thus, this study contributes to research method by combining network analysis and hypothesis testing.

4.12 Generalisation, reliability and validity

Generalisation

The generalisation for network studies is crucial to this research's implications. The generalisation of network studies can be achieved by choosing an ideal sample size or representative networks as cases (Scott, 1991; Nohria and Eccles, 1992; Burt, 2007; Borgatti, 2011). The ideal sample size for network studies is discussed in the section about data collection and sample size. This section discusses how to generalise the results through representative networks as cases. Each network can also be treated as a case to explore the specific SME connection characteristics. Networks as cases can help to examine the not clearly evident phenomenon in the SME context (Burt, 2007 and 2015). If the great details of phenomena can be observed in the cases, the findings will be helpful in adding content to the existing theories or building new theories (Lin, 1999a and 1999b; Blaikie, 2007). Networks as cases can provide considerable analysis, especially appropriate in exploring new research topics, such as network dynamics and structures. It has been suggested that the generalisation for network

studies can be achieved in the following ways:

1. The choices of 'networks' are crucial to generalisation (Weller and Romney, 1988). The cases should be representative in the selected context so that other studies using similar methods can find similar results (Gobo, 2009). Thus, this research selected representative rather than unique network cases.

2. The generalisation of network studies relies on how the research defines or refines the research questions (Payne and Williams, 2005). The more precisely focused and described research questions, the better chance of generalisation (Williams, 2000 and 2004). In this research, the proposed research questions are articulated and refined through the literature review.

3. The generalisation of network studies also relies on the context of the research topic (Williams, 2000 and 2004). Generalisation can be achieved if the findings from the selected cases are with explicitly formulated context. In this research, all the selected cases have detailed descriptions about how SME growth is progressed, such as network structures and dynamics in this study.

4. The generalisation of network studies is limited to a certain time period (Payne and Williams, 2005). The research topic needs to cover future tendencies

(Williams, 2000 and 2004). In other words, is the study cutting-edge? In this research, the selected cases are the representative and leading case in the context. The reason is that this study selected the most active areas (Beijing and Shanghai) and time period (2011 to 2015) in SME growth, in terms of volume of products and number of firms (Potrafke, 2015).

5. Finally, the generalisation of network studies relies on the type of research question (Donmoyer, 2008). The research questions in this study are about exploring network influences (research question 1), structures (research question 2) and dynamics (research question 3). These significant features of SMEs networks can be described in the findings from the selected cases.

Networks as cases are also recognised as particularly useful in the early stages of new exploratory investigations (Meredith, 1998; Lewis and Brown, 2012). The advantage of network studies is an in-depth observation of the details of a phenomenon (Voss, Tsikriktsis and Frohlich, 2002). This can help to identify the weaknesses in existing theories and make conceptual contributions (Siggelkow, 2007). The network cases can provide illustrative examples of how SMEs are connected. The network cases also provide arguments and new ideas to the existing network theories.

Reliability and validity

The robustness of regression modeling can be examined by 1) ADjR2 increases, 2) P value, and 3) consistency between different samples (Wasserman and Faust; 1994; Hanneman and Riddle, 2005).

$ADjR^2$ indicates how robust and accurate the overall model is. The higher $ADjR^2$ increases, the more robust and accurate the overall model is. If the R^2 increase is presented in the results, it can suggest the model has good robustness. It can also mean that open and closed connections can be used to predict SME revenue growth in both 3 and 5 years term.

In contrast to $ADjR^2$ increase, the value of P indicates how robust each variable in the model is rather than the overall model. A more strict definition, the value of P is to determine whether each variable in the model can be supported by the data. The lower P value, the more significant influence a variable has. The suggestions about P value (Wasserman and Faust; 1994; Hanneman and Riddle, 2005) are in the table below.

Table 4.2 P value

When P (significance level) is less than	In the model (Table 2, 4, and 5) marked as
0.01, very significant and very likely to be 'true'	** *(means p < 0.01)*
0.05, significant and likely to be 'true'	* *(means p < 0.05)*
0.10, can be considered as significant and 'true'	† *(means p ≤ 0.1)*

To avoid the data are from extremely outlier cases and make sure the consistency, the same regression modeling procedure is run on two different sets of samples. The collected data contains two SME clusters. The regression modeling results can be presented using the data of both SME clusters together. To make sure the robustness, the regression modeling results of these two SME clusters also need to be presented separately to check the consistency.

In sum, the robustness of this analysis can be proven by 1) ADjR square showing the overall model robustness and accuracy, 2) low P value showing the robustness and significance of each variable, and 3) the consistency between two different sample sets showing the consistency of the model.

4.13 Research philosophy and 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 of this study.

Ontology-wise, 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 growth or a result of SME growth. Burt's (2007 and 2015) explanation is that a firm's knowledge and skill differences shape the structures of networks. Kilduff and Brass's (2010) argument is that the structures of networks cause the 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 growth. The network did not exist before firms collaborate together or it can be concerned as a network with no relation among the firms. Then, the network was building up while the SME growth progressing. Therefore, this study suggests that networks are formed by SME growth which requires firms across different functional roles working together.

Epistemology-wise, network reflects the activities occurred in firm collaborations (Blau 1982; Castells, 2000; Whittaker and Banwell, 2002). This study uses networks as the independent variables, it actually reflects and represents the patterns of inter-firm structure in SME growth. Then, this study uses SME revenue growth as the dependent variables to test the relationship between networks and SME revenue growth, meanwhile, SME characteristics as the control variables. In other words, this study treats networks as one of the causes of SME growth. Thus, this study's research design is to explore network dynamics, structure and the impacts of networks.

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 of network analysis are usually descriptive. For example, network analysis can be adopted to quantify a firm's network position 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 growth outcomes. Positivism emphasises hypothesis testing to discover the cause-effect relations (Booth *et al*., 2008). This study uses the results of network analysis to test the proposed hypotheses. Thus, this study's research philosophy position is positivism.

4.14 Summary

This chapter discussed this study's method. Network analysis can be adopted to analyse the relationships between SME connections and growth outcomes (Burt and Minor, 1983; Law and Callon, 1992; Portes, 1998; Burt, 1992, 2004 and 2007). This research 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 can be used to test the relations between inter-firm connections and SMEs growth results. Second, network structures wise, network analysis can be used to find out the regular connection structures among SMEs. This can provide details about how SMEs connect with each other to achieve growth. Third, network dynamics can be interpreted by the tendencies of connections to show which SMEs tend to connect together in networks. This can improve the understanding of how SME connections evolve during SMEs growth.

The data analysis in this research is a possible way of explaining and predicting network dynamics, structures, and influences in SME growth. Network analysis can be used to predict and elaborate SMEs growth outcomes, as well as, the structures and dynamics of SME connections (Burt and Minor, 1983; Law and Callon, 1992; Portes, 1998; Burt, 1992, 2004 and 2007). Thus, this study investigates SMEs growth from a

network perspective.

Chapter 5 Empirical finding chapter 1: Exploring the network structures of SMEs

5.1 Introduction

The previous chapter showed the influences of open and closed SME connections in the design, engineering, and management consultancy sectors. A question left in the last finding chapter is, how SMEs are connected with each other in open and closed SME connections? Burt (2015) suggested that the details about open and closed SME connections still need further exploration, this can help firms to identify open and closed connections, then connect with each other more efficiently during their growth. Thus, this chapter is to provide further details about the network structures of open and closed SME connections. This study's literature review suggested that there is not only one type of open or closed SME connection. Thus, it is necessary to find out more detailed open and closed structures in SME clusters. The results of this chapter can improve the understanding of how SMEs are connected with each other.

This chapter provides answers to the second research question of how firms in the design, engineering, and management consultancy sectors are connected with each other in the open and closed structures of SME connections. The purpose of this research question is to find out more details of the structures of open and closed SME

connections, this can help SMEs to identify open and closed connections and connect with each other more efficiently. There were five types of open structures identified in this study's literature review, "liaison", "representative", "gatekeeper", "coordinator", and "consultancy", and four types of closed structures, "degree centrality", "betweeness centrality", "closeness centrality", and "eigenvector centrality". In the previous research, it is not clear which of these structures are important and frequently recurring in SMEs growth (Burt, 2007 and 2015).

The second research question is how SMEs are connected with each other during their growth. By answering the second research question, it can improve the understanding of how SMEs are connected with each other during their growth. There are five types of open SME connections and four types of closed SME connections are identified in the previous literature review. This chapter presents five types of open SME connections and four types of closed SME connections to show how SME are connected with each other. To achieve this, this chapter provides a discussion of findings to make the connections between the results of data analysis and existing theories. Thus, this chapter of empirical findings includes:

- Five types of open connection structures (which identified in the previous literature review) in Section 5.2

- Four types of closed connection structures (which identified in the previous literature review) in Section 5.3.

- And a summary of SME connection structures is provided in Section 5.4.

5.2 Five types of open SME connections structures

This section presents the findings of five types of open connections (Gould and Fernandez, 1989). This section begins with what open connection is and then presents the five types of open connection.

What is open connection?

Open connection is defined as an SME connecting two otherwise disconnected SMEs (Burt, 2007). Thus, an open connection consists of three firms, two connections, and one disconnected gap between two firms. The firm bridging the other two is brokerage. This brokerage firm bridges the disconnected gap between two firms. Open connections are considered as gaps between firms, which can be strategically connected to affect their behaviours in networks (Burt, 2007 and 2015). Open connections are also concerned as gaps between disconnected contacts in networks (Badaracco, 1991; Batjarga, 2003, 2006 and 2007; Nohria and Eccles, 1992; Grootaert, 2001). Open connections can be considered as constraints and

opportunities in networks. The constraints are two disconnected firms relying on the brokerage firm to connect them. The opportunities are brokerage firms can benefit by gaining various information and business resources from those two disconnected firms. Thus, SMEs connecting the others (as brokers) in open connections have advantages.

There are a large number of open connections in the networks (see Figure 6.1 and 6.2 presented in the later chapter). Table 5.1 (as below) summarises the number of open connections. There are 3261 open connections among 1041 firms. SMEs are able to manage the large-scale of collaborations across organisational boundaries, since successful collaborations can provide financial returns, experiences and motivations for future collaborations (Drunker, 1985, Fleming and Mingo, 2007; Fleming and Waguespack, 2007). However, previous research (Inkpen and Tsang, 2005) shows that SMEs tend to have no more than seven collaborations at the same time. Also, previous research (Dyer and Singh, 1998; Parkhe *et al*., 2006) suggests that SMEs are 'connected with' other firms but not 'connecting others' as bridges. This finding is different from these existing studies suggesting that open connections and brokers are only a few firms in the network (Paldam, 2000; Parkhe *et al*., 2006). The findings show that open connections and brokers are not only a few firms in the network, they are a large group of firms in the network (see Table 5.1). This highlights the importance of analysing the frequency of open and closed connections.

Number of SMEs	Number of ties	Number of open connections
		
1041	1187	3261

Table 5.1 Number of SME open connections in design, engineering, and management consultancy sectors

What the five types of open connections are

In the design, engineering, and management consultancy sectors, previous literature suggests that SMEs with open connections are the brokers in networks (Fu and Zhang, 2012; Ozkan-Canbolat and Beraha, 2016). This point is confirmed by the same findings in the context of the banking sector (Uzzi, 1996 and 1999), oil sector (Vasudeva *et al.*, 2012), biotechnology sector (Owen-Smith and Powell, 2004), manufacturing sector (Frishammar and Åke, 2005; Lau *et al.*, 2010), and media sector (Gilsing, V. and Nooteboom, 2005). Thus, open connections as brokers have been widely accepted by scholars.

Scholars have acknowledged that open connections are valuable in terms of

increasing firm's revenue growth (Burt, 1992, 2004, and 2007; Podolny and Baron, 1997). Open connections are considered as efficient collaboration structures in firm growth (Bernardi, 2012; Aalbers, Dolfsma, and Koppiu, 2013). However, the structures of open connections among firms need to be analysed to provide a classification of different types of open connections. Also, open connections do not only mean collaborations between firms, but also brokerage between firms (Friedkin, 1993 and 1999). The other types of open connections need to be analysed at inter-firm level to reveal what they are (Beugelsdijk and Van Schaik, 2005; Gulati, 1999). Thus, this chapter provides an analysis to improve the understanding of the classification of various open connections types.

As this study's literature review discussed, Gould and Fernandez (1989) argue that there are potentially five types of open connections: "liaison", "representative", "gatekeeper", "consultancy" and "coordinator" (see Figure 6.1). In Figure 6.1, the nodes represent SMEs. The lines between the nodes represent financial collaboration connections in their development. The circles around the nodes represent the boundary between different professional groups, for example, the boundary between design and engineering groups.

These five types of open SME connections are identified by performing the Gould and Fernandez test (G&F test) in network analysis. G&F test provides an analysis to count the number of each type of open connections in a network (Fombrun, 1982;

Hanneman and Riddle, 2005). In other words, it shows how many of each type of open connections a firm has in the network. A detailed discussion about this is provided in the methodology.

The analysis results show that there are five types of open connections in SME networks. The result of G&F test is presented in Table 6.2. This result suggests that all five types of open connections identified in the theoretical framework appear in the same network. This suggests that open SME connections have those five types. They are "liaison", "representative", "gatekeeper", "consultancy" and "coordinator". It shows that open connections are more complex than previous research (Zaheer *et al.*, 1998; Watson and Papamarcos, 2002).

Figure 5.1 Five types of open connections

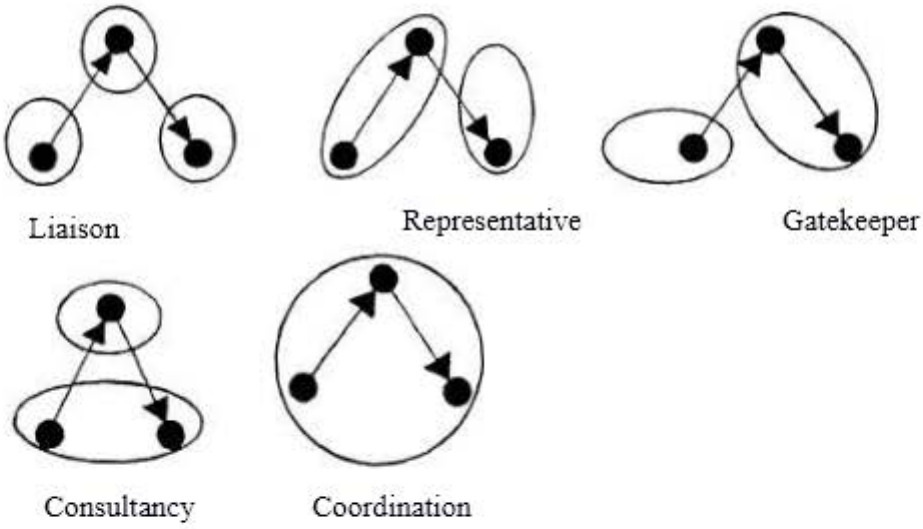


Table 5.2 Five types of open connections in each sector

Firms	Coordinator	Gatekeeper	Representative	Consultant	Liaison	Total
Management consultancy	201	217	233	221	235	1107
Design	237	239	217	218	238	1149
Engineering	205	197	199	196	208	1005

The data is based on firms in the design, engineering, and management consultancy sectors. A detailed discussion about the characteristics of these three sectors and how they can influence SME connections will be provided in Chapter 8 later. The reason for categorising firms into three sectors is due to data availability, firms are categorised in three sectors. The firm specialisation in the data shows that the sample covers these three sectors only. Thus, the result of G&F test breaks down the number of open connections by all three types of firm, design, engineering, and management consultancy (see Table 5.2).

Table 5.2 shows that all five types of open connections in the networks are almost equal in number. This indicates that SMEs with open connections include all these five types rather than just some of them. There are debates in the existing literature about whether there is only one type of open connections during firm development (Fernandez, 2002; Frishammar and Ake, 2005; Zou and Ingram, 2013; Clegg *et al.*, 2016). Fernandez (2002) argued that open connections can potentially have 'directional' difference, for example, a firm controlling the access to the firms connected with it (as gatekeeper in Figure 5.1) and a firm getting access to other firms for the firms connected with it (as representative in Figure 5.1). In this study's findings, these two

types are almost equal in numbers. Thus, this study's findings suggest that open SME connections are not only one type and they are a combination of "liaison", "representative", "gatekeeper", "consultancy" and "coordinator".

Table 5.2 also shows that not only management consultancy firms have these five types of open connections, but also design and engineering. Previous studies suggesting management consultancy are more likely to have open connections, since they act as brokers more often than design and engineering firms (Koka and Prescott, 2002; Platonov and Bergman; 2012; Gupta and Maltz, 2015; Cano-Kollmann *et al.*, 2016). This study suggests that open connections are almost equally own by all different types of firms in the network, rather than only by management consultancy in the context of SME growth. Borgatti (2011) suggested that three types of firms are sufficient to test open connection structures, since each open connection consists of just three firms and only one of them can be the broker connecting two others. In addition, Chapter 5 showed that the numbers of firms in these three sectors are almost equal. Thus, the almost equal numbers of open connections in these three sectors suggest they can all act as brokers in networks.

Gould and Fernandez (1989) suggested that there could be five types of open connections, but an interesting question remains that can firms have different types of open connections at the same time (Burt 2007 and 2015). In other words, are there any types of open connections unlikely to co-exist with the others? The existing

literature suggests that each small firm only maintains one kind of firm connections, due to its limited business resources (Aalbers, Dolfsma, and Koppius, 2013; Aalbers, Dolfsma, and Leenders, 2016). For instance, Obstfeld (2005) suggested that 'representative' and 'gatekeeper' are the types of open connections in the design, engineering, and management consultancy sector. Other studies also showed that 'liaison' as a type of open connections in these three sectors (Aalbers, Dolfsma, and Koppius, 2013; Aalbers, Dolfsma, and Leenders, 2016). However, this study suggests that most of the firms do not only have one type of open connections, they actually have all of them (see Table 5.3). Table 5.3 shows that 97 percent of them have all five types of open connections. Table 5.3 also shows that none of the SMEs with open connections has only one type of them. Thus, these findings show that when SMEs have open connections, they are likely to have all five types of them.

Table 5.3 SMEs with open connections in design, engineering, and management consultancy sectors

SMEs with all five types of open connections	SMEs with more than one type of open connections, but not all of them	SMEs with only one type of open connections
97%	3%	0%

This chapter presents the frequency of five open connection types. Open connection is important due to providing brokerage between firms to link business resources and information in firm development. Previous research noticed that there are a large number of collaborations as open connections among SMEs in their development (Rogers, 1966; Pittaway, *et al*., 2004). This research clarified the structures of open connections. Open connection was considered a firm bridge the disconnected others in collaborations (Cohen and Fields, 1999; Cohen and Prusak, 2001). These findings show that all five types of open connections frequently appear in SMEs growth. This helps to elaborate on the meaning of open connections further. Also, some literature highlighted the value of maintaining the number of open connections in networks (Patulny, and Svendsen, 2007; Lazzeretti and Capone, 2016). The number of open connections is positively related to a firm's success rate in new product development (Burt, 1992, 1997 and 2004). Firms with more open connections are more likely to enter new markets in the information technology sector (Owen-Smith and Powell, 2004; Lazzeretti and Capone, 2016). However, they have not explored the detailed structures of open connections. SMEs also need to consider the variety of open connections they have in the five types. Overall, this study's finding provided a better understanding of how open connections connect SMEs. Thus, this study's findings are complementary to the potential types of open connections (Gould and Fernandez, 1989) and the value of open connections (Burt, 2000 and 2004). Comparing to the previous research, the points in this section are:

- In the context of SME growth (in design, engineering, and management consultancy sectors), there are five types of open connections: "liaison", "representative", "gatekeeper", "consultancy" and "coordinator".
- Open connections are a combination of these five types. When SMEs (in design, engineering, and management consultancy sectors) have open connections in their development, they are likely to have all five types of them rather than only some of them.
- There are almost equal numbers of open connections in the three sectors, design, engineering and management consultancy. This suggests that any type of SMEs can connect others in open connections and it is not decided by which sector they are specialised in.

This section presented the findings of five types of open connections. A more detailed discussion is provided in Chapter 8 later. This chapter shows the details of these five types of open connections. Chapter 8 will provide a discussion about whether they are caused by the context of industrial sectors and why they are valuable in SME growth. The next section is to present the findings of closed connections.

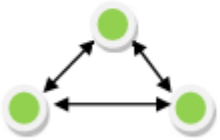
5.3 Four types of closed SME connection structures

This section presents the findings about four types of closed connections. As discussed in the literature review, closed SME connections can help SMEs progress fast, since their information and business resource exchanges can be through direct contacts, so that SMEs with closed connections can have better growth outcomes (Burt, 2007 and 2015; Hanaki, Nakajima and Ogura, 2010). Thus, it is necessary to explore the details of closed connections.

What is closed connection?

Closed connections are defined as inter-connected firms in networks (Tsai and Ghoshal, 1998; Ozkan-Canbolat and Beraha, 2016). The network snapshot presents the number of closed connections in the SME networks (see Figure 6.1 and Figure 6.2 in the later chapter). Table 5.4 shows that there are 212 closed connections among 1041 firms in the networks.

Table 5.4 Number of SME closed connections in design, engineering, and management consultancy sectors

Number of SMEs	Number of ties	Number of closed connections
		
1041	1187	212

Closed connections have three advantages in SME growth. First, closed connections provide more choices of firms to collaborate with, since they are inter-connected with each other (Nebus, 2006). In closed connections, each firm is not considered as a unique bridge to connect any others, since they are all directly connected with each other. Through these direct connections, the value of external resources and knowledge can be compared and confirmed by firms directly (Kraatz, 1998; Koka and Prescott; 2002). Thus, the closed connections can help SMEs to clarify the external resources and knowledge value for their growth (Nebus, 2006). Second, closed connections are more efficient in connecting cross-firm resources and knowledge, such as resources and knowledge about new markets and technologies (Uzzi, 1996). Reagans and Zukerman (2001) also highlighted that closed connections can help SMEs to share their knowledge and resources through direct connections. Although external resources and knowledge (for example about new markets and technologies) are not always valuable to all SMEs, they can be hugely beneficial to those SMEs who are able to implement them in business growth. In closed connections, these

resources and knowledge can be circulated among SMEs. Thus, these efforts of sharing resources and knowledge are likely to increase business growth (Nebus, 2006). Third, prior research showed advantages of closed connections in achieving a common view, which means agreements about achieving the business goal in inter-organisational collaborations (Uzzi, 1996). In the specific case of SME growth, closed connections can facilitate mutual understanding and help to build a common basis for implementing new ideas. Therefore, closed connections can support the transfer and implementation of diverse business resources and complicated ideas.

What the four types of closed connections are

As discussed in the literature review, closed SME connections can provide SMEs direct connections for information and business resource exchanges, so that SMEs with closed connections can have better growth outcomes (Burt, 2007 and 2015; Hanaki, Nakajima and Ogura, 2010). The analysis results suggest that these four types of closed connections frequently appear in SMEs growth (see Figure 6.2). The meaning of 'closed' was debated by scholars, they suggested there are different types of closed connections (Fu and Zhang, 2012; Ozkan-Canbolat and Beraha, 2016). They showed there are four ways of 'being closed' in network connections. The first type of closed connections is 'well-connected', which means firms can have a large number of connections then be interconnected with others in closed connections (Tsai and

Ghoshal, 1998; Boudreau and Robey, 2005). It is measured by degree centrality in network analysis. The second type of closed connections is 'network control power', which means firms control the connectivity in a network by frequently connecting two others as the shortest paths (Galaskiewicz, 2007). It is measured by betweeness centrality in network analysis. The third type of closed connections is 'network distance', which means firms can have a short network distance (through few firms to reach the others) to have closed connections (Fu and Zhang, 2012). This is measured by closeness centrality in network analysis. The fourth type of closed connections is 'connected to well-connected', which means a firm can have closed connections by just connecting to the well-connections firms (Ozkan-Canbolat and Beraha, 2016). This is measured by eigenvector centrality in network analysis. The rest of this section presents the findings about these four types of closed connections one by one.

Figure 5.2 Four types of closed connections (the red node has more closed connections than the others)

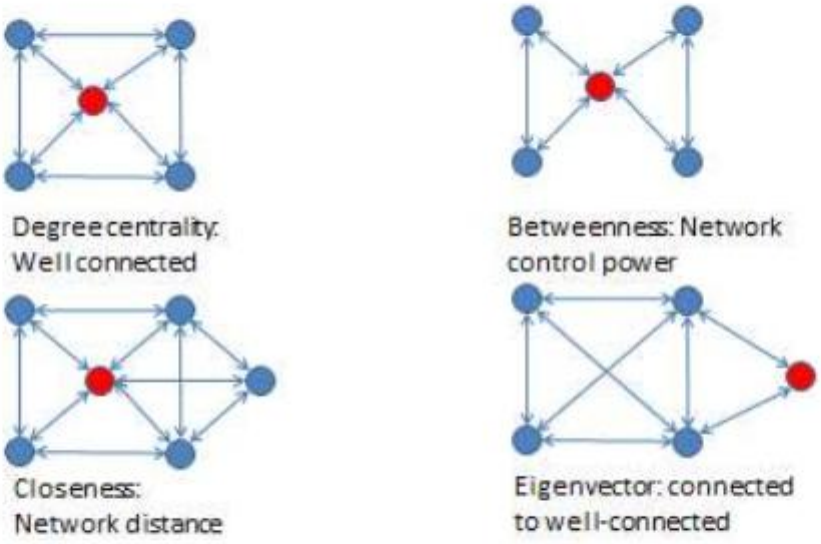


Table 5.5a Four types of closed connections by firm types

Firms	Well connected	Network distance	Network control power	Connected to well connected
Management consultancy	92	2	39	35
Design	95	3	37	37
Engineering	98	2	38	36

Table 5.5b The differences between firms with closed connections and without.

Firms	Well connected	Network distance	Network control power	Connected to well connected
SMEs with closed connections	96	2	39	37
SMEs without closed connections	1.2	9	1	1

Closed connection type 1: well-connected

The first type of closed connections is 'well-connected', which is measured by degree centrality in network analysis. Degree centrality shows how well-connected a firm is in the network by the number of connections it has (Freeman, 1979; Burt and Minor, 1983; Marsden, 2002). Table 5.5a shows degree centrality in the networks. As discussed in the methodology part, centrality measures can be used to describe the network structure. Table 5.5a shows that all three types of firms are almost equally well-connected, when they have closed connections. This can be seen in a similar value of degree centrality. This suggests that the firms in the three sections are well-connected at the same level. Also, a firm being well-connected is not decided by the sector.

SMEs with closed connections have an average of 96 connections, and SMEs without closed connections have an average of 1.2 connections (see Table 5.5b). Previous research suggests that SME network can only be either well-connected or not (Uzzi, 1996; Burt, 2004). However, it is neither of the cases. As mentioned above, SMEs with closed connections are well-connected (have average 96 connections) and SMEs

without closed connections are not well-connected (have average 1.2 connections). Thus, SMEs with closed connections are well connected.

Closed connection type 2: network control power

The first type of closed connections is 'network control power', which is measured by betweenness centrality in network analysis. Betweenness centrality measures how many times a firm connects two others as the shortest path in a given network (Freeman, 1979). Betweenness centrality shows network power by controlling the shortest network path. An SME's power of control is expressed by the number of shortest paths in the network passing through that SME. This measure can reflect the SME's control power in a network. Thus, this research uses betweenness centrality to reflect SMEs' network location advantages in controlling the network.

Firms have a high power of control which can be seen as in the high value of betweenness centrality in Table 5.5a and 5.5b. Table 5.5a indicates that no type of firm has a higher power of control in the network, since the values are similar in all three types of firms (see network control power in Table 5.5a). This suggests that the networks are not controlled by a certain type of firm. This is confirmed in Chapter 8 later, as those firms' strategic choices make them control the network. Also, Table 5.5b shows the difference in network control power between firms with closed connection (controlling average 96 shortest paths) and without connection (controlling

average 2 shortest paths). This suggests that the networks are controlled by SMEs with closed connections. The existing literature suggests that SME growth process in networks is unlikely controlled by those SMEs providing connections (Borgatti, 2011; Burt *et al*., 2013). This finding confirms that SMEs in the three industrial sectors have similar network control power (since similar values of network control power in Table 5.5a), however, the networks are controlled by SMEs with closed connections (since the difference in network control power in Table 5.5b). This is further confirmed in Chapter 8 later by comparing this study's findings with other sectors.

Closed connection type 3: network distance

The third type of closed connections is 'network distance', which is measured by closeness centrality in network analysis. Closeness centrality measures a firm passing through how many firms to reach the others averagely in a network (Freeman, 1979; Borgatti, 2011). Thus, closeness centrality shows a firm's network distance from all others. The result in Table 5.5a shows that all three types of firms with closed connections are very close to other firms in the network, which can be seen from the network distance of 2 or 3. Table 10b shows the difference in network distance between SMEs with closed connections and SMEs without. SMEs with closed connections can reach the other firms thorough only 2 firms in the middle on average. On the other hand, SMEs without closed connections can reach the other firms with averagely 9 firms in the middle. This means closed connection can make the network

path shorter. Firms can connect to others with fewer firms as brokers in the middle. Due to a large number of SMEs in the networks, these networks are very dense networks with short network distant between firms. Connections can be set up by going through just a few firms as brokers. In other words, SMEs network with closed connections is characterised by short path lengths and direct connections. Thus, the result suggests that SMEs with closed connections can connect other firms with fewer firms as brokers in the middle, than SMEs without closed connection.

Closed connection type 4: Connected to well-connected

The fourth type of closed connections is 'connected to well-connected', which is measured by eigenvector centrality in network analysis. Eigenvector centrality measures a firm's connections to the well-connected firms in a given network (Freeman, 1979; Borgatti, 2011). This measure can reflect an SME's indirect influences in the network. Such indirect influences are through the connections with well-connected firms in the network. Table 5.5a shows that all three types of firms have high values in 'connected to well-connected'. This suggests that those SMEs with closed connections are inter-connected together like a cluster. This finding fills the gap in the literature about what are the relationships between firms with closed connections (Burt and Merluzzi, 2014a and 2014b). It is important to fill this gap, because it shows how SMEs with closed connections collaborate together to share their network location

advantages in networks. Furthermore, Table 5.5b also indicates that SMEs with closed connections are more likely to be connected to well-connected firms than SMEs without. SMEs with closed connections have 39 times the chance of connecting to well-connected firms than SMEs without closed connections. Thus, this study suggests that firms with closed connections are interconnected in the context of SME growth.

In summary, the findings closed connections are:

- SMEs with closed connections are well connected in the design, engineering, and management consultancy sectors.
- SMEs with closed connections control the shortest network paths between the others in the design, engineering, and management consultancy sectors.
- SMEs with closed connections are closer to the other firms in the network comparing to SMEs without in the design, engineering, and management consultancy sectors.
- SMEs with closed connections are more likely to connect with the well-connected SMEs comparing to SMEs without in the design, engineering, and management consultancy sectors.

5.4 Summary

In order to answer the second research question, this chapter starts with analysing SMEs network structures. Then, this chapter uses network analysis to categorise open and closed SME connections into different types. In sum, this chapter provided answers to the second research question by suggesting that, five types of open SMEs connections and four types of closed SME connections frequently appear in SME growth, and they are crucial to SMEs growth outcomes. This chapter's findings show that firm collaborations are not organised in a hierarchical structure in inclusive growth. This also helps firms to locate themselves in networks and their network activities more efficiently.

This chapter addresses the following issues in theories. First, this chapter answered the question of what the SME network structure patterns are in inclusive growth. Second, this chapter answered the question of what kinds of SME connection structures appear and are the most effective in inclusive growth. And this chapter discovered open and closed SME connection structures which can trigger and enable SME growth. Third, this chapter explored how SMEs are connected in inclusive growth as five types of open and four types of closed connections. The last but not least, this chapter developed a model based on network theory for organising the connection structures in SMEs inclusive growth.

Comparing to the existing literature, the new findings of this study are:

1) Five types of open SME connection structures

Comparing to the theories about open connections, this chapter adds the following points for SMEs in design, engineering, and management consultancy sectors:

- This chapter suggests that there are five types of open connections in the design, engineering, and management consultancy sectors. They are "liaison", "representative", "gatekeeper", "consultancy" and "coordinator" brokers.
- SMEs with open connections have all these five types rather than just some of them.
- The number of open connections is not decided by which sector SMEs are specialised in.

2) Four types of closed SME connection structures

Comparing to the theories about closed connections, this chapter adds the following points for SMEs in design, engineering, and management consultancy sectors:

- This chapter suggests that SMEs with closed connections are well connected.
- This chapter suggests that SMEs with closed connections have high network control power.

- This chapter suggests that SMEs with closed connections have short network distance to the other firms in the network.
- This chapter suggests that SMEs with closed connections are interconnected with each other.

This chapter presented the findings about the structures of open and closed connections. A detailed discussion about these findings is provided in Chapter 8 later.

Chapter 6 Empirical finding chapter 2: SME connection influences on revenue growth

6.1 Introduction

Before presenting the findings, this section provides a connection between the research questions proposed in the previous literature review and the findings presented later.

The focus of this study's findings

SME growth is defined as increasing the supply of products and services, providing sustainable quality of life and structure of the economy, adopting sustainable ways of production, finding new sources of supply, and even exploring new markets (Stiglitz, 2016). SME growth 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 that leads to SMEs growth. The matter is how to measure the outcomes. Revenue growth is used in previous research (Landsperger, 2012; Baker, *et al*., 2016; Oparaocha, 2016), since it is:

- quantitative and comparable,
- officially declared by firms,
- and reflective to the growth.

Thus, this study measures SMEs performance as revenue growth. A formal definition of revenue growth is that the year's revenue increase compared to the previous year's revenue (Baker, *et al*., 2016).

As discussed in Chapter 2, 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 development. According to Burt's (2007) theory, complex connections do not stay static in SME growth. Obstfeld (2005) suggested that changing network dynamics is a process of creating both new open and closed structures between firms. These result in a theoretical gap in the structures, dynamics, and influences of inter-firm connections in SME growth. Thus, the findings of this study aim to improve the understanding of inter-firm connections in SME growth by exploring: the 1) influences 2) structures, and 3) dynamics of inter-firm connections.

The research questions to be answered and why they are important

There are three research questions proposed in the previous literature review. They are about 1) what are the influences of SME connections, 2) how SMEs are connected with each other, and 3) why those SME connections are formed in co-development. The literature review highlighted that SME growth often requires joint work with other firms. Especially, the inter-firm connections play an important role in SME growth, since they can facilitate collaborations among firms (Fukuyama, 1995 and 1997; Zaheer *et al*., 1998; Watson and Papamarcos, 2002; Davidsson and Honig, 2003; Funk, 2012; Landsperger, 2012; Oparaocha, 2016). In addition, previous research suggested that the theories for enterprise development by increasing SMEs sizes and improving their capabilities do not fit to the context of SMEs growth, since SMEs are unlikely able to internalised knowledge, skills and business resources (Landsperger, 2012; Baker, *et al*., 2016; Oparaocha, 2016). To resolve this, they suggested that the inter-connections among SMEs is more crucial in their development, since they can provide external knowledge, skills and business resources, but has rarely been explored. Network theories (Burt, 2007 and 2015) argue that SMEs can be strategically connected and contribute to SMEs performance, this leads to the first research question:

Research question 1: What is the relation between SME connections and revenue growth?

Also, the structures of SME connections remain unclear, this becomes the second research question:

Research question 2: How SMEs are connected with each other in SME growth?

Further, the third research question is about why the structures of SME connections are formed as the results of SMEs dynamics.

Research question 3: How do SME connections evolve towards to open and closed structures?

The links between the proposed three research questions are among SME inter-firm connection influences, structures, and dynamics. The first research question is to test 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 become the second research question that how SMEs are connected with each other in their co-development. One regular pattern in the SMEs networks is the closed structure due to the increase of connectivity. In the closed structures, SMEs are more interconnected together. The other regular pattern in the SMEs networks is the open structure. The second research question is to further explore the details of closed and open structures of SME connections. Then, the third research question is to explore why a network evolves from a few connections to a large number of highly complex open and closed connections during the progress of SMEs co-development. By answering these three research questions, this research sets out to find out the relations between the inter-firm

connections and SME growth results in inclusive growth. Thus, this research aims to answer these three questions about the influences, structures, and dynamics of SME connections in inclusive growth. Thus, this research focuses on SME connections in three questions: influences (Research question 1: what), structures (Research question 2: how), and dynamics (Research question 3: why) on SMEs growth. Table 6.1 summarises the research questions and hypotheses.

Table 6.1 The identified research questions and hypotheses

Previous literature	**Research questions and hypotheses**	**Related area and chapter**
Although, the influence of firm connections is highlighted by Borgatti (2011) and Burt (2007 and 2015). However, not all kinds of firm connections have influences on revenue growth. Thus, this study is to find out what types of firm connections are influential on revenue growth.	Research question 1: What is the relation between SME connections and revenue growth? To answer the first research question, three hypotheses are proposed as below: • Hypothesis 1: Do open connections positively influence SMEs growth? • Hypothesis 2: Do closed connections positively influence SMEs growth? • Hypothesis 3: Do open and closed connections jointly and positively influence SMEs growth?	Network influences, Chapter 5 Empirical finding

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 2: How SMEs are connected with each other in SME growth? To answer the second research question, descriptive statistics about network structures are provided and there is no hypothesis testing.	Network structures, Chapter 6 Empirical finding
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 3: How do SME connections evolve towards to open and closed structures? To answer the third research question, three hypotheses are proposed as below: • Hypothesis 1: The well-connected SMEs get more connected with others in SME growth. Well-connected ⟶ More connected • Hypothesis 2: The well-connected SMEs get more interconnected with each other in SME growth. Well-connected ⟶ interconnected • Hypothesis 3: SMEs with different roles of brokerage ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other. Different roles of brokerage connect	Network dynamics, Chapter 7 Empirical finding

What analysis is used

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 research 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 can be used to test the relations between inter-firm connections and SME growth results. Second, regarding network structures, network analysis can help to find out the regular connection structures among SMEs. Third, network dynamics are shaped by the tendencies of connections (Galbraith, 1974; Koka and Prescott, 2002; Labianca and Brass, 2006; Burt, 2007; Gardet and Fraiha, 2012). Thus, network dynamics can be analysed as that which SMEs tend to connect with together in networks.

The structure of this chapter

At the beginning of this study's empirical findings, this chapter presents and discusses the analysis result about the influences of SME connections. Then, the results of network structures and dynamics are presented in the following two empirical finding chapters. This chapter includes five sections:

1 The introduction section provides an overview of the findings and research questions.

2 The following section provides the regression modeling results of network influences.

3 Then, the analysis results section presents the robustness of this analysis.

4 A finding discussion section to compare the findings with previous literature.

5 A summary section to summarise the findings and discussion about SME connection influences.

6.2 The influence of open and closed connections

This section presents the findings for the first research question about what the influences of SME connections are. This section includes 1) The data used for the

analysis, 2) SME network snapshots, 3) What these network snapshots tell us, 4) The regression modeling results about SME connection influences, and 5) What these regression modeling results tell us.

The data used for the analysis

The data were collected from Firm-Level Micro-Data in the OECD ORBIS Database. The data covers SME connections 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 financially declared collaborations in the dataset. In this study's data, each SME in the networks contributes financially to their connections. Thus, the data collected covers all financially declared SMEs collaborations. Inter-firm collaboration is defined as two or more firms working together to achieve competitive advantages through joint investment, sharing information and business resources, making joint decisions, and sharing profits (Togar and Sridharan, 2002). As discussed in the methodology, formal networks are more likely to be influential on revenue growth than informal networks in firm development (Burt, 2015). The reason is that informal networks are usually overlapped with formal networks (such as formal financial collaborations) and they cannot represent the overall network structures (Borgatti, 2011). Thus, this study focuses on formal networks rather than informal networks.

The reason for using this dataset is that recent research (Potrafke, 2015) suggested they are the most active areas and the time period in SME collaborations, in terms of the number of SMEs. In order to present representative SME networks, network analysis research needs to choose networks with 1) a large number of connections (ideally bigger than 250), 2) successful network development results, and 3) active connections. To meet these requirements, the chosen dataset is SME networks with overall positive revenue growth in the time period and has 1041 active SMEs with 1187 collaborations. Therefore, this study chooses this dataset which covers SME growth in the active areas and time period. The detailed reasons of why these networks are chosen are discussed in the methodology chapter.

SME network snapshots

Figure 5.1 and 5.2 show the SME connections in Beijing and Shanghai. The nodes are SMEs. They are two separate clusters so that they are presented in two network snapshots. The reason for analysing two separate networks is to make sure the consistency of the findings and avoid extreme cases and outliers. The lines between them are collaborations, which represents development collaborations and partnerships between SMEs.

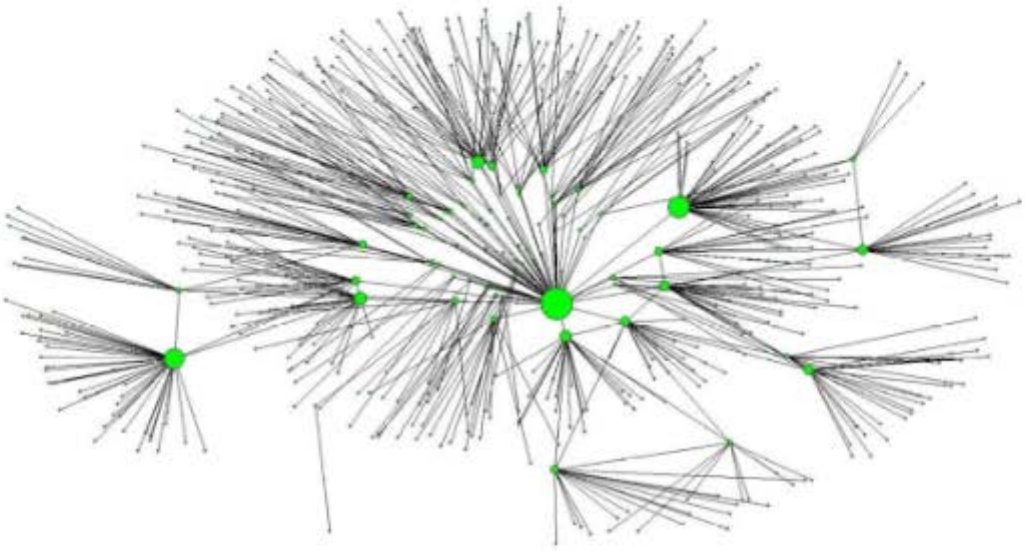


Figure 6.1 SMEs Cluster 1 in Beijing and Shanghai (Sample size: 529 SMEs, nodes are SMEs, lines are collaborations, the size of the node represents each SME's overall revenue growth in 3 years)

In Figure 6.1, the snapshot of network analysis about the first SMEs cluster in Beijing and Shanghai is presented. This SME network has an overall positive revenue growth in the time period and has 620 active SMEs with 529 collaborations. Each node represents an SME. And the lines are collaborations among those SMEs. This snapshot includes a large number of 620 connections among 529 SMEs identified in the data. These 620 connections formed 1723 open structures of SME connections and 115 closed structures of SME connections. This finding suggests that there are a large number of connections among those SMEs and a large number of open and closed structures exist in SMEs network.

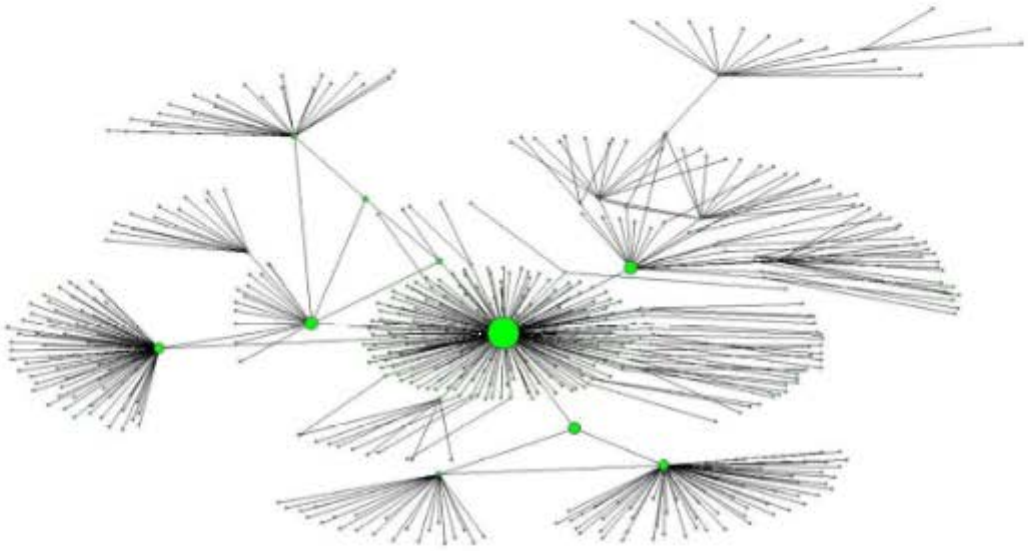


Figure 6.2 SMEs Cluster 2 in Beijing and Shanghai (Sample size: 512 SMEs, nodes are SMEs, lines are collaborations, the size of the node represents each SME's overall revenue growth in 3 years)

In Figure 6.2, the snapshot of network analysis about the second SMEs cluster in Beijing and Shanghai is presented. This SME network has an overall positive revenue growth in the time period and has 512 active SMEs with 567 collaborations. Similar to Figure 1, each node is an SME and the lines are collaborations among those SMEs. This snapshot includes a large number of 567 connections among 512 SMEs identified in the data. These 567 connections formed 1538 open structures of SME connections and 97 closed structures of SME connections. This finding is consistent with Figure 1 and confirms that there are a large number of connections among those SMEs and a large number of open and closed structures exist in SMEs network.

What these network snapshots tell us

Previous research argued that it is unlikely to have a large number (over a hundred) of connections, open and closed structures in SMEs network (Burt, 2007). The reason is that each connection is collaboration and needs efforts to maintain it. SMEs usually have limited resources, thus limit the number of connections they can possibly spend money and time on. However, it is noticed that the number of connections is positively associated with the number of SMEs in this study's findings. Figure 1 has 620 connections among 529 SMEs, while Figure 2 has a smaller size with a fewer number of 567 connections and 512 SMEs than the network in Figure 1. Thus, this study suggests that more SMEs in a network, the more connections are among them. Therefore, this finding is contradicted to Burt (2015) who argues the number limit of finance related connections in firm collaborations.

Also, previous research (Uzzi, 1996 and 1999; Burt, 2007) suggested that open and closed structures of connections can increase when the number of SMEs increases. This study confirms that the number of open and closed structures is positively associated with the number of SMEs and the number of connections. The reason is that the more firms in a network, the more connection structures they can possibly have (Burt, 2007). In Figure 1, 620 connections among 529 SMEs formed 1723 open structures and 115 closed structures. In Figure 2, a smaller number of 567 connections among 512 SMEs formed a relatively smaller number of 1538 open structures and 97

closed structures. This means that the more SMEs and connections in a network, the more open and closed structures they can form. This finding confirms the point (Uzzi, 1996 and 1999; Burt, 2007) that the number of open and closed structures is positively associated with the number of SMEs. SMEs are more likely to collaborate with each other in a large network, since they have more firms as connection choices (Burt, 2007). Therefore, this study implicates that SMEs seeking co-development should join large networks rather than small networks, because it is more likely to set up collaborations in large networks.

Test of data normality: Multicollinearity check, heteroscedasticity check, and descriptive statistics

Before presenting the regression modeling results about network influences, it is necessary to provide the results about 1) multicollinearity check, 2) heteroscedasticity check, and 3) descriptive statistics. Multicollinearity check and heteroscedasticity check are to decide whether the data can be used for regression modeling and what kind of regression modeling can be used. The results of descriptive statistics are to provide further details about the data, which include the mean (average) and standard deviation (how much differences between the firms) in firm's age, number of employees, revenue, turnover, industrial sectors (which are the control variables in the model), the number of open connections each SME has, the number of closed

connections each SME has (which are the independent variables in the model), and 3 and 5 year revenue growth (which are the dependent variables in the model).

First, the results of multicollinearity check (see Table 6.2) shows that the data do not have multicollinearity issue. The reason for doing multicollinearity check is to make sure the control and independent variables have influences on the dependent variables independently rather than overlapped influences (Field, 2018). In other words, the multicollinearity check is to make sure that each of the control and independent variables means different things rather than similar. These variables include company age, number of employees, turnover, revenue, industrial sector, the number of open connections, and the number of closed connections. The recommended rule for this is VIF value lower than 10 (Field, 2018). Table 6.2 shows that all the control and independent variables have VIF value lower than 10. Thus, these variables do not have overlapped influences and can be used for regression modeling.

Table 6.2 Multicollinearity check

Variable	VIF
Company age	1.002
No of employees	1.010
Revenue	1.003
Turnover	1.008
Industrial sector	1.002
Open	4.020
Closed	3.918

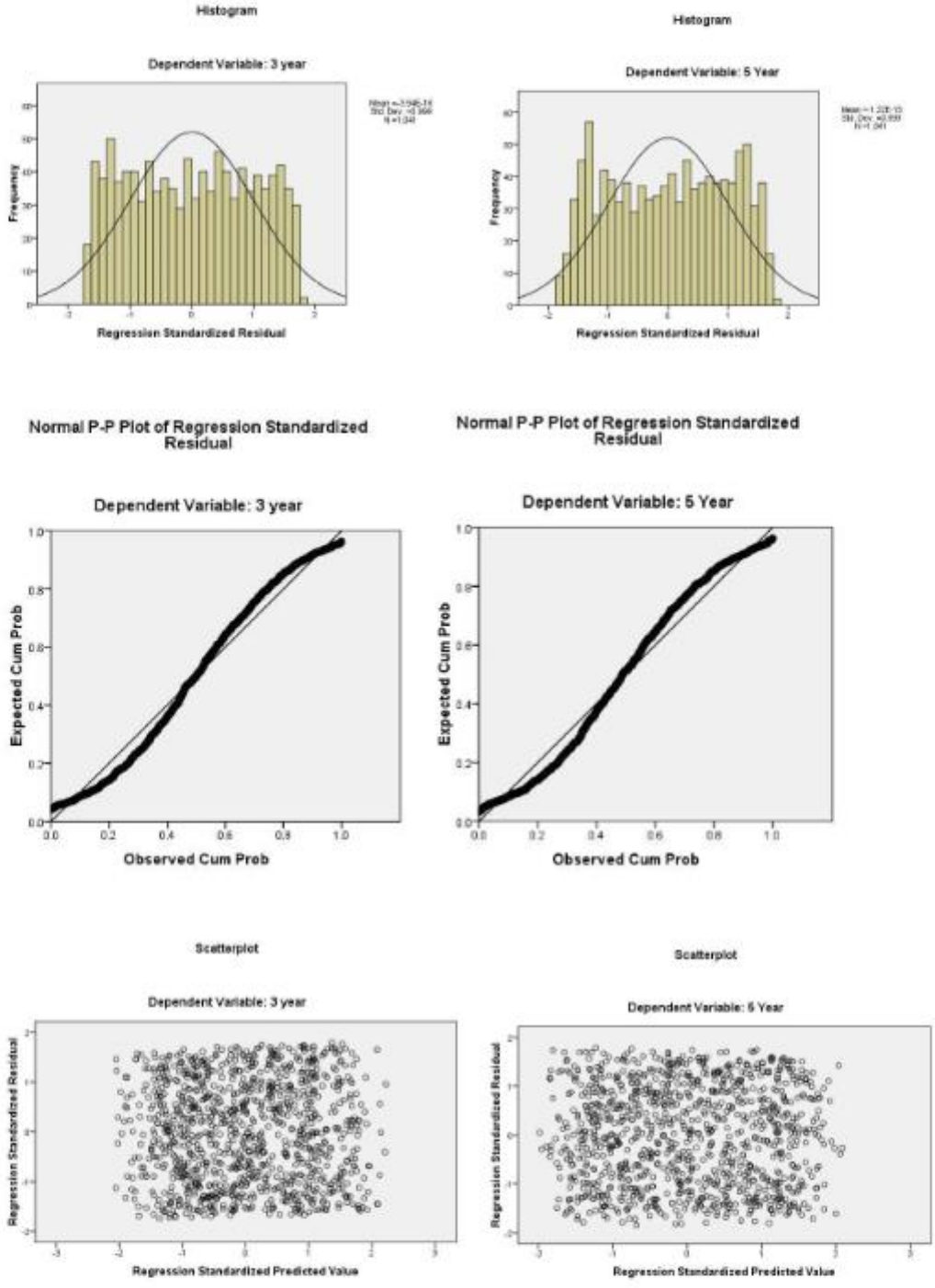
To further confirm there is no multicollinearity issue in the data, correlations between variables are presented in Table 6.3. According to the recommended rule, a significant correlation has a correlation value of greater than 0.1 and sig smaller than 0.01 (Field, 2018). According to this rule, there is no significant correlation between any two variables in Table 6.3. Thus, this confirms that the data does not have multicollinearity issue, which means the variables are different from each other rather than similar.

Table 6.3 Correlations between variables

		Company age	No of employees	Revenue	Turnover	Industrial sector	Open
Company age	Correlation						
	Sig. (2-tailed)						
No of employees	Correlation	.019					
	Sig. (2-tailed)	.547					
Revenue	Pearson Correlation	-.002	.020				
	Sig. (2-tailed)	.941	.509				
Turnover	Correlation	.029	.042	.031			
	Sig. (2-tailed)	.349	.176	.325			
Industrial sector	Pearson Correlation	-.007	.011	-.032	.019		
	Sig. (2-tailed)	.827	.728	.302	.532		
Open	Pearson Correlation	.015	.021	-.002	-.051	-.025	
	Sig. (2-tailed)	.625	.504	.939	.102	.424	
Closed	Pearson Correlation	-.022	.005	.001	-.046	-.019	.037
	Sig. (2-tailed)	.476	.880	.984	.137	.542	.230

Second, the results of heteroscedasticity check (see Figure 6.3) show that the data can be used for regression modeling. Figure 3 shows the distribution of the data against 3 year and 5 year revenue growth separately in the histogram, P-P plot, and scatterplot. The recommended rule is that 1) the histogram is close to the shape of the normal distribution curve, 2) P-P plot is close to the diagonal line in the square, and scatterplot is evenly distributed (Field, 2018). According to this rule, the data can be used for regression modeling. It is noticed that the histograms are not perfectly close to the normal distribution curve. However, this does not affect the regression modeling. The reason is that network analysis data requires randomised regression rather than linear regression, which does not require normal distribution in the data (Wasserman and Faust1994; Hanneman and Riddle, 2005). Thus, Figure 6.3 suggests that the data can be used for regression modeling.

Figure 6.3 Heteroscedasticity check results



Third, the results of the descriptive statistics are presented in Table 6.4. The descriptive statistics include range (difference between the largest and smallest value), minimum and maximum value of each variable, mean (average) and standard deviation (how much differences between the firms) in firm's age, number of employees, revenue, turnover, industrial sectors (which are the control variables in the model), the number of open connections each SME has, the number of closed connections each SME has (which are the independent variables in the model), and 3 and 5 year revenue growth (which are the dependent variables in the model).

Table 6.4 shows that the firm's age in the data is between 5 and 57 years. Number of employees is between 20 and 250. Revenue and turnover are from 26 thousand to 2.9 million and 23 thousand to 4.9 million US dollars. The numbers of firms in each sector are almost the same, since the mean for each industrial sector is very close (these numbers represent the percentage of firms in each sector). These firms in the data have from 0 open connections to 316. In terms of closed connections, these firms have from 0 to 23. Such a difference between the number of open and closed connections is caused by closed connections that need more firms to participate than open connections (Burt, 2007). And these firms' revenue growth is in a range of -135 thousand to 647 thousand US dollars in 3 years and -209 thousand to 1.1 million in 5 years. In terms of standard deviation, the largest difference among these firms is the size of turnover, since it has the largest value in the standard deviation column. Also, there are more differences in 5 year revenue growth than 3 years. These descriptive statistics provide a brief

description of the data. In order to provide more meaningful insights, the following sections present the results of regression modeling.

Table 6.4 Descriptive statistics

	Range	Minimum	Maximum	Mean	Std. Deviation
Company age	52	5	57	30.18	13.950
No of employees	230	20	250	139.33	66.652
Revenue (K USD)	2973	26	2999	1469.76	862.459
Turnover (K USD)	4970	23	4993	2445.16	1425.490
Industrial sector					
Consultant	1	0	1	.338	.733
Design	1	0	1	.319	.663
Engineering	1	0	1	.343	.749
Open and closed connections					
Open	316	0	316	2.85	221.638
Closed	23	0	23	.19	12.11
Both	23	0	23	.17	12.09
Revenue growth					
3 year (K USD)	782	-135	647	238.19	156.252
5 Year (K USD)	1346	-209	1138	435.36	283.208
Number of firms	**1041**				

Table 6.5 shows the correlations between (open and closed) connectivity and SMEs revenue. This is tested as the correlations between open connection and revenue, and also between closed connection and revenue. The results suggest that there is not significant correlation between neither of these two pairs of variables, since sig values are .939 and .984 bigger than the threshold .05. This result means neither open or closed connections can influence revenue individually. However, the result does not rule out the chance they can still influence revenue when they combine with other

variables. Thus, this study use regression model to see if they can have influence on revenue when they combine with other variables.

Table 6.5 Correlation between connectivity and SMEs revenue

		Revenue
Open	Pearson Correlation	-.002
	Sig. (2-tailed)	.939
Closed	Pearson Correlation	.001
	Sig. (2-tailed)	.984

The results of the regression modeling about SME connection influences

As discussed in the previous literature review, open and closed connections can influence SME's revenue growth. However, the question remaining here is to what extent they can influence SME's revenue growth. Thus, the regression modeling results are to compare the influences of open and closed connections (as independent variables) with other factors including firm's age, number of employees, revenue, and turnover (as control variables). These variables are discussed in the methodology chapter.

The reason for using regression modeling is to compare the influences of open and closed connections to other factors, including company age, number of employees, turnover, revenue, and industrial sector. In order to do this, seven models are tested which includes open and closed SME connections as independent variables one by one.

This shows the differences between each model by adding open and closed connections as variables. Model 1 shows the results without SME connection influences. Then it can be compared to Model 2 with open connection influences, Model 3 with closed connection influences, and Model 4 with both open and closed connection influences. To make sure the robustness of the results, this study uses two sets of data about the SMEs performance. They are 3 year and 5 year revenue. 3 year revenue is the dependent variable in Models 2, 3 and 4, while in Models 5, 6 and 7, 5 year revenue is the dependent variable. Therefore, Models 5, 6 and 7 are similar to Models 2, 3 and 4, but showing the SME connection influences in a longer term.

The following paragraphs are to describe the seven modeling results in order. The results of the regressions are shown in Table 6.5. Model 1 is to test the influences of firm's age, number of employees, revenue, and turnover without SME connections. The results suggest none of them can positively and significantly influence SME's revenue growth.

Model 2 adds open connections in the model together with the variables tested in model 1 to compare the difference. Open connections are measured by using each firm's overall broker score. As predicted in the theoretical framework, open connections have positive and significant on SME's revenue growth ($\beta = 0.2889$, $p = 0.002$). Model 3 adds closed connections in the model together with the variables tested in model 2 to compare the difference. Closed connections are measured by using each firm's

centrality score. As Model 3 highlights, the influence of closed connections on SME growth outcome is similar to that of open connections ($\beta_{open} = 0.3693$, $p = 0.007$ vs. $\beta_{closed} = 0.2918$, $p = 0.004$ respectively). Of interest is the relative magnitude of the effect of open and closed connections. These results suggest that open and closed connections can significantly and positively influence SMEs performance. In addition, the industrial sector (as management consultant, design and engineering in all models) has p values bigger than 0.05, which means no significant correlation between any of them and revenue growth. Thus, an SME's revenue growth is not influenced by which sector the SME is in, since industrial sector (as management consultancy, design, and engineering in all models) is not correlated with revenue growth.

Table6.6 Regression modeling result for SMEs cluster 1 and 2 (the cluster in Figure 6.1 and 6.2)

	Model 1 Without SME connection influences	Model 2 With open connection	Model 3 With closed connection	Model 4 With both open and closed connection	Model 5 With open connection	Model 6 With closed connection	Model 7 With both open and closed connection
	3 years revenue growth				5 years revenue growth		
Constant	−0.516	−0.482	−0.267	−0.185	0.1259	0.0129	0.0152
	(0.739)	(0.852)	(0.889)	(0.895)	(0.997)	(0.929)	(0.926)
Company age	−0.026**	−0.0298**	−0.0281**	−0.0279**	−0.0275**	−0.0272**	−0.0258**
	(0.015)	(0.017)	(0.016)	(0.014)	(0.017)	(0.018)	(0.017)
Number of employee	−0.0049	−0.007†	0.0019*	0.0022*	0.0362	0.0401*	0.0507*
	(0.029)	(0.028)	(0.019)	(0.017)	(0.025)	(0.027)	(0.026)
Revenue	0.0499	0.1178*	0.1158	0.1293	0.1692*	0.2573*	0.2688*
	(0.117)	(0.109)	(0.118)	(0.125)	(0.117)	(0.218)	(0.24)
Turnover	0.0691	0.0087	0.0298	0.0307	0.1407	0.0269	0.0395
	(0.137)	(0.133)	(0.162)	(0.188)	(0.169)	(0.147)	(0.121)
Group–Management consultant	0.2682	0.2858	0.2917	0.2925	−0.5923†	−0.6228†	−0.6397†
	(0.325)	(0.322)	(0.326)	(0.329)	(0.387)	(0.392)	(0.389)
Group–Design	0.1997	0.0652	0.0799	0.0826	−0.5367	−0.498	−0.4267
	(0.307)	(0.338)	(0.379)	(0.358)	(0.365)	(0.303)	(0.309)
Group–Engineering	0.2835	0.2267	0.967†	0.9772†	−0.8567	−0.2359	−0.2119
	(0.598)	(0.615)	(0.588)	(0.596)	(0.658)	(0.599)	(0.597)
Open		0.2889**	0.3693**	0.3718**	0.2857**	0.3688**	0.3793**
		(0.118)	(0.126)	(0.129)	(0.185)	(0.169)	(0.187)
Closed			0.2918**	0.2979**		0.4653**	0.4477**
			(0.129)	(0.137)		(0.152)	(0.156)
Both				0.1856**			0.1703**
				(0.069)			(0.067)
ADj R^2	0.4267	0.5893	0.6885	0.7269	0.5968	0.7239	0.7358

N = 1041; †$p \leq 0.1$; * $p < 0.05$; ** $p < 0.01$; two-tailed tests, robust standard errors in parentheses.

To ensure that the results are robust, this study tests the SME connection influences on revenue growth over a longer time period. Models 5, 6 and 7 focus on the 5 years revenue instead of 3 years revenue tested in model 2, 3 and 4. Model 5 suggests support for open connections contribute to SME's revenue growth ($\beta = 0.2857$, $p = 0.001$). More significantly, once the model 6 includes closed connections, the influence on SME's revenue growth increased ($\beta = 0.3688$, $p = 0.006$ and $\beta = 0.4653$, $p = 0.005$

respectively). These results confirm that open and closed connections can significantly and positively influence SME's revenue growth over a longer term of period.

The coefficients in these models can be used to predict an SME's revenue growth. For example, using Model 3 to predict an SME's revenue growth, it is as below:

A given SME's revenue growth over 3 years = −0.267 − 0.0281 × Firm's age + 0.0019 × Number of employees + 0.1158 × Current year's revenue + 0.0298 × Turnover + 0.2917 (if that SME is in management consultancy industry) + 0.0799 (if that SME is in management consultancy industry) + 0.967 (if that SME is in management consultancy industry) + 0.3693 × The number of open connections that SME has + 0.2918 × The of closed connections that SME has.

$ADjR^2$ indicates how accurate the model is. A more strict definition, $ADjR^2$ indicates the total variation of the dependent variable can be explained by independent variables. In this study, the differences in $ADjR^2$ between each model will show the influence of open and closed connections. For example, Model 1 includes only the variables without SME connections. Model 2 adds open connections. As predicted in the theoretical framework, adding brokers in the model can increase model accuracy by increasing $AdjR^2$ from 0.4267 to 0.5893. Model 3 adds both open and closed connections to the model. Then, the $ADjR^2$ increases from 0.5893 to 0.6885. A similar increase happens in model 5 and 6 which testing against the 5 years revenue. The

$ADjR^2$ increase suggests open and closed connections can significantly influence SMEs performance.

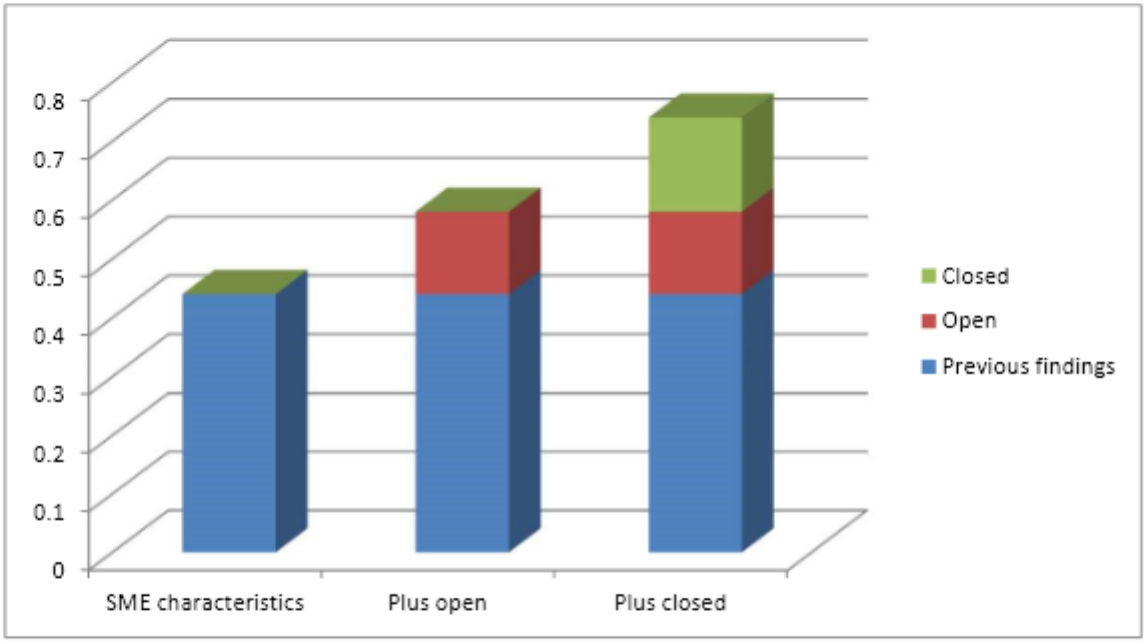
Here, while firm's characteristics matter for SMEs performance, each of their influence is less than that of open or/and closed connections. Open or/and closed connections have more influence on SMEs performance than each of firm's characteristics. Moreover, the influence of open connections is more significant when closed connections are added to the model, which suggests that having both of them can provide more extra effects on reverence growth than the sum of each alone, a 'one plus one bigger than two effects'. This is also confirmed by the positive value of 'both' in the model. Thus, the result suggests open and closed connections jointly have a significant influence on SMEs performance.

What these regression modeling results tell us

Figure 6.4 shows the $ADjR^2$ increase in regression modeling to compare the impact of open and closed connections with SME characteristics. The previous literature suggested firm's age, number of employees, revenue, and turnover can influence performance (Nohria and Eccles, 1992; Emirbayer and Goodwin, 1994; Haythornthwaite, 1996; Podolny and Baron, 1997; Tsai, 2000; Hinton *et al.*, 2012). $ADjR^2$ in the regression modeling (in Model 1) shows that all these previous findings

can influence about 42 percent of SME revenue growth. After introducing open connections in the model, $ADjR^2$ increases to about 58 percent with P value lower than 0.01. After introducing closed connections in the model, $ADjR^2$ increases to about 72 percent with P value lower than 0.01. This means open and closed connections can significantly influence a large part of SMEs performance. Both together can influence about 30 percent of SME revenue growth.

Figure 6.4 The influences of open and closed connections on SME growth



In sum, this study confirms that SME connection structures are considered as positive influences on SME performance. More importantly, this study shows the extent of

SME connection influence. Previous research showed that the influences of firm characteristics are more than firm connection structures on revenue growth (Nohria and Eccles, 1992; Emirbayer and Goodwin, 1994; Haythornthwaite, 1996; Podolny and Baron, 1997; Tsai, 2000; Hinton *et al*., 2012). However, this study suggests that SME connections are more influential on revenue growth than SME characteristics. A question left here is how robust and reliable these results are. Thus, the next section presents the robustness of these results.

6.3 The robustness of analysis

This section presents the robustness of the results presented in the previous section. The robustness of regression modeling can be examined by 1) $ADjR^2$ increases, 2) P value, and 3) consistency between different samples (Wasserman and Faust; 1994; Hanneman and Riddle, 2005).

$ADjR^2$ increases

$ADjR^2$ indicates how robust and accurate the overall model is. The higher $ADjR^2$ increases, the more robust and accurate the overall model is. The $ADjR^2$ increase has

been presented in the last section, which suggests the model has good robustness with about 30 percent of $ADjR^2$ increase. This also suggests that open and closed connections can be used to predict SME revenue growth in both 3 and 5 years term.

P value

In contrast to $ADjR^2$ increase, the value of P indicates how robust each variable in the model is rather than the overall model. A more strict definition, the value of P is to determine whether each variable in the model can be supported by the data. The lower P value, the more significant influence a variable has. The recommended rule about P value (Wasserman and Faust; 1994; Hanneman and Riddle, 2005) is as in the table below.

Table 6.7 P value

When P (significance level) is less than	In the model (Table 2, 4, and 5) marked as
0.01, very significant and very likely to be 'true'	** *(means p < 0.01)*
0.05, significant and likely to be 'true'	* *(means p < 0.05)*
0.10, can be considered as significant and 'true'	† *(means p ≤ 0.1)*

In the findings presented in the last section (see Table 6.6), open and closed structures in all models have P value lower than 0.01. This suggests the model is robust and the influences of open and closed are significant. This also means that the chance for an SME to have open or/and closed structures which do not influence its revenue growth is lower than 1 percent. In other words, if an SME has open or/and closed structures, there is more than a 99 percent chance to influence its performance. Again, the P value in the model also confirms the robustness.

Consistency between different samples

To avoid the data are from extremely outlier cases and make sure the consistency, this study separates the data into two parts and runs the same analysis on each part of the data separately. There are two SMEs networks presented previously (see network 1 as Figure 6.1 and network 2 as Figure 6.2). The same analysis results about each network separately are presented below. Table 6.7 presents the results of SME network 1 which contains 529 with 620 connections among them. And Table 6.8 presents the results of SME network 2 which includes 512 SMEs with 567 connections among them.

Table 6.8 Regression modeling result for SMEs cluster 1 (the cluster in Figure 6.1)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	3 years revenue growth				5 years revenue growth		
Constant	−0.502	−0.421	−0.201	−0.177	0.1232	0.0127	0.0121
	(0.723)	(0.817)	(0.891)	(0.897)	(1.002)	(0.926)	(0.917)
Company age	−0.021**	−0.0311**	−0.0221*	−0.0216*	−0.0201*	−0.0216**	−0.0223**
	(0.012)	(0.014)	(0.012)	(0.011)	(0.016)	(0.017)	(0.019)
Number of employee	−0.0051	−0.006†	0.0021*	0.0023*	0.0312	0.0417*	0.0426*
	(0.022)	(0.024)	(0.021)	(0.019)	(0.023)	(0.024)	(0.025)
Revenue	0.0531	0.1211*	0.1263	0.1339	0.1721*	0.2883*	0.2996*
	(0.101)	(0.112)	(0.127)	(0.136)	(0.126)	(0.211)	(0.23)
Turnover	0.071	0.0066	0.0317	0.0321	0.1102	0.0611	0.0507
	(0.12)	(0.112)	(0.149)	(0.151)	(0.176)	(0.152)	(0.142)
Group–Management and consultant	0.2201	0.2712	0.293	0.296	−0.6718†	−0.6532†	−0.6496†
	(0.31)	(0.324)	(0.33)	(0.332)	(0.374)	(0.349)	(0.337)
Group–Design	0.2174	0.0521	0.0827	0.0832	−0.5263	−0.417	−0.401
	(0.296)	(0.321)	(0.367)	(0.369)	(0.373)	(0.327)	(0.302)
Group–Engineering	0.2711	0.2122	1.003†	1.004†	−0.7002	−0.2271	−0.2001
	(0.579)	(0.633)	(0.591)	(0.587)	(0.687)	(0.609)	(0.602)
Open		0.2711*	0.3269**	0.3357**	0.2703*	0.3211**	0.3363**
		(0.16)	(0.141)	(0.137)	(0.181)	(0.173)	(0.169)
Closed			0.2801**	0.2862**		0.4719**	0.4692**
			(0.136)	(0.132)		(0.147)	(0.151)
Both				0.1723**			0.1607**
				(0.071)			(0.063)
$ADjR^2$	0.4426	0.5618	0.6772	0.6996	0.5767	0.7117	0.7211

$N = 529$; †$p \leq 0.1$; * $p < 0.05$; ** $p < 0.01$; two-tailed tests, robust standard errors in parentheses.

Table 6.9 Regression modeling result for SMEs cluster 2 (the cluster in Figure 6.2)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	3 years revenue growth				5 years revenue growth		
Constant	−0.517	−0.399	−0.226	−0.185	0.129	0.017	0.011
	(0.698)	(0.792)	(0.824)	(0.873)	(1.107)	(0.972)	(0.915)
Company age	−0.022*	−0.0291*	−0.0207*	−0.0225**	−0.0223*	−0.0209**	−0.0199**
	(0.017)	(0.012)	(0.011)	(0.015)	(0.019)	(0.018)	(0.02)
Number of employee	−0.0062	−0.005†	0.0023*	0.0026*	0.0292	0.0412*	0.0423*
	(0.025)	(0.022)	(0.02)	(0.021)	(0.026)	(0.022)	(0.023)
Revenue	0.0562	0.1201*	0.1257	0.1267	0.1801*	0.2963*	0.2967*
	(0.109)	(0.125)	(0.122)	(0.162)	(0.17)	(0.21)	(0.21)
Turnover	0.079	0.0065	0.0355	0.0389	0.1229	0.0671	0.0587
	(0.117)	(0.116)	(0.147)	(0.162)	(0.188)	(0.157)	(0.129)
Group–Management and consultant	0.2107	0.2942	0.2932	0.2917	−0.6217†	−0.6635†	−0.6692†
	(0.29)	(0.337)	(0.323)	(0.322)	(0.357)	(0.323)	(0.381)
Group–Design	0.2267	0.0582	0.0866	0.0857	−0.5197	−0.419	−0.397
	(0.266)	(0.312)	(0.359)	(0.368)	(0.367)	(0.325)	(0.298)
Group–Engineering	0.2318	0.2265	0.998†	0.929†	−0.7229	−0.2187	−0.1957
	(0.517)	(0.689)	(0.562)	(0.597)	(0.653)	(0.592)	(0.598)
Open		0.2923*	0.3566**	0.3877**	0.2902*	0.3525**	0.3779**
		(0.182)	(0.136)	(0.125)	(0.177)	(0.169)	(0.189)
Closed			0.3205**	0.3057**		0.4225**	0.4209**
			(0.141)	(0.147)		(0.151)	(0.157)
Both				0.1959**			0.172**
				(0.069)			(0.067)
$ADjR^2$	0.4256	0.5712	0.6723	0.7268	0.5929	0.6885	0.7389

$N = 512$; †$p \leq 0.1$; * $p < 0.05$; ** $p < 0.01$; two-tailed tests, robust standard errors in parentheses.

In Table 6.8 and 6.9, the $ADjR^2$ increases are consistent. Each result has good robustness with about 30 percent of $ADjR^2$ increase consistently. In these two separate tests, open and closed connections can still significantly influence about 30 percent of SMEs performance (3 and 5 year revenue growth). This suggests that the model is robust with consistency. Also, open and closed structures in all models have P value lower than 0.01 (marked as ** in Table 6.7 and 6.8). This confirms the model is robust and the influences of open and closed are consistently significant.

Overall, the model is robust. The robustness of this analysis is proven by 1) large R2 increases showing the overall model robustness and accuracy, 2) low P value showing the robustness and significance of each variable, and 3) the consistency between two different sample sets showing the consistency of the model.

6.4 Finding discussion of the open and closed connections influences

The findings suggest there are five types of open connections and four types of closed connections. The purpose of this section is to find out the nature of these connections and whether open and closed connections are caused by the industrial context. The data is based on design, engineering management consultancy firms in the information technology industry. This section is to discuss the characteristics of these three sectors and how they can influence SME connections. The industry map (see Figure 6.5) highlights that the information technology industry includes consultancy, design and engineering companies.

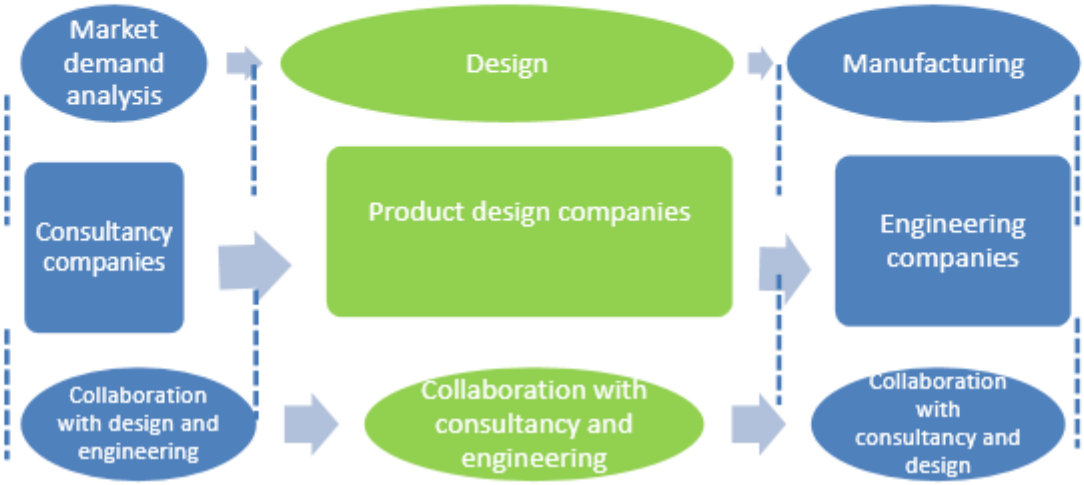


Figure 6.5 Map of three sectors in information technology industry (Zaina and Álvaro, 2015)

The information technology industry consists of three parts (Zaina and Álvaro, 2015). They are 'market demand analysis', 'product design', and 'manufacturing' (Figure 6.5). This map show the information technology industry is highly collaborative and there are collaborations among three types of firms. This figure suggests that the information technology industry is a collaborative industry with design, engineering, and management consultancy firms, and each of these three types of firms collaborate with the other two. In order to find out if this context results in the open and closed structures, this study compares the findings with a similar study in the context of the same industry and different industries.

In the same industry context, Hanaki, Nakajima, and Ogura (2010) suggested similar structures in a firm network with open and closed connections. Their data is based on

firms that resisted patents together (as connections) in the information technology industry in the US between 1985 and 1995. They also suggested open and closed connections can be strategic positions, since those firms with open and closed connections tend to have more registered patents than firms without. Their findings have two similar points with this study's findings of SME connection structures. First, this study found a large number of open and closed connections in SME networks, which are also found in Hanaki, Nakajima and Ogura's (2010) results. Secondly, the positive influences of open and closed connections on SMEs performances are suggested by both of the studies. Hanaki, Nakajima, and Ogura (2010) measured SME performance by the number of registered patents, and this study used revenue growth to measure SME performance. Although SMEs performances are measured differently, similar results about SME connection influences are presented. Based on the above discussion, the two networks in this study's findings are less likely to be extreme cases.

Also, open and closed connections have been found in different contexts. As discussed in Section 3.4 in Chapter 3, open and closed connections were found in the wine, defence, and green technology industry. This suggests that they are unlikely caused by the context of this study. Prior studies suggested that open and closed connections are usually in collaborative industries, such as information technology, creative design, biotechnology, and retails (Walker, *et al.*, 1997; Tsai and Ghoshal, 1998; Tsai, 2000; Gargiulo and Sosa, 2016). However, it was also argued that being

collaborative is not due to the industry context, instead, it is a strategic choice (Gilsing and Nooteboom, 2005; Ibarra, *et al*., 2005; Cross *et al*., 2015). In addition, Burt (2015) suggested open and closed connections can provide SMEs access to external resources and knowledge. Then, these external resources and knowledge can help firms to achieve business growth (McEvily and Zaheer, 1999). Thus, this study suggests that open and closed connections are not caused by the industrial context.

These findings show that the structure of SME connections is likely to influence their performance. However, in some studies (Hargadon and Sutton; 1997; Burt, 2015), closed connections do not provide the same influences on firm's revenue growth as open connections provided. These studies suggested that closed connections are less beneficial than open connections. This is unlikely to be true in this study's findings, since the regression modeling results in Chapter 5 show similar influences level of open connections and closed connections, and Table 8.2 shows that the top nine performed SMEs have both open connections and closed connections. However, is it appropriate to conclude that open SME connection structures can be as the same important as closed SME connection structures, in terms of improving revenue growth. For example, Hargadon and Sutton (1997) argued that only open connections can provide competitive advantages to SMEs and lead to revenue growth, closed connections cannot provide it. Hargadon and Sutton (1997) showed how a firm exploits its network connections and expand its business and increase revenue. They suggested the firm bridges between other firms, and all the collaborative linkages in

the network are only through the firm in the 'bridge' position, so that the network consists of only open connections, without any closed connections. They also found that firms with high revenue growth usually avoid other firms to have direct connections among them, so that there is no closed connection (as discussed in the literature review, closed connections consists of inter-connected direct connections among firms) around them. Hargadon and Sutton (1997) suggested that the firm gains network position advantage by a monopoly of the collaboration connections, all the collaborations between other firms need to be bridged by the firm, so all the other firms' collaborations rely on the firm to connect them. This 'monopoly' network position makes the firms not easy to be replaced in the network and results in its competitive advantage (Burt, 2015; Cross *et al*., 2015; Gargiulo and Sosa, 2016). Closed connections provide direct connections between firms, so that it harms the firm which monopolises the network connections (Cross *et al*., 2015). Hargadon and Sutton (1997) studied collaboration and resource sharing between competitors. The nature of connections between firms varies significantly between this study and Hargadon and Sutton (1997). Thus, open and closed connections as two salient network features of this study, are explained differently as firm monopoly behaviours in prior research about competitions in SME networks (Hargadon and Sutton, 1997; Burt, 2015; Cross *et al*., 2015; Gargiulo and Sosa, 2016). In contrast to these prior studies focusing on the competition in SME networks, this study focuses on the collaboration between SMEs. This study demonstrated the importance of

collaborations among SMEs to their revenue growth, especially, the benefits of SMEs having both open and closed connections.

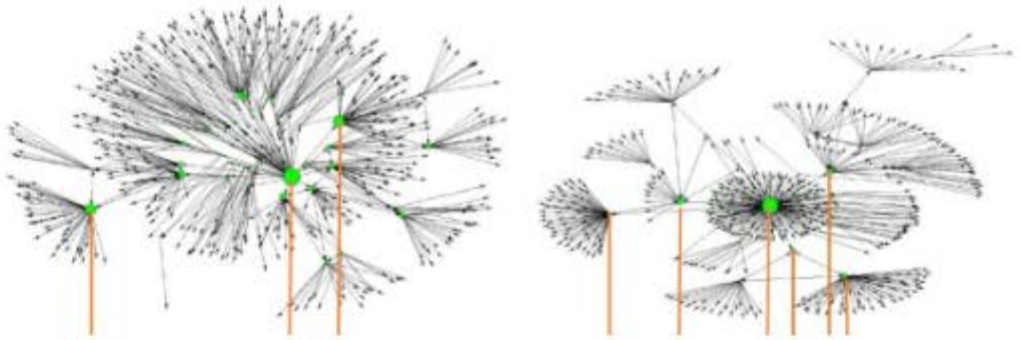
It is also necessary to compare the results between this study and prior research considering networks as resources for SME's revenue growth. As discussed in this study's literature review, prior literature also considered networks as business resources (Adler and Kwon, 1999; Lazzeretti and Capone, 2016; Leminen *et al*., 2016). SMEs collaborate with each other (for example, business resource and information sharing) through closed and open connections, and pay attention to the effects of their network structures on revenue growth (Adler and Kwon, 1999). In these SME collaborations, the benefits of business resource and information sharing are provided by having many open and closed connections. In an SME's network, developing new collaboration connections with other SMEs can increase revenue (Lazzeretti and Capone, 2016; Leminen *et al*., 2016). This is supported in this study's statistical analysis results. However, whether open and closed connections result in different SME growth results? Previous research (Burt, 2015; Uzzi 1996 and 1999) argued that open and closed connection can lead to two different beneficial outcomes. When rapid access to diverse business resources and information is essential, open connections are likely to be advantageous (Burt, 2015). Networks with many open connections provide resource and informational benefits but limit the number of partner firms and their collaborations. Partner firms exclusively tied to an SME in collaborations, and these partners firms provide business resources and information

within the network. Such a network would be ideal for an SME whose primary business is about the brokerage of other businesses, for example, technology or information (Hargadon and Sutton, 1997). Also, when a firm needs to increase the number of partner firms and collaborations among partners, close connections are likely to be advantageous (Uzzi 1996 and 1999). A network consists of interconnected collaboration connections among firms (closed connections) that would facilitate the development of agreements. Such a network is ideal for an SME seeking negotiation results over its buyers or suppliers (Lazzeretti and Capone, 2016). Such a network is also useful when an SME and its partner firms are faced with the common external threats, for example, political changes, legislative changes, or rapid technology substitution (Leminen *et al*., 2016). Thus, in general, the influences of open and closed SME connections are unlikely to be only limited in a particular context. When developing a collaborative SME environment and achieving revenue growth, networks with both open and closed connections are likely to be beneficial.

The previous empirical chapters showed SMEs revenue growth can be influenced by open and closed connections. This section uses the SMEs with high revenue growth as examples to show how their network positions influence their growth. This study picks the SMEs with revenue growth in 5 year term over one million US dollars. There are nine SMEs in the data, which achieve this amount of revenue growth. Figure 6.6 shows these nine SMEs in networks. And Table 6.10 shows the profiles of them in the order of numbers marked in Figure 6.6. These nine SMEs are selected in

order to address the key purpose, that how SMEs with high revenue growth are connected in networks. Thus, these nine SMEs present a good opportunity to explore what network positions can increase SME growth.

Figure 6.6 Top 9 SMEs in revenue growth



1 2 3 4 5 6 7 8 9

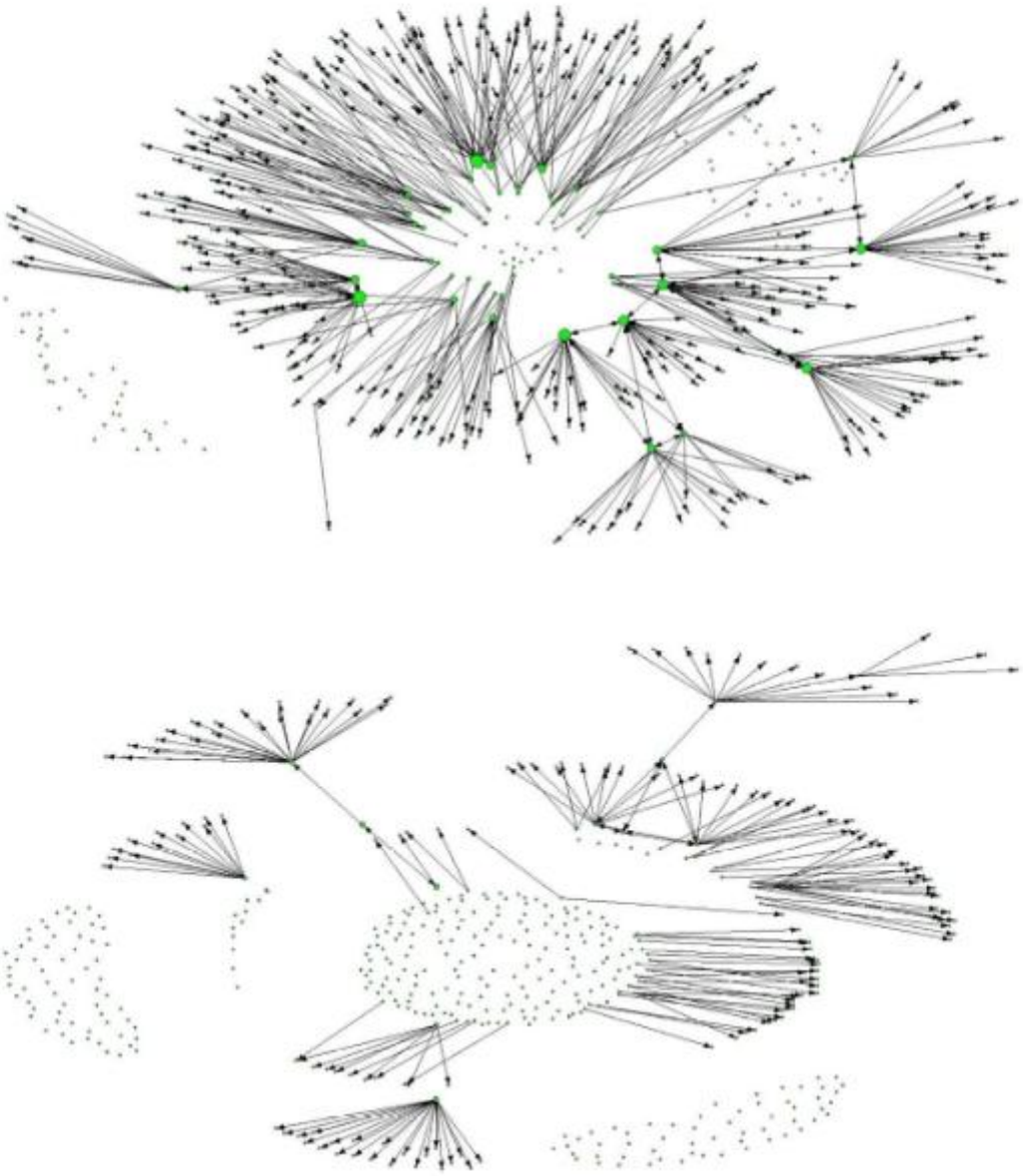
Table 6.10 The profiles of top 9 SMEs in revenue growth

	Company age	No of employee	Revenue (K USD)	Turnover (K USD)	Industrial sector	Open	Closed	3 year (K USD)	5 year (K USD)
1 QINGDAO	46	124	2,763	3,212	Engineering	278	6	597	1,030
2 SHANGHAI JIAHWA BC COMMUNICATIONS	45	235	2,988	4,097	Design	312	22	647	1,138
3 HEFEI MEILING	48	91	2,884	3,290	Consultant	297	7	598	1,032
4 SHANGHAI JAHWA	39	38	2,968	4,059	Consultant	256	1	581	1,002
5 SHANGHAI JIAHUA	33	172	2,552	4,961	Engineering	125	16	590	1,010
6 PA COMMUNICATIONS	28	85	2,967	3,452	Design	316	23	602	1,058
7 BAOXI INFORMATION TECHNOLOGY	37	191	2,756	3,237	Engineering	3	1	584	1,004
8 PINGAN CAIZHI TECHNOLOGY	14	236	2,766	4,894	Engineering	259	12	591	1,020
9 AGEAS	36	132	2,636	3,330	Consultant	273	1	580	1,002

All of these nine SMEs have both open and closed connections (Table 6.10). They

have a similar level of revenue growth in 5 year term, range from 1, 002 to 1.138 million USD, as well as, in 3 year term, range from 581'000 to 647'000 USD. Also, these are more than double comparing the average level of all the SMEs in the data, in 5 year term 435'360 USD and in 3 year term 238'190 USD (the average revenue growth of all the SMEs can be found in Table 6.4 in Chapter 6). However, SME number 7 (BAOXI INFORMATION TECHNOLOGY) has only 3 open connections and 1 closed connection. SME number 4 (SHANGHAI JAHWA) and 9 (AGEAS) have only 1 closed connection. An interesting observation about these three SMEs in Figure 6.6 is that each one of them connects a part network otherwise would be disconnected. This leaves a question that whether SME connections are strategic choices. As strategic choices, firms in the network usually occupy unique and valuable connections (Borgatt, 2011; Burt, 2007 and 2015). Thus, as below, Figure 6.7 shows the networks without these nine SMEs and their connections.

Figure 6.7 Networks without Top 9 SMEs in revenue growth



These findings are consistent with the previous findings about the influences of open and closed connections on SMEs revenue growth. Burt's (1992, 2007 and 2015) structural holes theory suggested that SMEs can achieve better financial performance by strategically occupying the network positions, which provide connections to all of them. Due to this, SMEs surround a few of them in a network (Borgatti, 2011).

Therefore, an SME network can fall apart without the top performed SMEs. To reveal this in this study's findings, Figure 6.7 presents that the networks are broken into parts by showing the disconnected SMEs. The findings and arguments of this study draw attention to three aspects that need to be considered as below.

First, SMEs performance can be differed by the network positions they have in the same network. The business resources SMEs received from their inter-firm connections can be related to their performance (Lazzeretti and Capone; 2012; Davis, 2016). Thus, it is important for SMEs to occupy the path in their network and control the connectivity (Ahuja, 1996; Burt, 2015). Figure 6.7 shows the connectivity change in the two SMEs networks, when the top 9 performed SMEs are deleted from the networks. Without the connections with these top 9 performed SMEs, the networks fall into disconnected parts. The inter-firm connections in these disconnected networks cannot connect the SMEs to provide information and resource sharing. Clearly, under this circumstance, the degree of firm collaboration is limited. This suggests that an SME strategy of occupying network connectivity is valuable, since the SME's connections cannot be substituted or bypassed by using other SMEs' connections in collaborations.

A second aspect, this study suggests that SME's direct and indirect connections do not provide the same level of benefits. In Figure 6.6, the top 9 SMEs have direct

connections in the center of the networks, the other SMEs can have indirect connections with each other through them. The benefits provided by direct and indirect connections are reflected in their financial performances. Thus, it is clear that, the magnitude of the benefits provided by direct connections is significantly different from those provided by indirect connections. The financial performances of those SMEs from indirect connections are relatively lower. Although this finding is limited to this study's setting and sample size, it confirms the previous research's suggestion about the weak influence of indirect connections on firm growth. Previous research's findings in this study's literature review suggested that indirect connections do not provide as much financial returns as direct connections. These previous research's findings include networks in various sectors including information technology, telecommunication, mining, energy, healthcare, banking, manufacturing, and service sectors from countries across Europe, Asia, Australia, and North America (Narula, 2004; Borgatti, 2011; Van Lancker, *et al*., 2016; Ritala and Almpanopoulou, 2017). Thus, this finding of direct and indirect connections is consistent with previous research. On the one hand, indirect connections can provide collaborations, which extend the SME's connection in the network and improve its access to business resources and information. On the other hand, these indirect ties are usually controlled by some SMEs (such as the top 9 performed SMEs in this study's results), which take the network position advantages. On top of these, this study suggests that direct connections are more beneficial to SMEs financial performances than indirect connections. Base on this discussion, this study suggests that increasing direct

connections in networks is considered as a better strategy than increasing indirect connections.

Third, it is not necessary to have many open and closed connections to be better. Table 6.6 shows that there are SMEs with few open and/or closed connections in the top 9 performed SMEs, they are Number 7 BAOXI INFORMATION with three open connections and one closed connection; Number 4 SHANGHAI JAHWA with one closed connections, and Number 9 AGEAS with one closed connections. Although the regression modeling results in Chapter 5 showed that individually higher numbers of open connections and closed connections are both beneficial to SMEs financial performance, these SMEs still achieved top performance by having only a few open and closed connections. Burt (2015) argued that, in terms of collaboration through open and closed connections, SMEs may be not able to profit from many open and closed connections, as they can only manage to maintain few connections. Thus, SMEs are constrained to absorb and act on the connected business resources and information. In addition, SME's ability to manage a large number of connections, the value of each connection is also likely to be a reasonable explanation on the number of an SME's open and closed connections. To support this, Figure 6.6 show that these top 9 performed SMEs with few open and/or closed connections have network positions like 'railway junction', where control the 'only path' between parts of the network (See Number 7 BAOXI INFORMATION with three open connection and one closed connection; Number 4 SHANGHAI JAHWA with one closed connections,

and Number 9 AGEAS with one closed connections in Figure 6.6). As discussed in this study's literature review, SMEs with better performance are likely to be located in a network position, where a cutting point can connect or disconnect a large number of others (McEvily and Zaheer, 1999; Bogartti, 2011; Burt, 2015). Thus, SMEs can have better financial performances by occupying the network position where they can choose to connect or disconnect the other SMEs in a network.

Based on the above discussion, SME connections are likely to be strategic moves with the purpose of having advantages positions in their network, as these nine SMEs did. The above arguments suggest three aspects and potential limits of SME connection influences. However, whether the influences of SME connections depend on the context being studied is not clear yet. To confirm this, the next section is to discuss in more detail about SME connection structures and dynamics.

Also, this section is to discuss the findings presented in the previous sections by comparing this study's findings with previous research. This discussion focuses on:

1) SMEs revenue growth is more likely to rely on co-development rather than individual firm development, which shows the importance of inclusive growth.

2) Compared to SME characteristics, SME connections are more influential on revenue growth, which shows the importance of SME connections in inclusive growth.
3) Rather than just connecting to networks, SMEs with open and closed connections have better revenue growth, which shows how to produce inclusive growth effectively.

First, the results of this study show the relations between SME connections and their revenue growth. The results show that there are a large number of connections among SMEs in their development process. The previous literature review highlights the influences of inter-firm connections as a theoretical gap in the area of SME growth. Previous theories suggest that enterprise development by increasing SMEs sizes and improving their capabilities do not lead to SMEs growth (Landsperger, 2012; Baker, *et al*., 2016; Oparaocha, 2016). This study suggests that SME growth often requires joint work with different firms. Firm's knowledge and resources are important ingredients of firm development, but the relationships between them and firm performance are very weak (Labianca and Brass, 2006; Candi *et al*., 2013). In SME growth, the firm's knowledge and resources contribute very little to the performance (Gargiulo and Sosa, 2016). The resources and information they need are usually external. Thus, SMEs growth relies on not only individual firm development but also co-development.

Second, while firm characteristics are important for performance, their influences are less important than that of open and closed connections. Model 1 shows that SME characteristics have influences about 42 percent of SME revenue growth. However, the large P values suggest that the influences of SME characteristics are weak and not significant when there are no SME connections in the model. In contrast, the influences of open and closed connections are more significant with lower P value when they are added to the model. This suggests that SME characteristics alone are less beneficial to SMEs revenue growth, which confirms previous research's point (Labianca and Brass, 2006; Candi *et al*., 2013; Gargiulo and Sosa, 2016). They can influence on about 42 percent of SME revenue growth only if there are open and closed connections. Thus, this study argues that SMEs revenue growth does not simply depend on budget, previous experience, and access to resources, but how they are located within an SME network. This study's results suggest that SME characteristics and connections together can influence about 70 percent of revenue growth. Although SME connections can influence about 30 percent of revenue growth which is less than SME characteristics, the influences of SME characteristics rely on whether there are SME connections. This confirms prior research's point about this (Labianca and Brass, 2006; Candi *et al*., 2013; Gargiulo and Sosa, 2016). Thus, this study suggests that how to connect with each other between firms is more important than how to change those firm characteristics in SME growth.

Third, not all of the SME connections can lead to revenue growth. This study's findings suggest that only those open and closed connections can lead to revenue growth, rather than all of the SMEs connections. Although this study's findings are consistent with previous literature in demonstrating that network structure plays an important role in firm performance (Landsperger, 2012; Oparaocha, 2016). The existing studies explored the relationship between network and firm performance outcomes (Holti, *et al*., 1997; Edelman, *et al*., 2004; Rodan and Galunic, 2004), which have implications on how to improve collaborations. However, this previous research did not find out what kinds of inter-firm level of SME connections are important. This study's findings add this to the previous theories by suggesting that SMEs with open and closed connections in a network are more likely to have better revenue growth. In other words, rather than simply connect to a network or not, it is SMEs' network positions associated with their revenue growth. These SMEs' network positions are discussed in Chapter 8.

In sum, this chapter explored SME connections at the inter-firm level and what their influences are on revenue growth. There is a lack of understanding of what the network patterns are and how SME networks at the inter-firm level affect their development (Ibarra, *et al*., 2005; Cross *et al*., 2015). When considering SMEs performance, open and closed SME connections' influences can be an explanation about revenue growth. Thus, this magnitude of open and closed connections in inclusive growth is particularly noteworthy.

6.5 Summary

The results demonstrated the significance of SME connections, especially, the influences on revenue growth. This chapter identified both open and closed structures can positively influence SMEs revenue growth. These findings can provide understandings about the extent of SME connection influences on revenue growth. These findings include:

1) SMEs growth is more likely to be co-development rather than individual firm development. This can be observed in a large number of SME connections in the network snapshots.
2) SME connections and SME characteristics together are more influential on revenue growth than just considering SME characteristics. Especially, the influences of SME characteristics on revenue growth rely on whether the SME has open and closed connections. This can be observed in the R2 increase and P values in the models.
3) Inter-firm connections do not always lead to revenue growth. SMEs need to have both open connections and closed connections in conjunction with each other. This can be observed in the regression modeling results.

Chapter 7 Empirical finding chapter 3: SME connection dynamics

7.1 Introduction

The last empirical finding chapter presented the results of open and closed connection structures. As discussed in the literature review, both open and closed connections can have positive impacts on SME growth (Uzzi, 1999; Burt, 2015). A question left is how the SME connections are formed as open and closed. The answer to this question is important, because it can help SMEs connect into open and closed connections to increase their growth results. Thus, in this study's literature review, the third research question is proposed as how the SME connections are formed as open and closed structures in the dynamics of SME connections. In order to answer the third research question, this analysis focuses on testing three hypotheses that are derived from this study's literature review. These three hypotheses are:

Hypothesis 1: The well-connected SMEs get more connected with others in SME growth (presented in section 7.2).

Hypothesis 2: The well-connected SMEs get more interconnected with each other in SME growth (presented in section 7.3).

Hypothesis 3: SMEs with different types of open connections ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other (presented in section 7.4).

Network dynamics are defined as changes in network structures during time (Burt, 2007). Borgatti (2011) suggested that research in network dynamics can help to understand how networks form certain structures such as open and closed by showing network structure changes across time periods. The data used in this study 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. The data were separated into every 6 month period between 2011 and 2015. As discussed earlier, the previous each SME's number of connections, number of inter-connections, and types of open connections can influence their connections in a later period of 6 months. Network data about organizational 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.

This empirical chapter provides the results of network dynamics analysis. The independent variables are network structures including each SME's number of connections, number of inter-connections, and types of open connections in the

previous period of 6 months. The dependent variables are SME's number of connections, the number of inter-connections, and the similarity of open connection types with connected SMEs in the later period of 6 months. Each SME's number of connections and inter-connections are calculated by Centrality function in UCinet. SME's open connection similarity is calculated by using the Ego Network Structure Count function in UCinet.

The following sections are structured as presenting and discussing the findings in each hypothesis testing. Section 7.2 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 7.3. Section 7.4 shows and discusses the third hypothesis testing results about open connection similarity.

7.2 Well-connected SMEs in SME connection dynamics

This section presents the results of the first hypothesis: the well-connected SMEs get more connected with others in SME growth. Figure 7.1 (from 7.1a to 7.1f) shows how 620 connections were set up among 529 SMEs between 2011 and 2015. In general, there are more SMEs connected in the network cross each time period. This can be seen from the increasing number of connections in each period after. Also, the number of open and closed structures also increases in each period after. This trend is shown from

Figure 7.1a to Figure 7.1f, 620 connections among 529 SMEs are set up during 5 years, and they formed 1723 open structures and 115 closed structures.

Changes in the number of SME connections during time

Previous research suggests the number of open and closed connections can decrease when more SMEs are connected in a network (Burt, 2007). The reason is that each SMEs connection costs time and effort. SMEs usually have limited resources, thus limiting the number of connections they can possibly develop (Burt *et al.*, 2013). However, this study's findings show that open and closed structures increase instead of decrease when more SMEs are connected in the network. In other words, the more SMEs connections in a network, the more chances of forming open and closed connection structures.

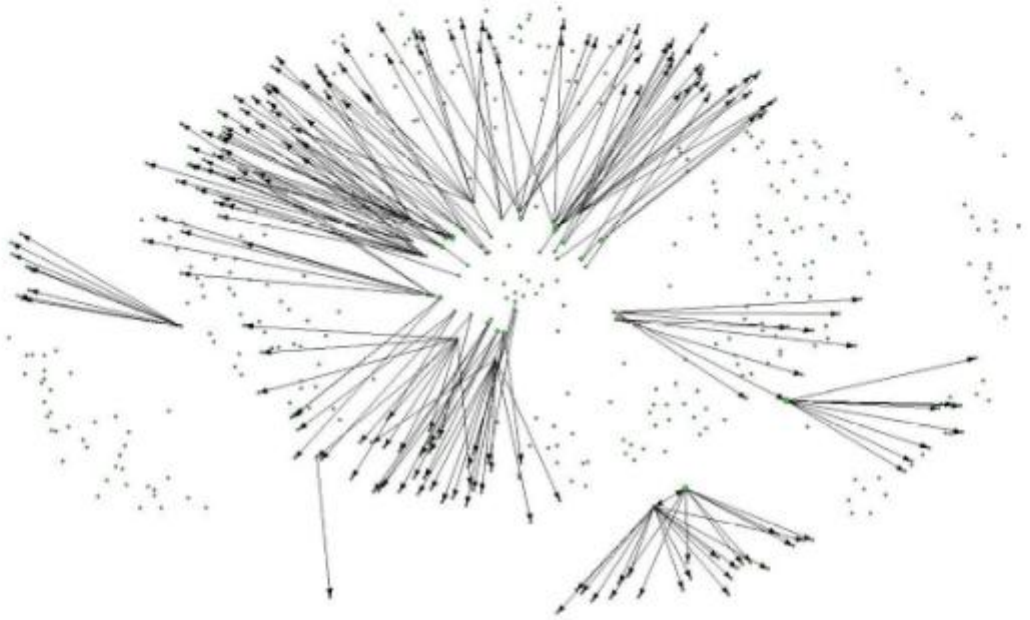


Figure 7.1a SMEs in Beijing and Shanghai at the beginning of 2011 (Sample size: 529 SMEs, nodes are SMEs, lines are collaborations)

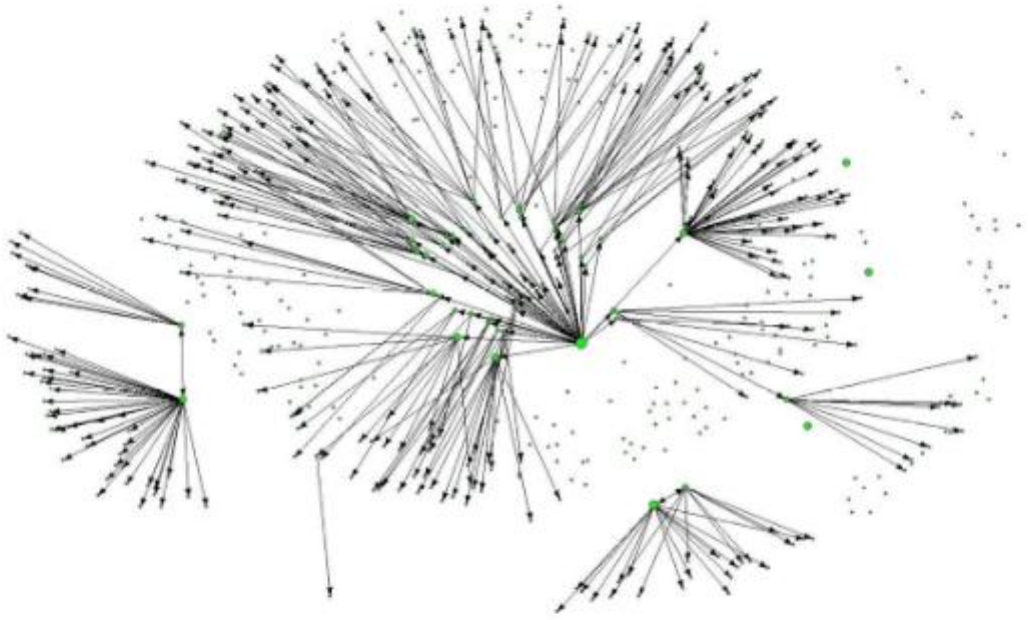


Figure 7.1b SMEs in Beijing and Shanghai in 2011 (Sample size: 529 SMEs, nodes are SMEs, lines are collaborations)

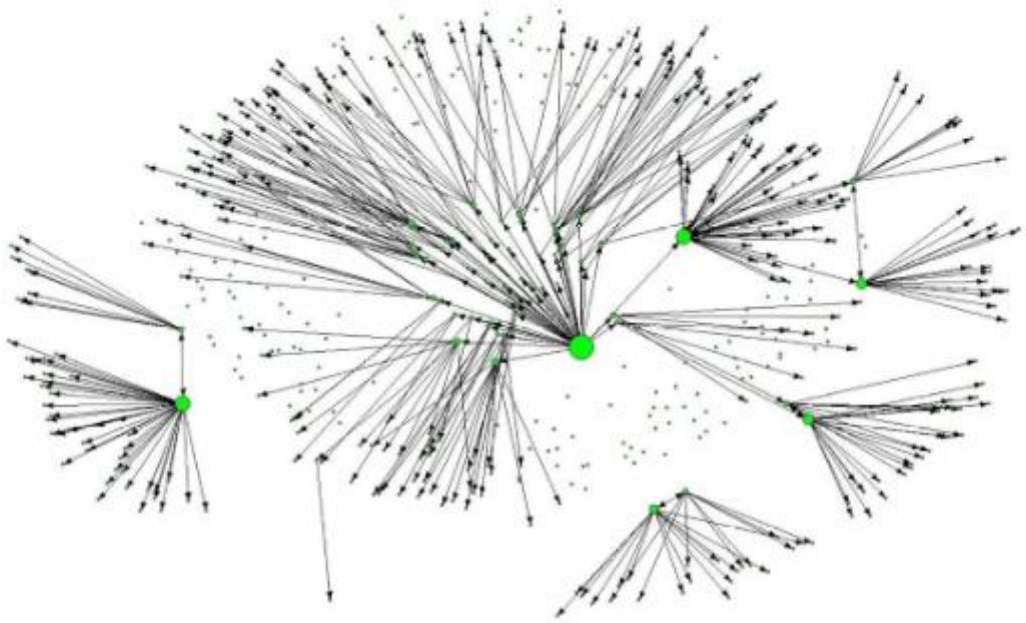


Figure 7.1c SMEs in Beijing and Shanghai in 2012 (Sample size: 529 SMEs, nodes are SMEs, lines are collaborations)

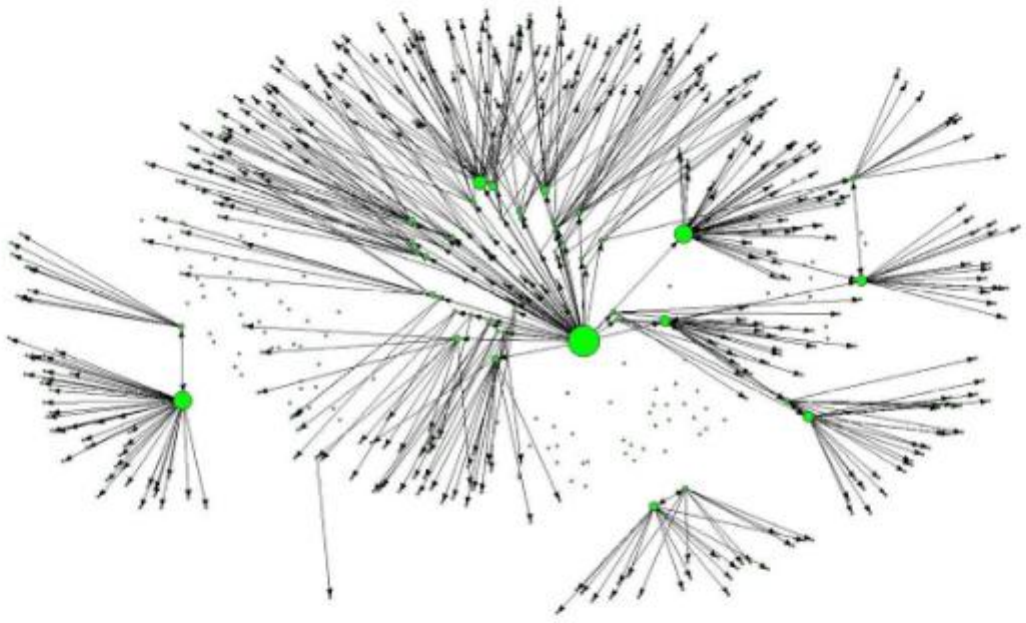


Figure 7.1d SMEs in Beijing and Shanghai in 2013 (Sample size: 529 SMEs, nodes are SMEs, lines are collaborations)

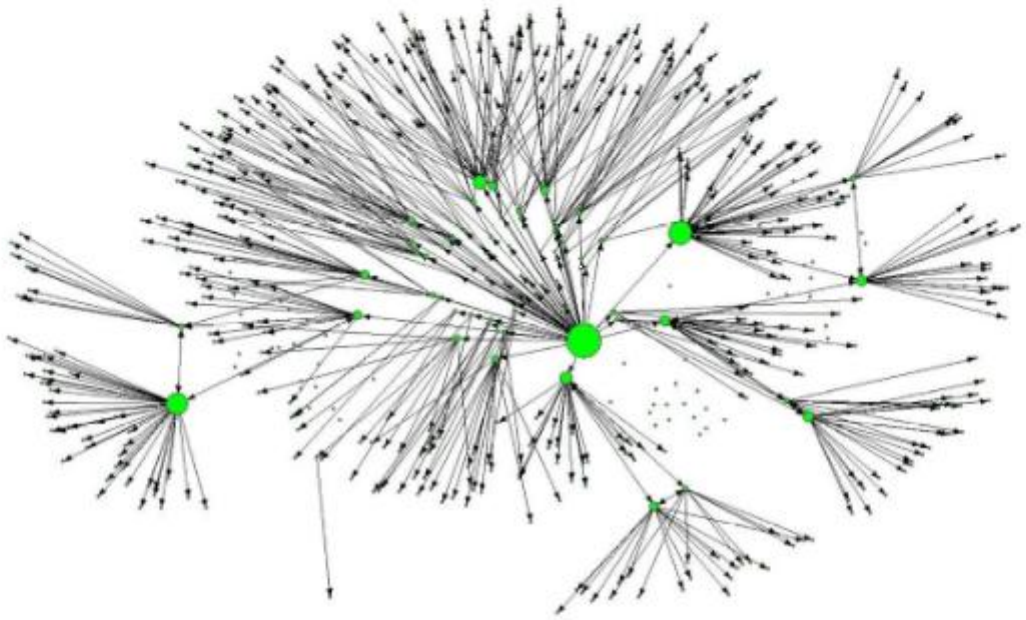


Figure 7.1e SMEs in Beijing and Shanghai in 2014 (Sample size: 529 SMEs, nodes are SMEs, lines are collaborations)

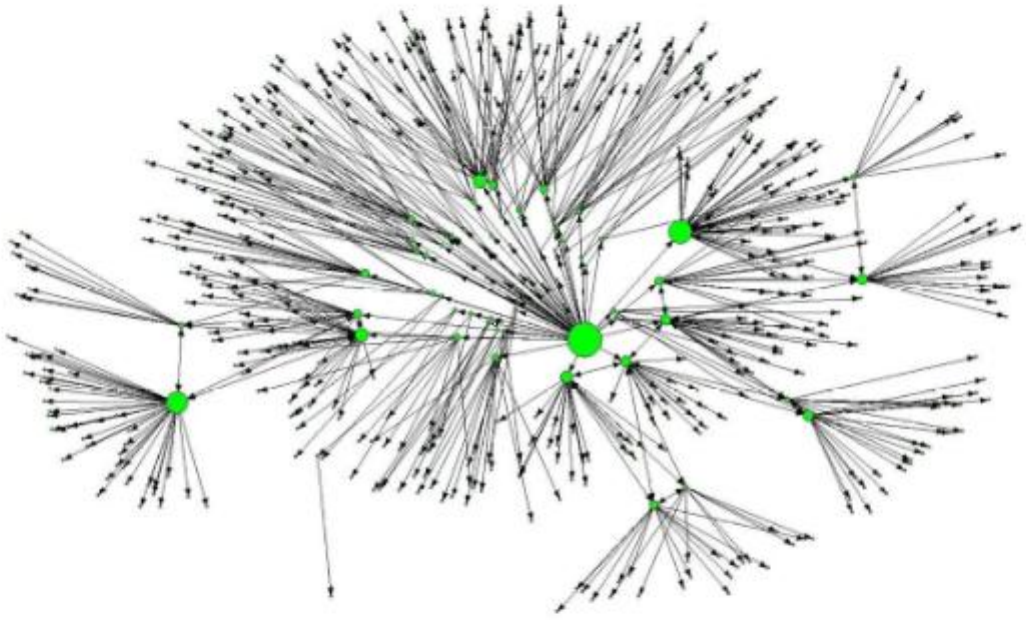


Figure 7.1f SMEs in Beijing and Shanghai in 2015 (Sample size: 529 SMEs, nodes are SMEs, lines are collaborations)

As discussed in the literature review, during SME growth, SMEs tend to increase their connections to be well-connected. However, this study's finding suggests some SMEs have a large number of connections and some SMEs only have a few of them. For example, those SMEs have hundreds of connections with others in the center (see the large size of nodes in Figure 7.1f). And those SMEs have only one connection on the periphery. While there are 1187 connections formed 3261 open structures of SME connections and 212 closed structures of SME connections, however, this large number of open structures and closed structures are formed by a small number of SMEs. 76 well-connected SMEs formed 3261 open structures of SME connections. And 29 well-connected SMEs formed 212 closed 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 open and closed structures, they are formed by a small number of SMEs. It is not clear the number limit of connections that an SME can have (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, because each connection means contribution, for example, finance, labor and time (Burt, 2007; Zeng, *et al*., 2010; Fernandez-Olmos and Ramirez-Aleson, 2017), especially when the connections are formal financial collaborations. On the other hand, SMEs can possibly have as many connections as they want, because each connection may give them financial returns in successful co-development (Narula, 2004; van de Vrande *et al*., 2009; Rosenbusch *et al*., 2011). Thus, SMEs cannot afford too many connections due

to their resource limitations, in the opposite, they can afford connections as these connections may help them to create profits. This study suggests that SMEs can have a large number of connections. Also, the finding in Chapter 5 suggests that SMEs with a large number of connections are more likely to have better revenue growth.

Regression modeling results

The well-connected SMEs get more connected with others in SME growth. To confirm this, the next few paragraphs present the regression modeling result. Table 7.1 shows the result of regression modeling. In the model, the results show that the number of connections in the previous period is positively associated with the number of connections in the later period ($\beta = 0.509$, $p = 0.001$). As mentioned before, the data were separated into every 6 month period between 2011 and 2015. This result means that a well-connected SME has 50.9 percent of chance (as $\beta = 0.509$) to connect with any SME which is not connected with yet in the next 6 month time period. And there is 0.1 percent of chance (as $p = 0.001$) not happening in the data.

The result also suggests that the number of connections an SME has in the later period can be positively influenced by the number in the previous period (as $\beta = 0.509$, which is larger than 0). This means well-connected SMEs were getting more connected and support the first hypothesis. The number of connections in the previous 6 month

period positively influences the number of connections in the later 6 month period. This means the more SMEs connections in the previous 6 month period the more SMEs connections in the later 6 month period. This finding is consistent with previous research about the increase of SMEs connections during the time periods of co-development (Burt, 2007; Cross *et al*, 2015; Gargiulo and Sosa, 2016).

Table 7.1 Regression results for supporting Hypothesis 1

Constant	-10.693
	(0.635)
Number of connections	0.509**
	(0.215)

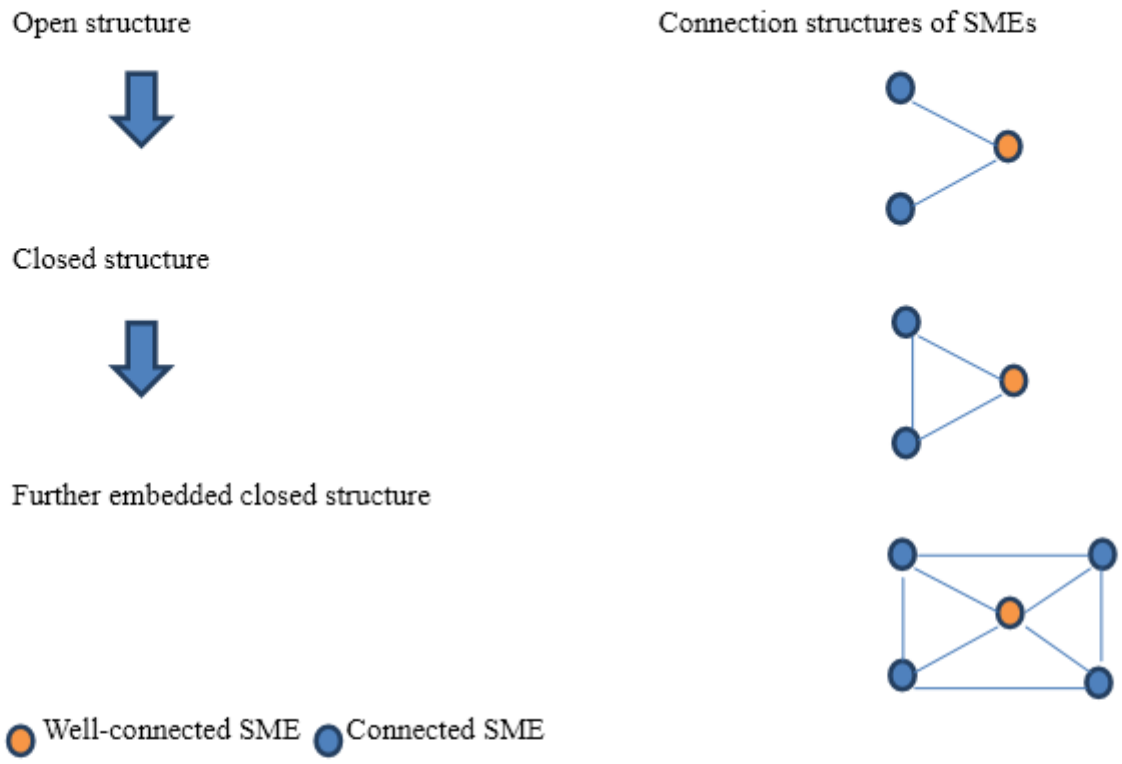
$N = 1056$; †$p \leq 0.1$; * $p < 0.05$; ** $p < 0.01$; Robust standard errors in parentheses

The regression results and network snapshots presented in this section suggest that SMEs become well-connected in three stages (see Figure 7.2). These three stages represent the most frequent changes during the period (from Figure 7.1a to Figure 7.1f) in well-connected SMEs' connections. Thus, these three stages provide further insights into how those well-connected SMEs emerge in networks. These three stages are: well-connected SMEs with open structures (stage 1), well-connected SMEs with closed structure (stage 2), and well-connected SMEs with further embedded closed structures (stage 3).

In stage 1, well-connected SMEs get open connections to connect the others. These SMEs are like bridges between the others. Without them, some SMEs would lose their

connections to the network. In stage 2, well-connected SMEs get closed connections to be interconnected. Those SMEs are connected to all others. Contrasting to open connections in stage 1, those SMEs do not have any third party acting as bridges between any two of them. In stage 3, well-connected SMEs get further embedded closed structures, which are SMEs with more than one closed structure.

Figure 7.2 Three stages of becoming well-connected SMEs: the process of well-connected SMEs getting more connected



SME Stage 1	SME Stage 2	SME Stage 3
Getting open structures	Getting closed structures	Getting further embedded closed structures

These three stages are how SMEs become well-connected in the presented networks. Previous literature suggested that well-connected SMEs are those SMEs with a large number of connections (Burt, 2007). However, this study's finding suggests that there are three stages of becoming well-connected SMEs, open, closed, and further embedded closed (see Figure 7.2). Thus, a question remains that whether being well-connected SMEs relies on the number of connections they have. In other words, do well-connected SMEs occur solely as a result of increasing the number of connections, or it is also dependent on the types of connections? This study's finding suggests that the answer is the latter. This study suggests whether an SME is well-connected relies on how it structurally connects with the others. A more detailed discussion about these three stages is provided in Chapter 8 later.

Table 7.2 Number of SMEs in the three stages of becoming well-connected (76 well-connected SMEs in total)

Being further embedded closed (stage 3)	**Being closed (stage 2)**	**Being open (stage 1)**
20%, 15 out of 76 well-connected SMEs	18%, 14 out of 76 well-connected SMEs	62%, 47 out of 76 well-connected SMEs

Table 7.2 shows what stage those well-connected SMEs are in (at the end of 5 year time period in the data). There are in total of 76 well-connected SMEs in the presented results. Only a few of the SMEs who are well-connected went through all three stages.

This is consistent with the SMEs' revenue growth in the data. Only 9 out of all 1056 SMEs reached over 1 million US dollars revenue growth in that 5 year time. And they all went through all these three stages. Thus, this could be the reason. Table 7.2 shows that 20% of well-connected SMEs went through all three stages, open, closed and further embedded closed. 18% of well-connected SMEs went through two stages, open and closed. Thus, the findings show that 38% of well-connected SMEs have both open and closed connections. And the rest of them, 62% of well-connected SMEs only have open structures, which is 47 out of 76 SMEs. This confirms the point of previous literature (Rosenbusch *et al.*, 2011; Fernandez-Olmos and Ramirez-Aleson, 2017), which suggested that well-connected SMEs usually have open structures of connections. And those well-connected SMEs are like bridges to connect the other in the network (Narula, 2004; Burt, 2007; Zeng, *et al.*, 2010). However, this study's results show that there is a small number of well-connected SMEs have both open and closed structures of connections, which is 18%, 14 out of 76 SMEs. Thus, this finding challenges the point of previous literature (Oh, Labienca and Chung, 2006; van de Vrande *et al.*, 2009) which suggested that well-connected SMEs only have either open or closed structures of connections. This study's results suggest that SMEs can have both open and closed structures of connections. Then, those well-connected SMEs are not only bridging the others but also interconnected with each other in the network.

In addition, the results show that there is also a small number of well-connected SMEs that have open structures of connections, closed structure of connections, and further

embedded closed structures of connections, which is 20%, 15 out of 76 SMEs. This finding adds further embedded closed structures to previous literature (Zou and Ingram, 2013; Clegg *et al.*, 2016), which suggested that well-connected SMEs can have open and closed structures of connections. This study suggests that they can also have further embedded closed structures of connections.

In sum, there are a small number of well-connected SMEs during their growth. The existing literature suggests that well-connected SMEs are SMEs with a large number of connections. There are three stages of being well-connected, open, closed, and further embedded closed. Thus, these findings are complementary to how SMEs evolve to be well-connected.

7.3 Interconnected SMEs in SME connection dynamics

This section presents the results of the second hypothesis: the well-connected SMEs get more interconnected with each other in SME growth. This includes the regression modeling results about interconnected SMEs. As discussed in the methodology, interconnected SMEs are measured by the number of inter-connected connection structure each SME has.

Table 7.3 Regression results for supporting Hypothesis 2

Constant	-15.823
	(0.597)
Inter-connections	
Inter-connections among three SMEs	2.3671** (0.265)
Inter-connections among four SMEs	1.9892** (0.237)
Inter-connections among five SMEs	1.2517**
	(0.125)
Inter-connections among six SMEs	1.085**
	(0.097)
Inter-connections among seven SMEs	1.5067**
	(0.112)
Inter-connections among eight SMEs	1.2573**
	(0.129)

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

Table 7.3 presents the regression results for Hypothesis 2. The model shows that the number of inter-connections is positively and significantly related to the number in the latter six months time period. The result indicates well-connected SMEs are connected to each other in the network during the time period. This means the well-connected SMEs are more likely to be interconnected with each other. This means the more SMEs connections the more interconnections among them. 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) about well-connected SMEs, which did not consider the relationship between well-connected SMEs and inter-connected SMEs. These show that well-connected SMEs are inter-connected like a cluster. These well-connected SMEs not only bridge other SMEs, but also are inter-connected like a cluster. This finding fills the gap in the literature about the connections between well-connected SMEs in SME growth.

7.4 Connected open structures in SME connection dynamics

This section presents the results about the third hypothesis: SMEs with different types of open connections ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other. As mentioned in the previous literature review, five types of open connections were defined by Gould and Fernandez (1989). They are "liaison", "representative", "gatekeeper", "consultancy" and "coordinator" brokers. However, it is not clear how they are connected with each other during network dynamics. A question left is whether they can influence SME connections. The findings of this study suggest that SMEs with different broker roles tend to connect together.

Table 7.4 Regression results for supporting Hypothesis 3

Constant	-12.699
	(0.598)
Open connection similarity	-2.5885**
	(1.209)

N = 1056; †*p* ≤ 0.1; * *p* < 0.05; ** *p* < 0.01; Robust standard errors in parentheses

Table 7.4 shows the results of regression modeling for Hypothesis 3. The data were separated into every 6 month period between 2011 and 2015. As discussed earlier, the previous each SME's open connections can influence their connections in a later period of 6 months. Open connection similarity in the previous period is negatively associated with connections in the later period (β = -2.5885, p = 0.001). The results suggest that open connection similarity in the previous period can negatively influence (as β = -2.5885) the number of connections in the later period. This means connections between SMEs with similar types of open connections are unlikely to happen. On the other hand, SMEs with different types of open connections are more likely to be connected. This is complementary to the previous literature (Burt, 2007; Cross *et al*, 2015; Gargiulo and Sosa, 2016), which did not consider how SMEs' open connections can influence who they are connecting with.

In this study's literature review, Gould and Fernandez (1989) suggested five independent types of open connections in the networks. However, it is not clear how these five types of open connections are connected as networks (Gilsing and

Nooteboom, 2005; Ibarra, *et al*., 2005; Cross *et al*., 2015). Each type of open connection is identified independently (Cross *et al*., 2015). Thus, the relations among them are not clear in network dynamics (Gargiulo and Sosa, 2016), which includes: 1) which types of open connections are likely to be connected with each other, and 2) which type of open connections are unlikely to be connected with each other. Thus, this study presents the findings of the relations among these five types of open connections.

Figure 7.3 shows that there are very weak connections between SMEs with similar types of open connection. The probability to have a connection between two liaison SMEs is 0.1%. This means there is only 1 connection between two SMEs with liaison roles in the data which covering 1041 SMEs with 1187 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 0.2%. This means there are only 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 types of open connection.

Figure 7.3 Five types of open connection in SME connection dynamics: Probabilities of connections between similar types of open connection

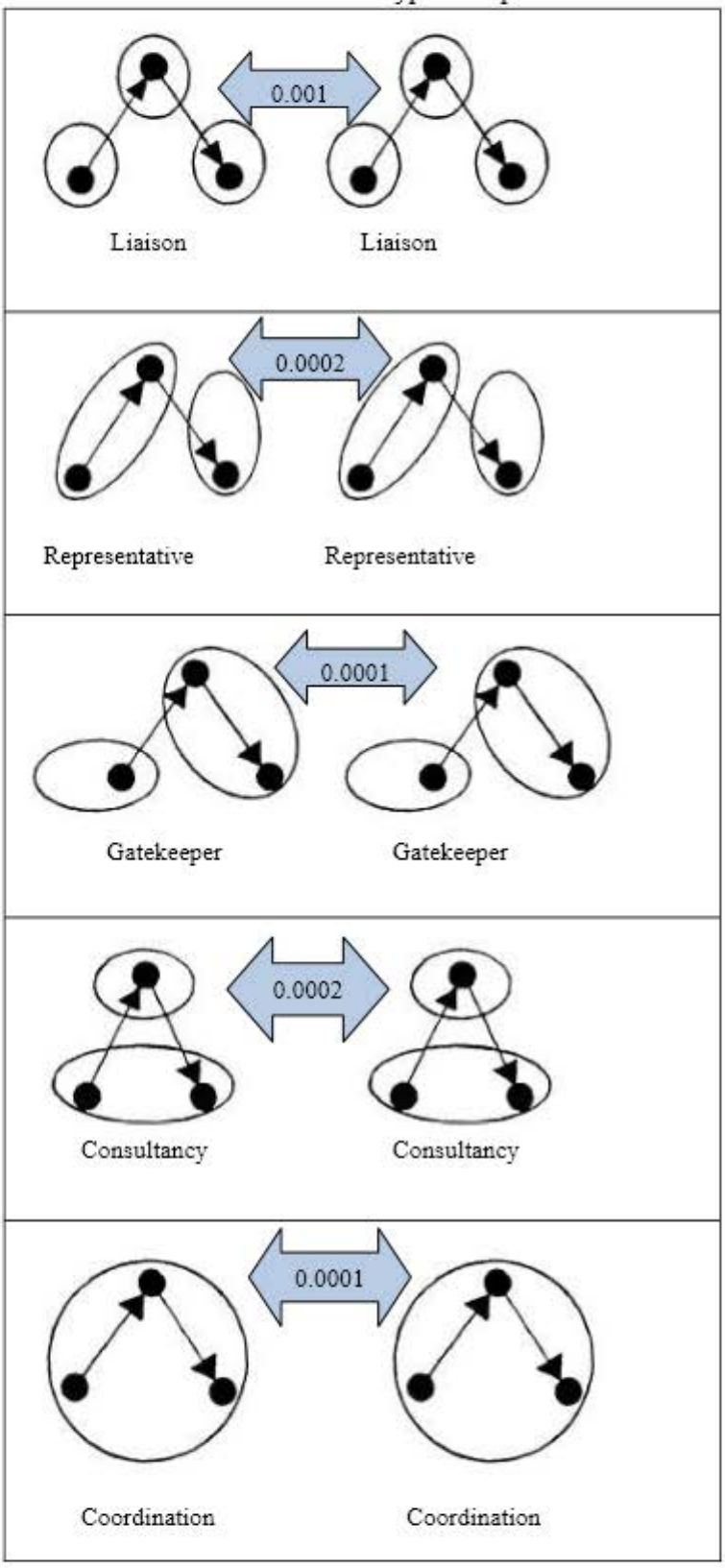


Figure 7.3 shows the probabilities of SMEs with similar types of open connection to be connected with each other. If two SMEs both have liaison roles in a network, the chance they can be connected is 0.1%. This means they are very unlikely to be connected with each other in a network. If two SMEs both have representative roles in a network, the chance they can be connected is 0.2%. 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 the 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 0.1%. This also suggests they are very unlikely to be connected with each other. Overall, the results in Figure 7.3 suggest that SMEs with similar types of open connections are very unlikely to be connected with each other. Based on the above results, this study adds a point about which SMEs are more likely to connect with each other. The previous literatures (Narula, 2004; Burt, 2007; van de Vrande *et al.*, 2009; Zeng, *et al.*, 2010; Rosenbusch *et al.*, 2011; Fernandez-Olmos and Ramirez-Aleson, 2017) did not consider how the variety of open connections can influence the chance of SMEs to be connected. This study's results show that the similarity of open connections can decrease the chance of SMEs to be connected.

On the other hand, there is a much bigger chance to have connections between SMEs with different types of open connection (see Figure 7.4). For example, there are 25%

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 gatekeeper is 23%. There are 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 types of open connections, which is no more than 0.2%. Therefore, this study's finding suggests that SMEs with different types of open connections are more likely to connect to each other, in contrast, SMEs with similar types of open connections are unlikely to connect to each other.

Table 7.5 Five types of open connection in SME connection dynamics: Probabilities of connections between different types of open connection

	Liaison	Representative	Gatekeeper	Coordination
Representative	0.25			
Gatekeeper	0.23	0.22		
Coordination	0.22	0.21	0.23	
Consultancy	0.21	0.25	0.25	0.23

Table 7.5 shows the probabilities of SMEs with different types of open connections to be connected with each other. The results suggest that an SME with the liaison role and an SME with the representative role are likely to be connected with a 25% chance. Also, an SME with the consultancy role and a SME with the representative role can be likely

connected with each other with a 25% chance. In addition, an SME with the consultancy role and an SME with the gatekeeper role have a 25% 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 23%. This means they are likely to be connected with each other in a network. There is also a 22% 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 21%. Overall, the results in Table 7.5 suggest that SMEs with different types of open connections 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 consider how different types of open connection can increase the chance of SMEs to be connected.

Table 7.6 presents the results of all three hypotheses together as a model. 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 types of open connections 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 research adds a new

point about SMEs with different types of open connections tending to be connected together.

Table 7.6 Regression results for supporting all three hypothesis

Constant	-12.589
	(0.529)
Number of connections	0.523**
	(0.199)
Inter-connections	
Inter-connections among three SMEs	2.5858**
	(0.299)
Inter-connections four SMEs	2.0517**
	(0.257)
Inter-connections among five SMEs	1.6589**
	(0.168)
Inter-connections among six SMEs	1.209**
	(0.107)
Inter-connections among seven SMEs	1.2085**
	(0.103)
Inter-connections among eight SMEs	1.2019**
	(0.101)
Open connection similarity	-2.3996**
	(1.189)

First, well-connected SMEs get more connected. This is supported by the positive correlation between the number of connections in the previous period and the number of connections in later period in Table 7.6. This means the more connections an SME

had in the previous time the more connections it will have in the later time period. Thus, this supports well-connected SMEs to 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 the previous period and the number of inter-connections in the later period in Table 7.6. This means the more connections an SME had in the previous time the more inter-connections it will have in the later time period. Thus, this supports the hypothesis that well-connected SMEs get more interconnected with each other. Third, SMEs with differences in their open connections 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 7.6. This means SMEs with similar types of open connections are unlikely to be connected with each other, on the other hand, SMEs with different types of open connections are more likely to be connected with each other.

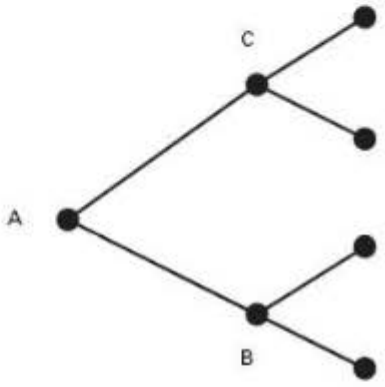
SMEs networks do not evolve in a random way. Those connections are strategic choices. For example, those well-connected SMEs with open structures, they are benefited from bridging the other otherwise disconnected SMEs during their growth. This will be shown in the later findings about the influence of SMEs networks. Also, those well-connected SMEs tend to be interconnected with each other. It looks like they are forming a winners club together during their growth. This will also be shown in the later findings about the influence of SMEs networks. In addition, the types of SMEs' open connections can be used to predict the chance that a pair of SMEs are connected or not. The findings show that SMEs tend to be connected with SMEs with different types

of open connections. This suggests SMEs are looking for complimentary partners rather than similar partners. The 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 is 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.

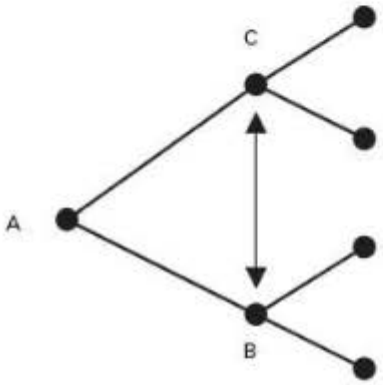
7.5 The reasons for clustering in SME connection dynamics

SME connection dynamics suggested by previous research (Obstfeld, 2005) as, connecting disconnected firms. In this SME network dynamics, there is a gap between B and C connected by A at the first stage (see Figure 7.5). Firm A acts as a broker between B and C (stage 2) and connection 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, Obstfeld suggests SME network dynamics is about connecting disconnected firms to increase connectivity in networks.

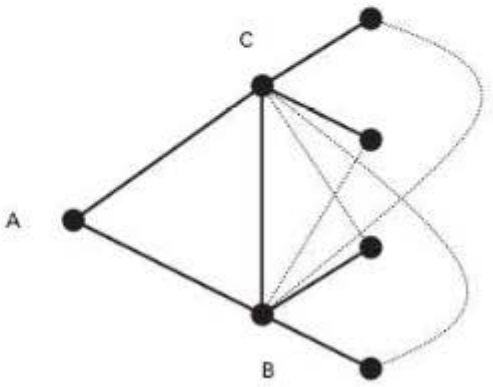
Figure 7.5 Network dynamics in SME growth (Obstfeld, 2005)



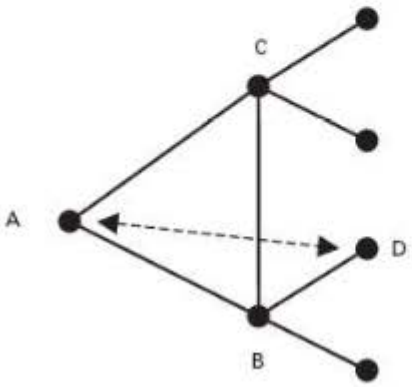
Network at Time 1



Time 2: Network after *tertius lungens* introduction



Time 3: New structural holes created



Time 4: Second reciprocal *tertius lungens* introduction

Hanaki, Nakajima, and Ogura (2010) also suggested similar dynamics about increasing connectivity in firm network (see Figure 8.9). This is supported by there were fewer firms connected with each other in 1991 than in 1995. Also, their study suggests that firm connection dynamics is not only about bridging the gaps between disconnected firms, but also building open and closed structures as strategic moves to

control the network path.

Figure 7.6 Network dynamics in the information technology industry in the US

Different from the previous research about network dynamics, this study suggests that the existing connections influence how new connections are formed between SMEs. The existing empirical studies have not fully addressed this dynamics aspect of inter-firm networks (Burt, 2015). Thus, this study is complementary to previous theories in network dynamics. This research adds three new tendencies of connections to SME network dynamics, which can help to predict SMEs' network structures. They are:

Tendency 1: The well-connected SMEs get more connected with others in SME growth.

The findings in Chapter 7 suggest that SMEs with a large number of connections are more likely to get connections than SMEs with few connections. In this study's literature review, prior studies suggested that firms are getting more densely connected by increasing their connections during their development progress (Granovetter, 1985; Krackhardt, 1992; Nohria and Eccles, 1992; Uzzi, 1996 and 1999). Obstfeld (2005)

disagreed about this and suggested firms only building connections to bridge the gaps between firms (see Figure 7.6). However, this study shows that only these well-connected SMEs were actively increasing their connections. This tendency helps to understand why connections in SMEs networks are centralised to a few SMEs (see Figure 8.1 and 8.2), since those well-connected SMEs were actively increasing their connections.

Tendency 2: The well-connected SMEs get more interconnected with each other in SME growth.

The findings in Chapter 7 suggest those well-connected SMEs are connected with each other. In this study's literature review, prior studies suggested that firms tend to build inter-connections among them (Reagans and Zukerman, 2001; Pittaway, *et al*., 2004). However, this study shows that those inter-connections are usually among well-connected SMEs. This finding suggests that well-connected SMEs occupy a part of network connections and provide connections between that part and the outside of it (See Figure 8.1 and 8.2).

Tendency 3: SMEs with different types of open connections ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other.

The findings in Chapter 7 suggest SMEs with different types of open connections are more likely to connect with each other than SMEs with similar types of them. Five independent types of open connections were suggested Gould and Fernandez (1989). Each type of open connection was identified independently. However, to form a network, those connections need to connect with each other, otherwise, the network will have disconnected parts (Gilsing and Nooteboom, 2005; Ibarra, *et al*., 2005; Cross *et al*., 2015). The relations among these five types of open connections are not clearly identified in network dynamics (Gargiulo and Sosa, 2016). To find out this, this tendency helps to identify: 1) which types of open connections are likely to be connected with each other, and 2) which type of open connections are unlikely to be connected with each other. This shows that SMEs with different types of open connections can be complementary to each other and potentially attract each other to be connected. In sum, this study suggests that previous inter-firm connections more likely to influence the later connections following these three tendencies.

7.6 Summary

Table 7.7 summaries the results of hypothesis testing. Overall, this study discovered how the number of connections, being inter-connected, and different types of open connections can influence SMEs network dynamics. The results suggest SMEs networks evolve during time in three ways. First, those SMEs with a large number of connections get more and more connections with the others in the network. Second, those well-connected SMEs with a large number of connections get to be connected with each other. Third, and most importantly, those SMEs with similar types of open connections do not tend to connect with each other in a network. Instead, those SMEs with different types of open connections tend to connect with each other in a network. These three findings can help to understand how SME networks evolve during time and predict the structures of SME networks in the future.

Table 7.7. Summary of findings in SME connection dynamics

Well-connected SMEs get more connected	Hypothesis 1 supported	Hypothesis 1 supported
Well-connected SMEs get more interconnected	Hypothesis 2 supported	Hypothesis 2 supported
Differences in open connections	Hypothesis 3 supported	Hypothesis 3 supported

In summary, the tendencies of SME connections are as follows.

- First, well-connected SMEs get more connections during time. Those well-connected SMEs are more densely connected over time. This can be seen in the results of the number increase in each firm's 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 open connection similarity as a variable in network dynamics. The results suggest firms with different types of open connections are more likely to connect with each other.

Chapter 8 Conclusion

8.1 Introduction

This chapter discusses the conclusion 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 the earlier chapters to show the significance of this study for knowledge and practice.

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

8.2 Differentiating this study from previous research

This section reflects on the previous empirical finding chapters to make a comparison of the results of data analysis and existing theories. Comparing to Burt's (2007 and 2015) network theory, this study's results provided further developments in SME connection influences, structures and dynamics. First, this study suggests that open and closed SME connections can influence revenue growth, since they are strategic choices to get network positions which other firms rely on their connections. Second, this study demonstrated that open and closed SME connections are not caused by the context of the information technology industry, in which this study's data is based. They are effective structures in inter-firm collaborations. Third, this study added three tendencies to explain how existing connections influence new connections formed between SMEs.

Consistent with these previous studies, this study's method is based on network analysis. Comparing the previous studies focusing on only a year's 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.

Table 8.1 summarises related research and their research questions and findings. Firstly, this study provided findings of network dynamics, which makes the difference

by focusing on the tendencies of SME connections. These findings show that SMEs tend to connect with 1) those firms with different types of open connections, 2) those well-connected firms, and 3) those inter-connected firms. It is recognised that network analysis is particularly useful in the early stages of "new exploratory investigations (Borgatti, 2011). These 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. Those previous studies in Table 8.1 suggested that open and closed connections are effective structures in firm development, however, firms have to balance their connection structures between open and closed. However, this study's findings make a difference in that firms do not need to balance their connection structures between open and closed. They can have open and closed with different firms. This is due to presenting the overall network structure.

Finally, this study provided the results of network influences. Those previous studies in Table 8.1 suggested that open and closed connections can positively influence SMEs growth. In contrast, this study's finding makes difference by suggesting that 1) the influences of open and closed connections are bigger than firm characteristics, 2) open and closed connections can positively influence SMEs growth, and jointly, they

can provide the extra positive effect.

Table 8.1 Related research and their research questions and findings

Previous literature	Prior findings	This study's 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)	Open and closed connections are effective structures in firm development, however, firms have to balance their connection structures between open and closed.	This study suggests that firms do not need to balance their connection structures between open and closed. They can have open and closed with different firms. This is due to presenting the overall network structure.
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)	Networks evolve as 'bridging firms' disconnected firms.	This study suggests that network dynamics is not only about bridging firms but also following three tendencies in the network.
The influence of firm connections are highlighted by Borgatt (2011) and Burt (1997 and 2007)	Open and closed connections can positively influence SMEs growth.	This study suggests that 1) the influences of open and closed connections are bigger than firm characteristics, 2) open and closed connections can positively influence on SMEs growth, and jointly, they can provide the 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 following three tendencies in the network. First, SMEs tend to connect with those well-connected firms during their growth, so that those well-connected SMEs are more densely connected over time. Second, those well-connected firms tend to be interconnected with each other. Third, the analysis considers open connection similarity in network dynamics and suggests firms with different types of open connections are more likely to connect with each other. This study also suggests that the existing network theory has weaknesses in explaining network structures. And this study demonstrated that network structures are not only about open and closed structures, but also the details about five types of open and four types of closed structures. Thus, SME networks in this study provided more details of SMEs activities.

The importance of networks in firm development has been recognised by scholars (Podolny *et al*., 1996; Leven, *et al*., 2014). This study makes contribution to network theories about open (Burt, 1992, 1997, 2004, 2007, 2014 and 2015) and closed connections (Uzzi, 1996 and 1999) by finding out: 1) the extent of networks can influence SMEs growth outcomes, 2) the details of connection structures, and 3) how SME connections change during their growth. This fills the gap in the theories about what kind of SME connections in networks can influence their growth and how these connections evolve.

8.3 Contributions to theories

This section provides a summary of the three finding chapters about the influences of open and closed SME connections (Chapter 6), the various structures of them (Chapter 5), and network dynamics (Chapter 7). This section discusses this study's implications to theory. This study not only focuses on the cause and effect between SMEs connections and SMEs revenue growth, but also the process of SME growth. The process here means the changes in the networks during SME growth (Bogartti, 2011; Burt, 2015). Thus, SME networks are also about complex processes rather than just causality. From this network perspective, this study adds knowledge to complex the processes in SMEs growth rather than causality only. Table 8.2 summaries this study's contribution to theories. In specific, this study explores SME connection influences, structures, and dynamics, then contributes to theories about inter-firm connections (Table 8.2). To breakdown this contribution in the finding chapters, they are SME inter-firm connection influences, structures, and dynamics.

First, this study's findings show the relation between SME connections and revenue growth. These findings provide answers to the question of how SME connections influence their growth outcomes. Chapter 6 tested what the relations between SME connections and revenue growth are. This study shows SME connections are more influential on revenue growth than SME characteristics, which confirms previous

literature (Borgatt, 2011, and Burt, 2007 and 2015) suggesting the influences of SME connections are greater than SME characteristics. After adding the network variables in the model, the model can explain about 70 percent of SME growth outcomes which can be considered as a robust model. Especially, open and closed connections alone can influence about 30 percent of SME growth outcomes. Thus, SME networks have a significant influence on their growth outcomes. These findings contribute to theories in SME growth by showing 1) the more open connections an SME has, the more revenue growth, 2) the more closed connections an SME has, the more revenue growth, and 3) when an SME has both of open and closed connections, there is an extra positive effect on revenue growth.

Second, this study's findings show SMEs connectivity during their growth. As a result of SME connection influences, the network structures are very complex with various types of open and closed connections in the network snapshots. Therefore, the SME connection structures were further explored in Chapter 5 to find out how SMEs are connected with each other in their co-development. The frequently appearing structures in the SMEs networks are open and closed connections, due to the increase of connectivity. Chapter 5 suggested that five types of open connections and four types of closed connection are almost equally appeared in this study's SME networks. This contributes to literatures (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) about which types of open and closed connections SMEs are

more likely to have. These findings provide details about five types of open connections and four types of closed connections. This study suggests all of them as a combination exist in SMEs growth rather than each alone exists. The implication of this is to emphasize the variety of open and closed connections. More importantly, five types of open connections and four types of closed connections are equally important in SME growth. These findings have a contribution to the theories about network location advantages. This study confirms that there are five types of open and four types of closed connections in SME networks. These findings also contribute to theories in SME growth by showing how SMEs are connected with each other to achieve growth.

Third, this study's findings show how SME connections evolve towards open and closed structures during their growth. Chapter 7 explored how a network evolves from a few connections to a large number of highly complex open and closed connections during the progress of SMEs growth. This study suggests the regular patterns in SME network dynamics are not only bridging firms but also tends to be interlocked and connecting to different brokerage firms. This study suggests three tendencies of SMEs connecting with each other. The implication of this is about how to predict and manage future SME connections based on current and past connections. This can be added to theories in the area of SME network dynamics. These findings contribute to theories in SME growth by showing 1) SMEs tend to connect with the well-connected SMEs, 2) well-SMEs tend to connect with each other in the network, and 3) SMEs

with different types of brokerage roles are more likely to connect with each other. These three tendencies contribute to literature (Granovetter, 1985; Krackhardt, 1992; Nohria and Eccles, 1992; Uzzi, 1996 and 1999; Reagans and Zukerman, 2001; Pittaway, *et al*., 2004) about who is more likely connecting with whom in firm development. These findings help to identify the regular structural patterns in SME connection dynamics. In these three finding chapters, this study provided further understanding of the relations between the inter-firm connections and SMEs growth results. And, this study added knowledge about the influences, structures, and dynamics of SME connections in SME growth. Therefore, this study's contributions to inter-firm connections are: SME connection influences, structures, and dynamics.

Fourth, this study contributes to theories in inclusive growth by providing a network model. Prior studies have demonstrated there is no direct relationship between long term vision and SMEs profit growth (Herrera, 2015 and 2016). Studies also argued that the model of value chain structure does not fit to SMEs growth, since SMEs are usually too small to have the whole value chain structure (Charpe, *et al*., 2014; Santiago, 2014). Pouw and Bruijne (2015) showed that SME alone is usually incapable to deal with Porter's five forces in strategic changes. Therefore, these prior studies argued that SMEs growth does not follow the pathway of improving their capabilities and increasing their sizes. This study shows that SMEs inclusive growth relies on 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). This study demonstrated that SMEs inclusive growth relies on the collaboration and knowledge inter-dependency among them. This is considered as the major barrier to SMEs growth (Herrera, 2015 and 2016). Thus, this study contributes to the management of SMEs inclusive growth by providing a network model, which shows how the inter-dependency among SMEs influences their development.

Table 8.2 A summary of this study's contribution to theories

Related research question and chapter	**Hypotheses**	**This study's contribution to theories**
Research question 1: What is the relation between SME connections and revenue growth? Chapter 5 Empirical finding of network influences	• Hypothesis 1: Do open connections positively influence SMEs revenue growth? • Hypothesis 2: Do closed connections positively influence SMEs revenue growth? • Hypothesis 3: Do open and closed connections jointly and positively influence SMEs revenue growth?	Hypothesis 1 is supported, which suggests that the more open connections an SME has, the more revenue growth. Hypothesis 2 is supported, which suggests the more closed connections an SME has, the more revenue growth. Hypothesis 3 is supported, when an SME has both open and closed connections, there is an extra positive effect on revenue growth.
Research question 2: How SMEs are connected with each other? Chapter 6 Empirical	To answer the second research question, descriptive statistics about network structures are provided and there is no	This study confirms that there are five types of open and four types of closed connections in SME networks.

finding of network structures	hypothesis testing	
Research question 3: How do SME connections evolve towards to open and closed structures? Chapter 7 Empirical finding of network dynamics	• Hypothesis 1: The well-connected SMEs get more connected with others in SME growth. Well-connected ⟶ More connected • Hypothesis 2: The well-connected SMEs get more interconnected with each other in SME growth. Well-connected ⟶ interconnected • Hypothesis 3: SMEs with different roles of brokerage ("liaison", "representative", "gatekeeper", "consultancy", "consultancy", and "coordinator") are more likely to connect with each other. Different roles of brokerage connect	Hypothesis 1 is supported, which suggests that SMEs tend to connect with the well-connected SMEs. Hypothesis 2 is supported, which suggests that well-connected SMEs tend to connect with each other in the network. Hypothesis 3 is supported, which suggests SMEs with different types of brokerage roles are more likely to connect with each other.

More broadly, this study also contributes to theories in SMEs growth. SME growth is defined as increasing the supply of products and services, providing sustainable quality of life and structure of the economy, adopting sustainable ways of production, finding new sources of supply, and even exploring new markets (Stiglitz, 2016). SME growth 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 connections as networks lead to SMEs growth. However, SMEs usually do not develop alone (Stiglitz, 2016). In relation to SME growth, previous research often argued that SMEs can benefit from inter-firm connections during their growth (Burt, 2015; Baker, *et al*., 2016). In a situation that external knowledge and resources are valuable to access, inter-firm connections enable SMEs to combine their knowledge and resources to achieve their development. This study explores what are the structures, dynamics, and influences of inter-firm connections in SMEs growth. Thus, the findings of this study can improve the understanding of inter-firm connection structures, dynamics, and influences in SME growth.

8.4 Contributions to research methods

This section discusses this study's implications for 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 show how SMEs are connected to each other during

their growth. The analysis focuses on the influences, structures, and dynamics of SME connections. First, network regression modeling is used to test the relations between inter-firm connections and SMEs growth results. Second, network structures wise, network analysis is used to find out the details about connection structures among SMEs. Third, network dynamics are interpreted by the tendencies of connections to show which SMEs tend to be connected together in networks.

The analysis conducted in this study is a possible way to study network dynamics, structures, and SMEs growth outcomes. This study confirms that SME growth can be investigated from a network perspective (Burt, 2007 and 2015; Bogartti, 2011). Network analysis can be used to study and also elaborate SMEs growth outcomes, process and the structures of SME connections. This study provided evidence about how SMEs revenue growth is related to their networks. Thus, network can be an important indicator of SMEs growth.

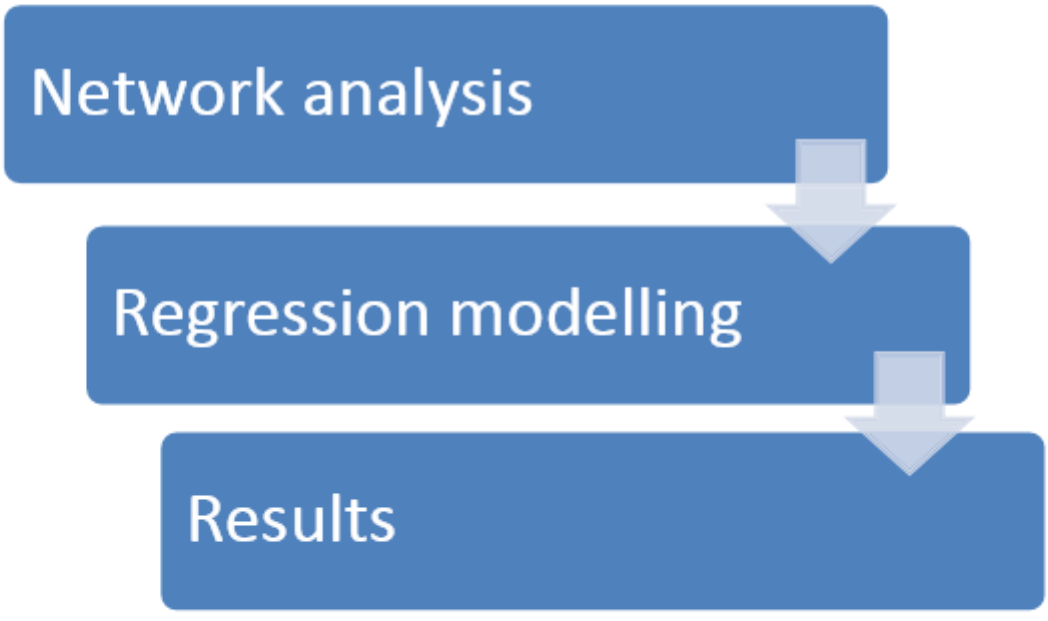


Figure 8.1 'Three-layer' analysis

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 recent years (Bogartti, 2011; Burt, 2015). The fundamental advantage of big data is not the amount of data. It is the analysis of data generated by data, which means further analysis on the analysis results. 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, since this 'multiple' analysis refines the data into useful results. This 'three-layer' analysis approach also transfers the focus from cause-effect to network as process and links the SMEs networks with their performance. Thus, this study contributes to research method by combining network analysis and hypothesis testing, which provide a way of interpretation of SME growth.

8.5 Contributions to practices

This section discusses this study's implications to practice in SME management. This study's findings show SME networks influence their performance. This study also suggests that open and closed connections are important to SMEs growth. Open and

closed connections show how to strategically connect with other SMEs. This shows SMEs managers which firms they need to connect with, and the influence of open and closed connections on revenue growth. 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 management practice. First, the network is not only a way of presenting the data but also a perspective. SME growth 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 (Tsai, 2000; Perry-Smith and Shalley. 2003; Brass *et al*., 2004; Kilduff and Brass, 2010) emphasised relations in networks, the interaction in social relations, dyadic relations, the complex structure of connectivity, and network connections as firm growth outcomes' indicators. The results of this study's analysis presented the processes of SME growth and suggested network as indicators to performance. Second, the network is not just about structure, because of the processes of SME growth. SME networks certainly exist in a dynamic way rather than a static image. The findings of 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. These details are that, in order to increase revenue growth, SMEs need to 1) connect with the well-connected SMEs, 2) be interconnected with other SMEs, and 3) connect with SMEs with different types of brokerage roles. Previous studies (Podolny and Page,

1998; Podolny, 2001) suggested that a network form of organisations can be better studied through network analysis. 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 open and closed connections with others.

8.6 Limitations

This section discusses the limitations of this study, what networks are incapable as theory and method. This study categorises firms into three sectors, which is due to data availability. With data from different sectors or categorisation, a different outcome may appear. Also, the nature of SME connection can cover more types of SME connections. For example, information exchange between two firms, this is related to the interpersonal level of interactions between people in SME growth. The networks in this study are not able to explain such connections at the individual level. In addition, networks are able to explain failure in SME growth, since SME failure could be caused by other factors, such as competition, policy change, or simply just some accidents. In these situations, it might need qualitative research to be carried out.

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 of an active tie or no tie implies that SME connections sometimes can simultaneously exist and not exist. For instance, 0.75 means there is a 75 percent chance of a tie between two SMEs. However, this also indicates that SME connections are simultaneously existing and not existing. 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.

8.7 Future research

Further research can improve this study's model with more data across 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 of using network analysis to investigate SME growth 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 connection. 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 larger dataset with more time points in the data can enable research to find out more details about SME connections. This will provide more detailed information about how SME networks evolve. Network dynamics has been a cutting-edge direction in network research, due to its application in business predictions. A large data set can be used for the analysis of network dynamics to find out more regular patterns of SME network evolution.

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