The impacts of engagement in science park collaborative network on innovation capabilities and financial performance of tenant firms

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ABSTRACT

This study aims to examine how engagement in science park collaborative network (ESPCN) influences innovation capabilities and financial performance of on-park firms. Based on the survey towards Beijing and Shanghai science parks in China, it explores how science park ecosystem creates value for their hosted firms. This research address three research questions, including (1) What should the measurement scale of ESPCN entail in order help tenants exploit benefits associated with science park location? (2) What is the impact of ESPCN on innovation capabilities and financial performance of tenant firms? (2) What are individual impacts of four dimensions of ESPCN on innovation capabilities and financial performance of tenant firms.

Firstly, this study develops a multi-dimensional construct of ESPCN, which is composed of four first-order factors, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial institutions. The ESPCN scale is validated by a sample size of 312 managers of firms on Chinese science parks. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are applied to the validation of measurement scale.

Secondly, this study extends science park literature by exploring how collaborative network within science park ecosystem contributes to innovation achievement and commercial value of tenants. The results indicate that ESPCN has positive and significant effects on tenant firms' innovation capabilities, which in turn contributes to superior financial performance. Firms that develop close network relationships with different science park actors can exploit more benefits from science park location.

Finally, individual effects of ESPCN dimensions have been tested in terms of their effects on innovative and financial outcomes of firms. The results indicate that academic-industry collaboration exerts the greatest impacts on tenants in terms of both innovative and financial outcomes. Interaction with financial institutions is also positively related to both innovation and financial performance. Inter-firm network and interaction with technology intermediaries have positive influences on innovation while do not show positive impacts on financial performance. Compared with individual-effect model, overall-effect model demonstrates better performance with regard to the effectiveness in improving firms' outcomes. Firms can reap more benefits from adoption of four practices simultaneously than only focus on one of them.

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AUTHOR'S DECLARATION

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

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AIC – Academic-industry collaboration

CFA – Confirmatory Factor Analysis

EFA – Exploratory Factor analysis

ESPCN – Engagement in science park collaborative network

FP – Financial performance

IC – Innovation capabilities

IFC – Inter-firm collaboration

IFI – Interaction with financial institutions

IG – Idea generation

ITI – Interaction with technology intermediaries

KBV – Knowledge-based view

NTBF – New technology-based firms

OL – Organisational learning

PcD – Process development

PD – Product development

RBV – Resource-based view

R&D – Research and Development

SEM – Structural equation modeling

CHAPTER 1 INTRODUCTION

1.1 RESEARCH BACKGROUND

In the era of knowledge economy, firms are faced with speeding up of technological change and increasing knowledge intensity (Jansen, 2017; Gandini, 2015). Growing R&D costs and increasing complexity of innovation process makes it difficult for a single firm to maintain sustained competitive advantage (Najafi-Tavani et al., 2018). In order to adapt to rapid technological change, firms need to have control of essential resources and capabilities to cope with such adaptations (Rothaermel, 2001). Companies in high technology industries encounter challenges in their quest of survival in dynamic and unprecedented industries. Nowadays firms tend to seek knowledge across their own boundaries in order to survive in increasingly competitive business environment in the long term. Collaborative network allows for sharing of risk and costs with partners. Exchange of resources, knowledge, skills and expertise enables firms to accelerate their innovation process as well as rapidly adapt to rapid changes in market demands and technology trends (George et al., 2002; Tomlinson, 2010; Lin and Lin, 2016) Network becomes more and more popular with increasing complexity of technology and growing innovation costs.

Nowadays innovation is lifeblood for knowledge-based firms, which provides firms with first mover and lead market advantages (Rothaermel, 2001). Firms with innovation capabilities have a superior position in achieving competitive advantage, leading to long-term profitability. It is believed that innovation process involves high risk and long-term financial investment is required. Innovation is a problem-solving process in which insights into problems are gained via continuous search and efforts (Schilling and Phelps, 2007). It is a dynamic and complex process that involves interactive learning and cumulative interactions (Konsti-Laakso et al., 2012). However, it is almost unlikely that a single firm can generate all essential resources for innovation. It is a costly, complex and time-consuming process to accumulate a variety of technological capabilities. Inter-organisational network is a solution to firms' deficiencies in resources for technological innovation.

According to Hu (2007), science parks are characterized by synergies created among diverse institutions. The agglomeration of R&D institutions, technology-based companies and knowledge-intensive service providers creates an favourable environment that nurtures continuous innovation. A hybrid network of public or private organizations with the provision is the seedbed for local innovation success (Etzkowitz and Klofsten, 2005). A range of location benefits are associated with the location within science parks, such as quick access to customers and supplier, well-developed technological infrastructure, high-skilled human resources, diverse consulting services, various sources of capital etc (Shearmur and Doloreux, 2000; Miller, 2013).

Intense science park network facilitates knowledge dissemination, communication and collective problem-solving (Schilling and Phelps, 2007). Spatial proximity and frequent interactions between actors enable faster access to relevant knowledge and deeper understanding of new knowledge or technology. Long-term and face-to-face communication fosters mutual trust and interactive learning (Lorenzoni and Lipparini, 1999). Science parks create a favourable environment for collective learning, which fosters the emergence of creative ideas and innovations. Universities and research institutions serve as centres of knowledge creation and knowledge diffusion (Tsai, 2009). They are key sources of new scientific and technological knowledge as well as high-qualified and high-skilled talents (Petruzelli, 2011). Collaboration between firms in similar areas or sectors enables firms to share risk, costs, knowledge with their partners. Technology intermediaries such as industrial associations, training institutions, innovation centres, They can act as knowledge brokers who integrate knowledge bases of different innovation actors and introduce new combinations of knowledge (De Silva et al., 2018). Finally, financial institutions can provide science park firms with access to both technology funding and necessary financial services.

This research is grounded in the resource-based view (RBV) and knowledge-based view (KBV) of firms. The main notion of RBV is that firms is a bundle of tangible and intangible resources. It suggests that internal resources or capabilities or resources are the main drivers for achievement of sustainable competitive advantage (Wernerfelt, 1984; Barney, 1991). This study argues that collaborations with external actors enable firms to overcome scarcity of internal resources or competencies. Few firms have control over all resources and assets required for developing innovation (Goes and Park, 1997). Firms are embedded in external knowledge network for the purpose of enhancing accessibility to complementary resources. Collaborative network with different actors in science parks is valuable, non-imitable and non-substitutable resources for firms, which form the basis for firms to create and maintain competitive advantage in the markets.

1.2 RESEARCH SCOPE

The study is conducted in Chinese context. Previous studies provide rich evidence on the effects of science parks on firms in developed economies (Lindelof and Lofsten, 2003; Ferguson and Olofsson, 2004; Yang et al., 2009; Lamperati et al., 2015). By contrast, empirical studies that measure the effectiveness of science parks within developing countries in fostering business growth are relatively limited. China is the largest developing country in the world. This study examines whether science parks in China provide a catalytic environment for the growth of firms. On the other hand, it is easier to get access to data in Chinese context due to nationality of the researcher.

In order to meet challenges brought by competition in global business environment, the

Chinese government initiated Torch Program in 1988 (Hu, 2007). As the largest developing country, China strives to strengthen core competencies of hi-tech industrial sectors in order to gain and sustain national competitiveness (Rodriguez-Pose and Hardy, 2014). Torch Program is an important science and technology initiative initiated by the Chinese government with the purpose of the transition from labour-intensive to technology-intensive economy. The creation of science parks is the dominant idea of Torch Program. Under the Torch Program, more than 100 science parks have been established in major cities since the late 1980s. The government regards science parks as a mechanism to bridge the gap between China and developed economies in high technology fields (Hu, 2007). The government expects the science parks to generate synergies between innovation-led firms, academic institutions and diverse business service providers. Preferential government policies of attracting investment in science parks lead to development of the innovative milieu.

Firm located on science parks in Beijing and Shanghai are the focus of the survey. 312 responses of questionnaire have been collected from managers of science park firms by email and/or Wechat. Beijing and Shanghai concentrate the largest share of basic research of public research institutions and top universities in China (Cao, 2004). Zhongguancun Science Park of Beijing is the most intensive scientific, education and talent resource base in China. It has formed a high and new-tech industrial cluster characterized by the dominance of companies in information technology and electronics sector. Shanghai has built its strong biotechnology industrial base in Zhangjiang Hi-tech Park, which aims to become China's "Medicine Valley" (Zhang and Wu, 2012). In 1999, Shanghai municipal government adopted a policy called "Focusing on Zhangjiang", giving a series of preferential policies with regard to talents, land and capital.

1.3 RESEARCH GAP

There is a growing number of studies examining the effectiveness of science parks in creating value for tenant firms. There are methodological difficulties inherent in the approach to measurement of science parks' effects on firms. Comparing the performance of firms inside and outside parks is a widely used method to assess the impacts of science parks on tenant firms. A large amount of research measures the effectiveness of science parks by comparing on-park and off-park firms due to the availability of statistical data sources (Westhead, 1997; Lindelof and Lofsten, 2003; Ferguson and Olofsson, 2004; Yang et al., 2009; Lamperati et al., 2015; Liberati et al., 2016). They demonstrate mixed results with regard to the effects of science parks on firms. Some studies reveal positive effects of science parks when they compare performance of firms located on and off parks. Based on a survey of Italian science parks, Lamperati et al. (2015) reveals much higher level of tenants' patent applications and R&D expenditure than that of off-park firms. The findings of Lofsten and Lindelof (2002) demonstrate significantly higher performance of tenant firms on Swedish science parks than off-park ones in terms of growth in sales and employment. The study of Ferguson and Olofsson (2004) on Swedish science parks have found that survival rates of hosted firms is greater than firms located outside parks.

However, some authors did not find out positive impacts of science parks on tenant firms. The evidence regarding whether science parks successfully sustain tenants' performance remains doubtful. The survey of Italian science parks conducted by Liberati et al. (2016) fails to find out the evidence that affiliated firms have better performance in terms of number of patents and the ratio between intangible investment and total assets. The study of Lindelof and Lofsten (2003) on Swedish science parks does not find significant differences between new technology-based firms (NTBFS) on parks and off parks regarding patents. Westhead (1997) conducted a survey of firms located inside and outside UK science parks. The results reveal no significant differences between two groups of firms in both R&D inputs (i.e. R&D expenditure and R&D intensity) and R&D outputs (i.e. number of patents, copyrights, new products).

First of all, they fail to explore the processes of knowledge creation and knowledge sharing that occurs in network between different actors in science park ecosystem. There is a lack of an integrated framework tackling how knowledge sharing and collaborative innovation process involved in science park ecosystem influence tenants' performance. Few studies examine the contribution of collaborative network to competitive advantage of firms located on science parks. Secondly, they do not take into account heterogeneous effects of science park location on the performance of hosted firms. Prior studies have found mixed results when they evaluate the effects of science parks. Some of studies that compare the performance of on- and off-park firms reveal satisfactory results while others fail to find positive effects of science parks on park firms. There is no guarantee that science park location brings about superior firm performance. The performance of on-park firms depends not only on external resources and support provided by science parks, but also on their capabilities and strategies to exploit the location benefits (Diez-Vial and Fernandez-Olmos, 2015). This research proposes that firms' outcomes depend on firms' ability to exploit resources or knowledge available to facilitate innovation capabilities. Conditions are similar for businesses located within a science park, thus, business growth also depends on their own ability to develop and maintain external collaborative relationships (Lechner and Dowling, 2003). Last but not least, it is obvious that an extensive body of literature focus on assessing the effectiveness of science parks in developed countries in promoting the growth of affiliated firms. There are rich evidence about the effects of science parks on firms in advanced economies. By contrast, empirical studies that measure the effectiveness of science parks in emerging economies through quantitative approach are relatively limited.

1.4 MOTIVATION, CONTRIBUTION AND IMPLICATIONS

The motivation for conducting research in the context of science parks is personal interests. The research topic that researcher identified for masters dissertation is university-industry linkages within Cambridge Science Park. To further study the phenomenon of science parks, the researcher's PhD project explores how science park collaboration network contributes to innovation improvement and business growth of tenant firms. The target of investigation has changed into science parks in the largest developing country, China.

The study contributes to literature in several ways. On the one hand, it develops a theoretical framework that explores the effectiveness of science park ecosystem in facilitating firms' achievement in innovation and commercial value. It justifies how science parks collaborative network creates value for tenant firms. The impacts of knowledge sharing and technology flow that occur in science park ecosystem on innovation and financial performance of tenant firms have been explored. On the other hand, this study also examines the effects of individual dimensions of science park collaborative network on affiliated firms. It extends the literature by exploring which type of collaboration existing in science park ecosystem has stronger or weaker impacts on tenant firms.

In terms of policy implications, it is necessary for management teams of Chinese science parks initiate policies or strategies that facilitate collaborative relationships between tenants and various types of organizations or institutions. Apart from offering space, office and facilities to their hosted firms, science parks should take an active part in fostering networking and interactions that makes technology diffusion and knowledge flow easier. Park managers should also help hosted firms overcome challenges and mitigate risk involved in network relationships. For managers of science park firms, they can be aware of the importance of developing close linkages with different organizations involved in science park ecosystem simultaneously. They also need to seek methods to eliminate barriers to collaborative relationships with other organizations.

1.5 RESEARCH QUESTIONS AND OBJECTIVES

This study explores how science park ecosystem creates value for its tenant firms in China. It examines how benefits derived from science park collaborative network can be channeled to enhance innovative and financial outcomes of tenant firms. It will look into the following research questions:

RQ1) What would measurement scale of ESPCN entail?

RQ2) What is aggregate impact of ESPCN on innovation capabilities and financial performance of tenant firms?

RQ3) What are individual impacts of ESPCN's four sub-dimensions on innovation capabilities and financial performance of tenant firms?

This study aims to address the following research objectives based on research questions above:

RO1) Produce the literature review of science parks as well as collaborative relationships exist in science park ecosystem.

RO2) Conduct scale development for "engagement in science park collaborative network" (ESPCN).

RO3) Test the validity and reliability of ESPCN measurement scale.

RO4) Develop theoretical framework that reveals the relationships between ESPCN and tenants' innovation capabilities and financial performance.

RO5) Examine the hypotheses proposed in the theoretical model.

1.6 THESIS STRUCTURE

Chapter 1 provides an overview of research background, and presents research questions and objectives on the basis of the identification of research gap.

Chapter 2 reviews the literature in the area of science parks, inter-organizational network and innovation capabilities. Definitions, functions and objectives of science parks are summarized. The overview of science parks in China is presented. The review of empirical studies regarding science parks is provided in order to identify research gap. This chapter also reviews literature on different types of inter-organizational network exists in science parks, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries and financial institutions. Moreover, the summary of studies on innovation capabilities is included in this part. Finally, this chapter lays out underlying theories for the research, including resource-based view (RBV), knowledge-based view (KBV), and dynamic capabilities are included in this chapter.

Chapter 3 presents research methods employed in this research. This chapter illustrates the process of questionnaire design and data collection. It reveals the selection of research strategy and identifies questionnaire-based survey as the major approach to data collection. In addition, this chapter justifies the reasons for the application of structural equation modeling (SEM) to this study. The steps of developing and validating the conceptual model have been clarified.

Chapter 4 develops the conceptual framework underlying the present study and proposes hypotheses to be tested. This chapter identifies nine constructs, including four components of “engagement in science park collaborative network”, four components of “innovation capabilities”, and financial performance of tenant firms. Hypotheses that reflect the relationships between those constructs have been identified.

Chapter 5 demonstrates the results of data analysis. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are employed to test the validity of the measurement model. Model fit of two structural models are assessed after the validation of measurement model. Two structural models measure overall effects of ESPCN and individual effects of ESPCN's four dimensions on innovation capabilites and financial performance of tenant firms respectively. The hypotheses proposed in Chapter 4 are also tested.

Chapter 6 discusses and analyses the empirical results. It presents discussions about the measurement scale of ESPCN, the individual impacts of four dimensions of ESPCN on innovation and financial performance of science park firms, and overall effects of ESPCN on tenant firms. Theoretical contribution and managerial implications of this study have been presented in this chapter.

Chapter 7 provides a conclusion of the thesis. This chapter clarifies how research findings address research questions proposed in introduction chapter. Theoretical and managerial implications of this research are suammarised in this section. This section also points out the limitations of the research and provides a couple of suggestions for future research in the area of science parks.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

This research is conducted in science park context, thus a review of science park literature is presented in the first section of this chapter. Definitions, functions and objectives of science parks are summarised, which leads to the identification of major research aim. Science parks are committed to promoting technology transfer between academia and industry, facilitating the creation and growth of technology-based firms, and stimulating regional economic growth. This research focus on exploring the role of science parks in contributing to the growth of technology-based firms. Besides, this chapter presents the background of creation and development of Chinese science parks, which are the focus of this study. In addition, this chapter reviews empirical studies related to science parks, putting an emphasis on studies with regard to the impacts of science parks on performance of hosted firms. It helps with the identification of research gap in prior science park literature.

This research highlights the role of network in contributing to science park firms' outcomes. It examines how network relationships with different types of organisations or institutions involved in science park ecosystem influences firms' achievement in innovation and commercial value. Thus, relevant literature including academic-industry links, inter-firm network, technology intermediaries and financial institutions are reviewed. As the impacts of science parks on firms' innovative achievement is the core of this research, review of studies relevant to innovation capabilities is presented. The literature review of innovation capabilities enables the author to conceptualise innovation capabilities. It helps with clarifying the elements comprising innovation capabilities of firms.

The first section of this chapter presents the literature view of science parks. Firstly, definition of science parks has been discussed. Secondly, three major functions or objectives of science parks have been identified, including stimulating knowledge-based entrepreneurship, facilitating synergies and networking, and promoting regional development. Thirdly, an overview of science parks in China has been provided. Finally, empirical studies about science parks are summarised. Next section of this chapter focuses on four types of actor on science park ecosystem, including academic institutions, commercial businesses, technology intermediaries, and financial institutions. The last section presents a review of literature on innovation capabilities.

2.2 LITERATURE REVIEW OF SCIENCE PARKS

2.2.1 Definitions of science parks

There is no agreement on the definition of science parks. Various terms can be used to describe science parks, including technology parks, innovation parks, research parks, technopoles, etc. Different types of park-based models that cater different demands of regional contexts or industrial sectors contribute to ambiguity in defining science parks. Moreover, different types of organizations involved in science park ecosystem have different objectives. Local authorities pursue improvement of regional economy, growth in employment as well as attraction of foreign direct investment (FDI). Universities aim to supplement funding through commercial exploitation of scientific research. Firms attempt to acquire commercial benefits from location on science parks.

Individual science park associations define science parks in their own way. International Association of Science Parks and Areas of Innovation (IASP) is headquartered in Spain. It defines a science park as “an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions (IASP, 2019).” According to IASP (2019), a science park should satisfy several criteria to meet their goals: “

- Stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets;
- Facilitates the creation and growth of innovation-based companies through incubation and spin-off processes;
- Provides other value-added services together with high quality space and facilities."

The United Kingdom Science Park Association (UKSPA, 2019) clarifies that science parks are supposed to fulfil criteria as follows. "A science park is a business support and technology initiative that:

- Encourages and supports the start-up and incubation of innovation-led, high-growth, knowledge-based businesses;
- Provides an environment where larger and international businesses can develop specific and close interactions with a particular centre of knowledge creation for their mutual benefit;
- Has formal and operational links with centres of knowledge creation such as universities, higher education institutes and research organisations (UKSPA, 2019)."

The Association of University Research Parks (AURP) was set up in 1986 on an international conference in the United States. A science park is defined by AURP as "a property-based venture which,

- Master plans properly designed for research and commemoration;
- Creates partnerships with universities and research institutions;
- Encourages the growth of new companies;
- Translates technology;
- Drives technology-led economic development." (AURP, 2019)

Besides, European Union (1990) defines a science park as:

"*...a place where newly created firms are concentrated in a limited space. Its aim is to improve the chance of growth and rate of survival of these firms by providing them with a modular building with common facilities (telefax, computing facilities, etc.) as well as with managerial support and back-up services. The main emphasis is on local development and job creation. The technology orientation is often marginal.*"

AURP's definition has adopted a set of distinguishable criteria for defining university research parks. IASP and UKSPA have provided similar criteria. However, their definitions include science parks, research parks, technology parks and innovation centres. EU places an emphasis on the idea of seeing science parks as a mechanism to boost regional development and job creation. It focuses on the provision of space and physical facilities for businesses. IASP and UKSPA definitions regard science parks as facilitators for entrepreneurship and technology transfer. The dominant idea of their definitions lies in science parks' formal and operational linkages with HEIs or research centres. European Commission (2013) identify three generations of science parks. The first generation of science parks in the 1980s are property sites with active linkages with higher education institutions. During the 1990s, second generation of science parks have started to focus on the role of developing stronger and more complex network that allows tenants to access requisite resources. In 2006, the workshop of directors, consultants and academics from world-leading parks defined the third generation of science parks. Third-generation parks are dedicated to creation of collaborative spaces that contribute to higher level innovation. They bring together diverse groups of organizations, institutions or individuals together in order to generate creativity and innovation, enhance process productivity, and transform new ideas or concepts into marketable products or services.

Despite a variety of definitions of science parks, they have several characteristics in common.

They share three similar objectives, including regional economic development, technology transfer, and growth of technology-based companies (Castells and Hall, 1994). The generation of employment and wealth for local economy is one of the primary objectives of establishment of science parks (EU, 1990; Hansson, 2007). They provide incentives for technology transfer from knowledge base to commercial community. Besides, science parks contribute to the innovation and competitiveness of tenant firms (Massey and Wield,, 1992).

Science parks have a vital function in the formation and development of new technology-based firms (NTBFs) (Rodriguez-Pose and Hardy, 2014). They are growth poles for the flourishment of technology-based firms (Shearmur and Doloreux, 2000). The fundamental objective of science parks is to provide a platform that is conducive to innovation (Rodriguez-Pose and Hardy, 2014). Cultivating knowledge-intensive start-ups is the key to sustainable innovation in the local economy. Heterogeneous entities, including knowledge-intensive business services, venture capital, incubators etc., concentrate on science parks. Science parks play a signpost role in assisting tenants to identify the sources of capital, knowledge, talents they require. Such policy settings mitigate tenants' scarcity of resources to pursue knowledge-based development (Etzkowitz and Zhou, 2018). Science parks are proactive in support of new technology businesses by provision of specialised property and facilities. Additionally, a diversity of professional business support are designed for satisfying the demands of knowledge-based firms at start-up and early stages. European Commission (2013) categorises four types of services provided by science parks, including property linked services, business support services, innovation services and networking services. Property-linked services ensure the efficient operation of working environment for park tenants (e.g., conference or meeting rooms, laboratories, internet access, social and entertainment facilities). Secondly, science parks have a network of professional consultants or advisors that provide business support such as marketing advice, globalisation, talents, business planning and quality control. In addition, they also offer services in support of tenants' R&D, technology transfer and networking activities.

Science parks are characterised by proximity to knowledge institutions and its associated staff, resources and facilities (Etzkowitz and Zhou, 2017). They usually have formal linkages with HEIs or research institutions (Miller, 2014). The cross-fertilisation between academic community and business community is the dominating idea of science parks. Science parks are seen as a catalyst for technology transfer and synergies between academia and industry (Shearmur and Doloreux, 2000).

Last but not the least, science parks play a catalyst role in the growth of regional economy (Rodriguez-Pose and Hardy, 2014). The objective of science parks is related to improving employment prospects and boosting economic growth through encouraging the formation of innovative science-based firms (Hansson, 2007). In general, the central or regional government plays a decision role in the development of science parks with the purpose of attracting investment from private enterprises.

2.2.2 Functions and objectives of science parks

2.2.2.1 The growth pole for knowledge-based firms

In the era of knowledge-based competition, Science parks provide a catalytic environment for the creation and growth of resident firms. The benefits associated with a science park location include image effects, innovation culture, quick access to a skilled labour market etc (Gwebu et al., 2018). Innovative and entrepreneurial culture and a supply of high-skilled workforce are key resources for the formation and growth of businesses in technology-based sectors (Gwebu et al., 2018). Creating a dynamic ecosystem for innovation and entrepreneurship is the major objective of science parks (Benneworth, 2014). This objective can be achieved by attracting companies with technological competencies and encouraging the growth of knowledge-intensive start-ups. Science parks serve as a growth pole for attracting enterprises in hi-tech industrial sectors (Hansson, 2007). The provision of knowledge infrastructure is designed to support the creation of technology-based start-ups and speed up the growth of existing enterprises (European Commission, 2013). Many of disruptive innovations emerge within start-ups. Science parks create an environment that provide incentives for knowledge-based start-ups to conduct R&D and to create innovation (Rodriguez-Pose and Hardy, 2014). They are innovative milieu that ensure the supply of regional resources to breed technology-oriented businesses (European Commission, 2013).

Science parks are policy settings that support the transformation of innovative ideas into commercial start-ups (Hansson, 2007). They serve as business support infrastructure for technology-based start-ups and early stage firms (European Commission, 2013). Science parks are committed to performing enabling functions for tenants' innovation process (Miller, 2014). They secure public sector support for tenants to undertake innovation-related activities. They nurture an environment conducive to innovation by providing value-added business services, financial support, and assistance in technological development (Rodriguez-Pose and Hardy, 2014). Hansson et al. (2005) maintain that modern science parks support all stages of innovation process, ranging from R&D to commercialisation. Science parks contribute to the transformation of innovation from a linear process within industry to a non-linear process (Etzkowitz and Zhou, 2017). The innovation process goes beyond the industrial sector, extending from research to the market. Such mechanisms provide tenants with access to connections with both other tenants and the wider environment. Science parks provide "hard" technology services such as laboratories, equipment and facilities, as well as "soft" services including IPR, training, and financial services (Shearmur and Doloreux, 2000). Tenant firms get easy access to inter-firm synergies, academic-industry synergies, thick labour market, and local pool of funding (Gwebu et al., 2018).

The places where innovation activities are concentrated tend to develop adaptability to rapid-changing business environment fast-growing hi-tech industries (Rodriguez-Pose and Hardy, 2014). Knowledge accumulation of science parks gives entrepreneurs opportunities to cope with threats associated with dynamic environment (Gwebu et al., 2018). Compared to traditional industries, high-technology sectors rely on the knowledge and information related to raid response to fast-changing markets and technology to a larger degree (Shearmur and Doloreux, 2000). Science parks are regarded as a policy tool that provides slack resources that help firms cope with internal or external challenges (Gwebu et al., 2018). Their support helps tenants quickly identify and respond to opportunities promptly and mitigate challenges brought by environmental dynamism. With support provided by parks, SMEs can do a better job in identification of firm position and formulation of market strategies. Entrepreneurs can get quick access to customers and suppliers, high-qualified human resources, various consulting services, and well-developed technological infrastructure (Shearmur and Doloreux, 2000). The accumulation of resources or reserves is likely to better scan and monitor changes or opportunities. Resource- and opportunity-rich environments allow tenants to achieve sustained competitive advantage (Gwebu et al., 2018).

2.2.2.2 The facilitator for synergies, networking, and technology transfer

A single site agglomerates academic institutions, SMEs and large firms, young and established companies, and knowledge-intensive business services, building an innovative community (Benneworth, 2014). Science park is a policy tool dedicated to facilitating knowledge exchange and synergies between various actors (Gwebu et al., 2018). The development of effective functioning network depends on mutual trust, historical ties, and previous experience. Spatial proximity is a contributing factor to network formation (Ter Wal and Boschma, 2009). Geographical closeness allows for face-to-face interactions, frequent contacts, and close interpersonal linkages, reducing the transaction costs of technical knowledge (Rodriguez-Pose and Hardy, 2014). Close interaction is associated with trust-based relationships and cooperations, which makes the transmission of tacit knowledge easier (Ter Wal and Boschma, 2009). Polyani (1957) believe that tacit knowledge tends to remain geographically localized, spreading over concentrated economic landscapes. Technological breakthroughs are diffused "only incompletely and gradually, not fully and instantaneously (Quah 2001, p.90)." The cumulative learning process forms the basis for technological innovation.

Science parks can be seen as an intermediary linking knowledge producers and exploiters for stimulating technological innovation development (Benneworth, 2014). They foster knowledge spillover from knowledge-based institutions, facilitating knowledge flows between knowledge institutions and business sector (Rodriguez-Pose and Hardy, 2014). They "fill the gaps in innovation processes where knowledge producers and exploiters are too far apart." The spaces serve as bridge between academic community and business community, fostering entrepreneurial science. The "third mission" of universities is featured by increasingly intense interaction with business sector and regional authorities (Rodriguez-Pose and Hardy, 2014). They are not simply providers of knowledge, but take an active part in development and commercialisation of technological innovation. Etzkowitz and Klofsten (2005) believe the university as an incubator supporting staff or students' entrepreneurship, and a seedbed for new interdisciplinary fields and emerging high-tech sector. The universities with high-level research capabilities play a contributor role in developing a knowledge-based regional economy.

Even though the government is indispensable as a source of public support, universities are considered as crucial to the success of science parks (European Commission, 2013). Universities play a critical role in the development of science parks, such as Stanford University for Silicon Valley, Harvard University and MIT for Route 128, Cambridge

University for “Cambridge Phenomenon” etc. Firstly, they can generate new ideas and knowledge for the knowledge-based economy (Castells and Hall, 1994). They are a source of raw materials and human resources that science parks need (Massey et al., 1992). Secondly, they can provide training courses for industrial engineers and technicians (Castells and Hall, 1994). Thirdly, universities can play a direct entrepreneurial role, supporting the spin-off process of their academic research into a network of commercial enterprises (Massey et al., 1992; Rodriguez-Pose and Hardy, 2014).

2.2.2.3 The catalyst for regional development

Science parks is seen as a catalyst for regional development by stimulating technology-based entrepreneurship. They support and encourage the creation and growth of technology-based firms that revitalise local economy (Castells and Hall, 1994). They also help regional agencies achieve the objective of job creation. Clustering of firms and knowledge flows from research community contribute to regional vitality. European Commission (2013) regards science parks as an innovation ecosystem with the goal of regional economic growth and job creation. The past decades have witnessed science parks becoming a pivotal element of science and technology policy of Western countries. They play an increasingly crucial role in developing local or regional economy. Hansson (2007) argue that science parks combine a local policy interest in growth of regional economy with a more general policy interest in promoting entrepreneurship. The government creates science parks primarily for local benefits (Shearmur and Doloreux, 2000). They encourage the creation of high-technology companies and high-quality jobs. Local economy can benefit from the institutional frameworks that allows for knowledge dissemination and innovation creation. Science parks are a source of local technological competitiveness.

According to Marshall (1920), localised knowledge spillover is the sources of advantages associated with agglomeration economies, including collective learning, productivity growth, employment growth etc. Such knowledge-intensive environments provide a viable technological foundation, which is seen as an innovation hub revitalising regional economy. Science parks foster the restructuring of regional economic activities and formation of localized entrepreneurial network (Parker, 2010). They facilitate collaboration between regional agencies, universities, and knowledge-based firms (Rodriguez-Pose and Hardy, 2014). A hybrid network of public or private organisations with the provision of information, expertise and capital is the seedbed for local innovation success (Etzkowitz and Klofsten, 2005). They are strategic assets for regional development as "they contribute to the critical mass of services and other support mechanisms offered in the region… (European Commission, 2013)." It is a prerequisite for science parks to create a viable environment for securing sustainable innovation and continuous technological upgrading in the region. Science parks are seen as policy vehicle that stimulates continuous improvement within their localities. Technology diffusion through science park network stimulates regional dynamism and economic vitality (Peters et al., 1998). Science parks are conducive to transforming a region into a knowledge pole. 2013)."

2.2.3 Science parks in China

It is widely known that the phenomenon of science parks originated in Silicon Valley of USA. Inspired by the success of Silicon Valley, European countries have put a lot of efforts in creating science parks for promoting innovation and entrepreneurship. Overview of three well-known science parks in Western countries are presented in Appendix 2 (page). Emerging markets, which aim to catch up with developed economies in high-technology sectors, have devoted considerable resources and capital to the development of such innovative milieu (Zhu and Tann, 2007).

As the largest developing economy in the world, China pursues the transition from labour-intensive to knowledge-intensive economy. The Chinese government has initiated policy initiatives boosting the development of science and technology (Hu, 2007). In 1986, the government embarked on the High Technology Research and Development Plan (863 Plan) in attempt to bridge the gap between China and developed economies in high technology fields (Hu, 2007). 863 plan provides preferential policies for technology-based companies in particular (Walcott, 2002). Policies that support developing high-tech firms include Torch Program initiated by the Ministry of Science and Technology in 1988 (ADB Institute, 2018). The program aims to "develop high- and new-technology products, establish technology-oriented enterprises, and pave the way for the commercialization of innovations that will come out of major national science and technology programs" (Hu 2007). The Torch Program is one of key projects for the purpose of bridging China's technology gap with the world frontier. The dominant ideas of Torch Program include the creation of science parks, promoting technology commercialization and innovation-oriented entrepreneurship. Policy incentives provided by science parks such as tax holidays stimulate formation of knowledge-intensive enterprises. More than 100 science parks have been created under Torch Program The Chinese government developed "Talent Strategy" and "Chun Hui Program" to attract overseas Chinese scientists and entrepreneurs to return from abroad (Wu, 2007).

Beijing Zhongguancun Science Park (ZSP) has seen as a technology hub with the largest cluster of electronics and information technology companies in China (Liu et al., 2010). With the concentration of education and research institutions, ZSP is known as the most important intellectual region in China. Sep up in 1988, ZSP is the first science park in China. There are more than 40 universities and more than 200 research institutions concentrated in the neighbourhood of ZSP (Yu, 2018). Apart from leading universities such as Tsinghua University and Peking University, national research institutes including Chinese Academy of Science

(CAS) and Chinese Academy of Engineering are also important sources of technological innovation development in Zhongguancun. Under market reform, the government restructured the existing education and research system by diminishing funding to universities and public research institutions, which stimulates them to set up businesses to overcome funding scarcity (Zhu and Tann, 2007). As result, there was a boom of technology-based firms led by academics, such as Tongfang Group of Tsinghua university, Founder Group of Peking University. Lenovo Group of Computer Technology Institute of CAS, which have been leading enterprises in China (Lyu et al., 2017).

The management team of ZSP has encouraged the provision of intermediary services in order to provide an enabling environment for technology diffusion and knowledge flows in ZSP (Zhu and Tann, 2005). Intermediaries within ZSP include productivity promotion centres, technology markets, talent development centres, headhunters, industry alliances, industrial societies etc. They play an important role in facilitating network relationships, knowledge transfer and technology transactions. Location on one of the most populous cities in the world enables science park firms to get access to a large customer market (Hu, 2007). Both Beijing and Shanghai concentrate a huge pool of educational and research resources (Hu, 2007).

Shanghai's technological development is facilitated by the metropolis' role as the economic centre of China. Zhangjiang Science Park (ZJSP) in Pudong New District is known as "Medicine Valley" in China (Kroll et al., 2008). It has become a hub for multinational enterprises in pharmaceutical and biotechnology sectors (Wu, 2007). In 1999, Shanghai Government developed "Focusing on Zhangjiang" strategy which leading industrial sectors of the park. In order to stimulate the growth of ZJSP, it adopted a range of policies with regard to land development, provision of financial resources and human resources, attraction of foreign investment, etc (Kroll et al., 2008). Top universities such as Fudan University and Shanghai

Jiaotong University, as well as research institutes such as National Centre for Drug Screening, National Human Genome Centre in Shanghai provides strong science base for intellectual development of ZJSP (Wu, 2007). The availability of a large pool of high-skilled and cheap workforce attracts the influx of multinational enterprises. Local government set up financial institutions that support the survival and growth of start-ups in ZJSP. ZJSP rests heavily on state-run investors such as Shanghai Venture Capital and Shanghai Commission of Science and Technology (Su and Hung, 2009). ZJHP has created professional service platforms that support innovative activities of hosted firms (Wu, 2007). The platforms promote technology transfer between academia and business sector, integrate information and equipment from various sources, and provide technical consultancy services that support drug screening, clinical trial and market launch.

2.2.4 Empirical studies of science parks

Against the theoretical propositions linked to the STPs' operation and the objectives stated by policy makers and Park promoters, a constantly increasing empirical body of literature has attempted to test some of the assumptions of the STP model and assess the Parks' actual added value. Firm-level studies (micro level) examine the added-value derived from operating in a Park (Lindelof and Lofsten, 2003; Ferguson and Olofsson, 2004; Lamperati, et al., 2015; Liberati et al., 2016). Studies focusing on science parks (meso level) examine their viability and growth and whether they have achieved the objectives set by the promoters (Lin and Zeng, 2009; Zeng et al., 2010; Nahavandi et al., 2012). Regional level (macro) assessments focus on the broader impact on the region (Keeble, 1989; Goldstein and Luger, 1990; Park, 2002; Landoni et al., 2010). In relation to their location, studies following the advancement of science parks in developed countries and advanced economies (primarily the United States and Western Europe) represent the majority, although increasingly there is work on less developed countries and regions. The body of literature on science parks is reviewed here, focusing on the science parks' proposed functions and regional development role. The objective is to shed light on the actual results of the science park model, to identify points of criticism of the science park model and to discuss methodological issues related to the analysis and evaluation of science parks.

2.2.4.1 Assessment framework of science parks' overall performance

Many of science park studies contribute to developing an overall framework for performance evaluation of science parks. Single science park case studies combining qualitative and quantitative data, comparative analyses of two or more science parks with different Park structures and cross-section analyses from a large population of science parks based on broadly available data or surveys have been used by researchers. Assessing performance of science parks is of vital importance for stakeholders involved in science park activities. Firstly, the formation and development of science parks are usually supported by public sector bodies, such as central government, local government, regional development agencies etc. The study of Monck and Peters (2009) indicates that the public sector expects specific goals to be achieved and satisfactory outcomes to be derived from their expenditures. Being able to track the evidence of the efficiency and effectiveness of their spending is important. The evidence not only helps public bodies in decision-making of funding and resource allocation, but also motivates them to continuously support the growth and development of science parks.

Secondly, performance measurement is also important for the science park side. The competition for funding and incentives from public sector is fierce. Demonstrating positive feedback stemming from public expenditure facilitates science parks to obtain more support from public agencies (Monck and Peters, 2009). Science park managers can decide which aspects to develop and the shortcomings to modify. This process helps them identify the key factors affecting the effects of their parks on tenants, which in turn improves competitiveness of the parks. Berbegal-Mirabent et al. (2019) examine the relationship between mission statement of science parks and their performance. Thirdly, as for entrepreneurs, performance assessment allows them to compare science parks and select the best performers (Ferrara et al., 2016). These data provide information for potential entrepreneurs about which science parks can better support start-ups. These are the reasons for an increasing demand for performance assessment methods based on robust and sound theoretical framework.

However, because of the complex set of activities science parks are typically engaged in, it is complex to evaluate their performances. As a matter of fact, the mission statements of science parks are usually all-embracing and generic (Bigliardi et al., 2006). A variety of actors, ranging from universities and research institutes to high-tech enterprises, banks, venture capital firms, government etc., are involved in these ecosystems with different expectations (Ribeiro et al., 2016). There is no consensus on which set of indicators are supposed to be employed for assessing and comparing different parks systematically. It is a difficult task to create a specific tool which is able to capture various dimensions of performance of science parks. In order to assess the success or failure of science parks, a numerous set of metrics would be measured and a number of different stakeholders would be surveyed (Ferrara et al., 2016).

On the other hand, the issue of aggregating multidimensional performances in simple indexes also emerges as a result of the complex nature of science parks. The availability of relevant data is often limited. Besides, Ferrara et al. (2016) point out that it is hard for different stakeholders reach an agreement on the weight assigned to each attribute. People with different background have heterogeneous preferences. Furthermore, a simple sum of relative weight of each metric is not sufficient for performance evaluation of science parks as interactions between different attributes are not taken into account. Groups of metrics can count more or less than a simple weighted sum. Thus, there is no widely accepted and sufficiently tested methodological approach to assessing overall performance of science parks. Developing an effective performance evaluation system of science parks is still an open issue for academics, parks' managers and policy makers.

There are several studies providing subjective conceptual models for evaluating science park. Koh et al. (2005) propose an analytical framework for examining how science parks operate and evolves over time. The performance of a science park could be evaluated in terms of three aspects, First of all, they identify the main growth mechanisms, which are agglomeration effects, creation of new firms and infrastructure provision by government. Secondly, the level of technological capabilities within a science park is also one of the success criteria of a science park. The third aspect of the framework is the role of the science park in national and global economies. This study presents the theoretical basis of tracing the evolutionary path of science parks. However, it is totally subjective without justified numerical results. Bigliardi et al. (2006) design a theory-grounded framework for performance measurement of science parks based on real mission, life-cycle stage of science parks, stakeholders' interests, local economic conditions, legal forms, and technological-scientific competence base within the university which interacts with the science park. This study is also subjective lacking objectively quantitative assessment. Dabrowska (2011) present a performance measurement system for evaluating the success of science parks. A matrix of performance indicators have been proposed, consisting of four dimensions: commercial, stakeholder perspective, brand and reputation, and internal business processes. The author does not take into account how to aggregate the values of each indicators for overall evaluation.

Some authors strive to develop an evaluation tool that allows for the evaluation of science parks with complex and heterogeneous sets of indicators. Nahavandi et al. (2012) design a Fuzzy Expert System for evaluation of science parks, which enables the comparison between high number of science parks with numerous indicators. The evaluation approach proposed by

Ferrara et al. (2016) sorts out the issue of disagreement among different stakeholders on the relative importance of each attribute. allows diverse stakeholders to choose the best performers in the light of their own preferences. The set of weights assigned to each dimension depends on nothing else than individual preferences. The paper of Zeng et al. (2010) provides a system model measuring innovation capabilities of science parks based on a case study of Qingdao Science Park. They apply factor analysis to dealing with the problems with multiple-variable data. The model they propose for evaluating the science park innovation system comprises three components, including Innovation Organisation Sub-System (i.e. innovation firms and research institutions), Innovation Support Sub-System (i.e. innovation infrastructure and technology intermediaries), and Innovation Environmental Sub-System (i.e. policies and regulations, cultural environment, financial environment). Corrocher et al. (2019) find that innovation intensity of science park is dependent on the

Science parks and industry clusters share similar objectives and functions to stimulate innovation and entrepreneurship (Sadeghi and Sadabadi, 2015). Considering the similarities in their goals and missions, some studies combine these two topics together. Porter (1998) discovered that clusters could enhance competitive advantage of enterprises through clusters of productivity, clusters of innovation, and clusters of new business formation. Porter (2000) further identified four critical drivers of competitive advantage of clusters, i.e. factor conditions, demand conditions, related and supporting industries, and competitive context. Factor conditions refers to the availability of high-quality and specialised innovation inputs, such as well-developed infrastructure, a pool of scientists and engineers etc. Demand conditions is the nature of domestic demand for cluster producers and services. Demanding home customers stimulate firms to pursue innovation. The third driver is the presence of capable local suppliers and competitive and related industries, which generates positive externalities. The final driver refers to the intensity of local competitive context.

Several studies apply Potter's model to exploring the sources of competitive advantage enjoyed by science parks. Lai and Shyu (2005) base their study on Porter's (2000) model, providing a comparison of innovation capacity of Shanghai Zhangjiang High-tech Park and Taiwan Hsinchu Science Park. Their results indicate that Zhangjiang is weakest in "related and supporting industries" while Hsinchu is weakest in "factor conditions". Porter's (2000) model is also employed by Zhao et al. (2009) as a framework to evaluate the competitiveness of Dalian Software Park. Their study reveals that the competitive advantage of Dalian Software Park comes from supportive government policies, close network among firms, integrating into international value chain of activities etc. On the basis of Porter's (2000) four-dimensional model of clusters, Lin and Tzeng (2009) come up with a value-created system of science park composed of four aspects (i.e. human resource, technological resource, investment environment, and market development). These factors affect the enterprises' decisions about choosing suitable places for production, R&D and marketing. They believe that industry clusters or science parks can grow sustainably.

2.2.4.2 The impacts of science parks on tenants' performance

Science parks are increasingly regarded as mechanisms for driving the promotion of new technology-based firms and growth of affiliated businesses. In spite of the wide spread worldwide, the effectiveness of science parks as a means of promoting enhancement of technology and innovation development are still open issues. Despite growing interest in science park phenomenon in recent years, the evidence regarding whether on-park location is successful in sustaining tenants' performance is mixed and the role of science parks on tenants remains doubtful. A wide range of literature examine location by comparing on-park and off-park companies (Lamperti et al., 2015; Liberati et al., 2016). The effectiveness of science parks in creating value for their affiliated firms remain unclear.

Impacts on innovative performance of tenants

Some studies have found out positive impacts of science parks on tenants' innovation performance. Based on a survey of Italian science parks, Corrocher et al. (2019) provide evidence that science parks are effective in improving tenants' innovation performance. on-park firms show stronger innovation performance than off-park firms. Squiciarini (2008) focuses on Finnish science parks and explores the role of science parks in improving innovativeness and competitiveness of tenant firms. On-park location is positively associated with affiliated firms' innovativeness. Yang et al. (2009) compare the innovative performance of NTBFs located inside and outside Taiwan Hsinchu Science Park. This study finds positive relationships between on-park location and firms' innovation, Firms located on parks display substantially higher innovative productivity than their off-park counterparts, arising from the fact that the positive network effects provided by science parks. Lamperti et al. (2015) explore the effectiveness of science parks through analysis of the differences between performances of located within a park and a carefully constructed control group of off-park companies. The study investigates the location effects on associated firms' performance in terms of innovativeness, expenditures on R&D activities and sales growth. The results demonstrate much higher level of tenants' patent applications and R&D investments than that of comparable off-park companies. That is to say, science parks have significant and positive impacts on hosted firms with respect to both innovativeness and research-related expenditures. Colombo and Delmastro (2002) explore the effectiveness of incubators located within Italian science parks through comparing NTBFs incubated on a science park and their off-incubator counterparts. This research contributes to literature by taking into account a more comprehensive set of indicators, including the characteristics of firm founders, the growth and innovative performance of firms, their collaboration with universities and and other businesses, and access to public funding. The findings of this study supports the positive impacts of on-park location on firms. Firstly, the results confirm the success of Italian science parks in attracting high quality entrepreneurs. Incubated firms' founders with PhD or Masters degree account for higher proportion than off-incubator counterparts. Secondly, firms located on incubators enjoy better performance with respect to adoption of new knowledge and technology, likelihood of collaboration with firms and universities, access to public subsidies, tendency to take part in international R&D projects etc.

However, some authors fail to provide evidence that the location on science parks has positive impacts on innovative performance of hosted firms. The findings of Lindelof and Lofsten (2003) do not find significant differences between NTBFs on parks and NTBFs off parks in terms of innovative performance. This study reveals that NTBFs on science parks seem to be not capable to transform resource investments into greater innovative outputs such as patents compared with NTBFs not located on a science park. The results regarding impacts on innovative outputs is also supported by the research of Westhead (1997). The author did not observe positive relationships between science park location and innovative performance of tenant firms as well. The results reveal no significant differences between on-park and off-park firms with regard to R&D expenditure, R&D intensity (i.e. the ratio of R&D investment to sales revenue), as well as R&D outputs including patents, copyrights, and ability to launch new products or services. Liberati et al. (2016) investigate the impacts of park location on their hosted firms based on a survey of Italian science parks conducted by the Bank of Italy in 2012. This study contributes to science park literature by measuring whether science parks have been effective in sustaining tenants' various aspects of performance. Annual sales and operative value added are used for measuring production performance; return on assets and gross operative margin over total assets are considered as profitability indicators; the ratio between investment and total sales is exploited as the indicator for investment propensity; and innovation capacity is measured by number of patents and the ratio between intangible investment and total assets. The authors find that science parks have positive effects on sales and added value. Absent evidence is shown with respect to effects on profitability and innovative capacity.

Impacts on growth performance of tenants

New technology-based firms (NTBFs) play a key role in enhancing entrepreneurship, accelerating technology diffusion and promoting growth of national and regional economy (Siegel et al., 2003; Lindelof and Lofsten, 2003)). Lofsten and Lindelof have published a series of studies regarding how Swedish science parks influence performance of on-park NTBFs (Lofsten and Lindelof, 2002; Lindelof and Lofsten, 2002; Lindelof and Lofsten, 2003). Their studies focus on assessing the effects of on-park location by comparing performance of on-park NTBFs with off-park counterparts. With respect to growth in sales and employment, the performance of on-park firms is substantially higher than comparable off-park firms. Hasan et al. (2018) put an emphasis on small- and medium-sized enterprises (SMEs). The study provides evidence that science parks can effectively support development of SMEs located on parks. It confirms that SMEs in science parks of Taiwan generate higher productivity in comparison to SMEs located elsewhere. Ferguson and Olofsson (2004) observe higher level of survival rates and more image benefits enjoyed by on-park NTBFs than off-park ones.

However, some authors report opposite effect of science parks. Lofsten and Lindelof (2002) have found no evidence that location on a park has direct impacts on tenants' profitability. The study of Ferguson and Olofsson (2004) do not find significant difference between NTBFs located inside and outside Swedish science parks in terms of growth in sales and employment. Lamperati et al. (2015) find absent association between on-park location and firms' growth performance. Results about firms' growth in sales appear not to be affected neither directly or indirectly by location within science parks. In short, this study indicates that science parks play a seedbed role of innovation rather than enclaves. Besides, the study contributes to the literature by identifying the main drivers of the location effects. Among diverse park features, the presence of research centres turns out to be the main driver for sustaining innovativeness of hosted firms.

The study of Arauzo-Carod et al. (2018) differs from prior studies by identifying heterogeneous effects of science parks on firms' performance. They find that the location inside science parks has dual effects on tenants' performance in terms of sales and employment . The extent to tenant firms benefit from belonging to a science park is not the same. Park location is positively associated with performance of high-growth tenants while it is negatively associated with that of low-growth tenants.

Impact of parks' characteristics on tenants' performance

Most studies focus on homogeneous effects of science park location, however, heterogeneity of science parks has been ignored for a long time. A series of studies examine how park characteristics, such as park size, park age, ownership, influence affiliated firms' performance. Liberati et al. (2016) fills in gap by taking different impacts of different types of Italian science parks into account. It can be seen from their study that older science parks have much stronger impacts on performance of hosted firms than young parks. As for park ownership, the evidence shows that public parks have positive effects on production performance of tenants while non-public ones positively influence firms' propensity to invest. With respect to industry specialisation, non-specialised parks (i.e. those who host companies in various sectors) play an effective role in growth of tenants' sales while specialised parks affect positively investment of tenants. Liberati et al. (2018) analyse the heterogeneous effects of science parks as policy instruments for supporting firms' innovation. They relate heterogeneous effects to several park characteristics including park size, park age, park location and service provision by management team. First, the empirical results show that park size has positive effects on innovation performance of tenants, which is measured by sales from new products. Second, very new or longer established parks are more beneficial for innovation of tenants. Third, firms located in less technologically developed areas benefit more from on-park location. However, Gwebu et al. (2018) argue that park size is not a significant contributor to performance of tenants' firms. Their study does not find positive relationship between park size and tenants' performance with regard to sales.

Several studies explore whether performance of hosted firms is influenced by the nature of science parks. Arauzo-Carod et al. (2018) differentiate between science parks and technology parks. They compare the effectiveness of science parks with technology parks in fostering the development of tenants. The results show that the stronger effects of science parks on firms than that of technology parks. Science parks play a more effective role as policy instruments for supporting firms. Albahari et al. (2017) investigate how different types of parks influence innovative performances of tenants. This study distinguishes four types of parks according to the degree of university involvement within parks, ranging from pure science parks, pure technology parks, mixed parks to technology parks with university. It has found the relationships between the level of university involvement and firms' innovation outcomes. that firms located on pure science parks perform best for patents and worst for product innovations, while firms of pure technology parks have the best performance for sales of new products and lowest patenting levels. The authors explain the result by the existence of different types of knowledge in different types of parks.

Impact of firms' characteristics on tenants' performance

In recent years, there has been growing interest in assessing how firm characteristics affect the performances of firms located in science parks (Huang et al., 2012; Diez-Vial and Fernandez-Olmos, 2016; Liberati et al., 2016). Heterogeneity of park tenants have been considered widely among recent literature about evaluating the impacts of science parks on firm performance. On-park location effects are not homogeneous for all tenant firms (Ubeda et al., 2018; Liberati et al., 2016). Squiciarini (2009) uncovers the relationship between park characteristics, firm features and their innovative output performance. They argue that the success of science parks in promoting innovation depends on a combination of characteristics of science parks and tenants' features.

In terms of firm size, the results of Huang et al. (2012) suggest that firms with smaller size can benefit more from locating within parks or clusters. They can better enhance their innovativeness through obtaining knowledge and resources from external partnerships in a park or cluster. Small firms can enjoy positive innovative performance, while larger firms benefit more from location effect in terms of market performance. Besides, Liberati et al. (2016) observe that the magnitude of location effects depends on firm characteristics such as age and size. Their results confirm that science parks effectively improve sales and investment of smaller firms.

The age of science park firms has heterogeneous effects on their performance. Diez-Vial and Fernandez-Olmos (2016) find that firm age has negative impacts on innovative performance of tenant firms, which is measured by the percentage of sales from new products. Younger firms are liable to develop external networks to compensate for their "liability of newness" while established firms are less interested in establishing relationships with other firms or institutions. Young companies benefit more from science park network than old companies. As a result, the positive effects of science parks on firms reduce as firms age. On the contrary, Gwebu et al. (2018) observe the positive relationship between age of tenants firms and their performance with regard to sales growth.

Diez-Vial and Fernandez-Olmos (2015) believe that the performance of on-park firms depends not only on external resources and support provided by parks, but also on their internal capacity and strategies. The findings demonstrate that development of formal partnerships with universities or research centres has positive influences on product innovation of on-park firms. Besides, firms that make more internal R&D efforts show better innovative performance. The on-park firms with internal R&D efforts and cooperation with academics or researchers would benefit more from the parks. Their have higher capacity to exploit on-park knowledge spillovers and incorporate external knowledge into their products, processes or services. The study of Ubeda et al. (2018) regards absorptive capacity of tenants as a moderating factor, which is measured by R&D expenditure, number of PhDs and expenditure on R&D by public finance). The tenants with higher absorptive capacity benefit more from location on science park while firms with low absorptive capacity do not enhance their innovation by locating on parks. High level of absorptive capacity facilitates tenants to better exploit knowledge spillovers and learning opportunities provided by science parks. Based on a survey of Taiwan's manufacturing firms located on science parks or clusters, Huang et al. (2012) explore how science park firms' innovation performance (i.e. patents) is influenced by in-house R&D capability. However, their results suggest that firms with inferior in-house R&D capability benefit more from location in a park or a cluster. The explanation for this results is that the location provides them with complementary assets or resources to improve their innovation.

Rather than consider science park benefits as constant over time, Diez-Vial and Fernandez-Olmos (2016) evaluate on-park location effects on hosted firms from a dynamic perspective. They argue that the benefits associated with location within science parks depend on the stage of industry life cycle. With the maturity of a industry, there is a tendency that the focus of the industry evolves from supply of product innovation to improvement of product variety and manufacturing process. The findings of the research indicate that as the industry evolves, the benefits associated with on-park location tend to diminish gradually. Maturity of industry negatively influence the growth and innovative performance of on-park firms.

2.2.4.3 The impacts of science parks on networking and technology transfer

The location within science parks facilitates the development of diverse cooperative relationships. Science parks guarantee geographical proximity, which contributes to knowledge flows, technology transfer as well as building of mutual trust between tenants within the park (Vasquez-Urriago et al., 2016; Torre and Gilly, 2000). The location of a science park provides firms geographical proximity to important customers, suppliers, academics and other firms.

The previous empirical studies reveal different performances of science parks in terms of technology transfer. Several empirical studies provide evidence that location in a science park fosters linkages and networking for innovation. Fukugawa (2006) investigates whether on-park new technology-based firms (NTBFs) have a higher tendency to engage in research collaboration with local higher education institutions (HEI). The findings suggest that on-park NTBFs to are more likely to establish linkages with university academics and scientists. Lofsten and Lindelof (2005) explore the R&D networks created by NTBFs on science parks in Sweden. This study identifies the role of science parks in promoting links between on-park NTBFs and HEIs. NTBFs located within parks have an interest in collaboration with academic institutions. This research makes it clear that science park mechanisms provide a supportive environment for the formation and development of R&D network.

Vasquez-Urriago et al. (2016) investigate the influence of Spanish science parks on cooperation for innovation. The findings indicate that the location within a science park enhances the likelihood of innovation cooperation between companies and knowledge providers. Their study also extends the literature by analysing the intangible benefits of collaboration with the innovation partners. Cooperation for innovation improves firms’ ability in terms of strategies making, human resources, information management and relationship management. In addition, Phillimore (1999) surveyed interaction and cooperation within Western Australian Technology Park (WATP). The results of the research reveal that frequent and significant collaboration not only takes place among the firms located within the science park, but also occurs between on-park firms and Curtin University. Most WATP firms indeed engage in relationships with others in close geographical proximity.

Nevertheless, some studies provide no favourable evidence that science parks promote university-industry links and inter-firm links. The work of Massey et al. (1992) was among the first who doubted the role of science parks in promoting technology transfer. They believe that science parks are not major sources of technology development, and account for very little in nurturing and generating productive synergies. Science parks are considered as “high tech fantasies”, many of them are found to be primarily a form of prestigious real estate development. Kihlgren’s (2003) case study of science parks in St. Peterburg suggests that the transfer of technology from academic institutions to tenant firms has been weak within the parks.

Some research shows that science parks work as a driving force for the formation of informal and personal interaction, however, they do not present substantial effects on formal linkages and collaboration. Bakouros et al. (2002) contributes to filling in the gap in literature by evaluating the performances about university-industry links and inter-firm links of science parks in Greece. Their results show that the effects of three Greek science parks on university-industry linkages are not the same. Informal interaction and personal contacts between academics and companies are widespread in all three parks. Formals interaction with local university are only developed by companies within one science park (i.e. joint research, research contract, consultancy, analysis and testing in university department). The authors do not observe much formal interactions in the other two parks. As for interactions between firms located within the parks, commercial transactions and social interaction are the two most common categories of inter-firm links. These three science parks all have the issue of scarcity of research-based collaborations among on-park firms such as joint research. Vedovello's (1997) study examines the linkages established between university and industry based on a case study of Surrey Research Park in the UK. The study categorises university-industry links into three main types: formal links, informal links and human resource links. Their findings suggest that the science park context promotes the building of informal links and human resources links between university and companies. That is to say, geographical proximity provided by science park mechanisms facilitates interaction and synergies between the innovation partners. However, science parks do not play a significant role in the establishment of formal links, which are more related to the development of research. In summary, informal relationship and human resource links could be strengthened by science park mechanism while formal research collaboration are not enhanced by geographical proximity.

2.2.4.4 The impacts of science parks on regional development

Castells and Hall (1994) regard promoting regional development as one of the main motives for the creation of science parks. Link and Scott (2007) consider science parks as a catalyst for regional economic growth. Successful science parks are effective vehicles for enhancing the image of location, creating high-level jobs, attracting high-quality talents, facilitating regional technological development, and further realising economic revitalisation of the region (Dabrowska, 2011; Lamine et al., 2016). They play a key role in boosting the development of knowledge-oriented regional economy. However, compared with a wide range of studies examining added-value of science parks to their tenants, relatively fewer studies contributes to exploring the impacts of science parks on regional development. There are limited literature examining the contribution of science parks to regional economy.

Science parks are seen as “the mainstays of high technology industrial development” (Oakey, 2012). Link and Siegel (2007) highlight the role of science parks in stimulating technology-based economic development and improvement of the image of location. Science parks support the transition of a region towards an innovative entrepreneurial economy with strong technology base and high quality talents. Malecki (1991) argue that technology is a key driver for growth of regional economy. High-technology enterprises can offer high-level, highly-paid jobs for workforce. Moreover, it is believed that science park mechanisms play a connecting role in creating networks among universities, research institutions, entrepreneurs, investors, regional development agencies, etc (Lamine et al., 2016). Such mechanisms are key to improving creativity and fostering an innovative culture at a regional level. The study of Landoni et al. (2010) explore whether science parks contribute to regional innovation system in terms of both scientific output (i.e. publications, research collaborations) and technological output (i.e. patents, EU collaborative research projects). Their findings suggest that the science park significantly contributes to local scientific development.

The last few decades have witnessed the increasing role of science parks as bridging mechanisms between innovative entrepreneurship and regional ecosystems (Lamine et al., 2016). Attraction of R&D businesses or innovative activities to the region is the most significant effect of the presence of a science park within the region (Goldstein and Luger, 1990). A successful science park, with a large pool of high-quality workers or scientists, an innovative business culture, knowledge-intensive services etc., is likely to attract more and more R&D-oriented firms to agglomerate within the region. The agglomeration effects induce continuous growth in R&D sector of the region. Park (2002) conducted research on a science park in Sweden. The study indicates that by stimulating technological innovation and R&D activities, the science park has been enhancing the knowledge generation capability of the surrounding region.

Science parks serve as drivers for the enhancement of regional economy in terms of industrial revitalisation and employment growth (Abetti, 2004; Aaboen, 2009). In developed economies, these science parks are used as mechanisms to accelerate the process of "economic restructuring", which means that "old manufacturing industries give way to high-technology and research-oriented businesses" (Goldstein and Luger, 1990). This process is accompanied by job creation, employment stability, and changes in wage. Newer industries tend to locate in urbanised core regions while traditional manufacturing industries like coal or iron concentrate in a few key regions or cities (Castells and Hall, 1994). Some issues emerge with the rapid development of urbanised regions, such as environmental pollution, traffic congestion, rising housing price, etc. In order to realise the objective of reindustrialisation, the newer industries in core regions are encouraged to locate in those periphical regions. Large and established firms locate part of their operations as branches in less developed regions to respond to such incentives. The settlement of innovative industries can revitalise the declining economy of traditional industrial base and diffuse new technology throughout the regions.

Based on the case of Cambridge region, the study of Keeble (1989) discusses local multiplier effects of science parks. Firstly, technology-based companies create external income for the local economy. They bring a large amount of revenues into the Cambridge region by selling their products and services outside the region. Secondly, the generation of local procurement and subcontracting linkages is another source of high local multiplier impacts. The local synergies contribute to the emergence and growth of new business services companies. The third reason for significant multiplier effects is the above-average level of salary paid to technology-based firms' staff. The injection of high-income, high-tech workforce has multiplier impact on all local public and private sectors such as retailing, leisure, construction etc.

Goldstein and Luger (1990) classify potential effects of science parks on regional economy. Primary impacts are those related to economic growth in terms of jobs, productivity, personal income etc. Distributional dimensions of primary impacts include industry sector, ownership type, workforce segment etc. Secondary impacts stem from primary impacts are associated with changes in economic structure. The authors discuss the relationship between the presence of a science park and regional economy as well. They come up with three factors that influence the magnitude of the effects above (Goldstein and Luger, 1990). First of all, the economic structure of the region affect the impacts of science parks. Large metropolitan can provide the science park "breath and depth of labour supply, business services, proximity to headquarters functions and, proximity to large concentration of manufacturing activity." Firms can get access to depth and breadth of manufacturing sectors and powerful manufacturing base. In large metropolitan regions, business expansions and founding of new plant are more likely to occur through backward linkages. A relatively underdeveloped region with a university or public research institution could also be an ideal location for the park. Due to lack of diversification of labour skills, business services and prior concentration of manufacturing, innovation activities within those regions may focus on particular areas, depending on strongest areas of university departments or in research institutions. Business growth is more likely to be realised through forward linkages in those less developed regions.

Second, park characteristics also have impacts on the regional development outcomes (Goldstein and Luger, 1990). The recruiting policy of a science park determines it attracts R&D branches of large corporations or small and medium-sized enterprises (SMEs). The authors suggest that a larger proportion of SMEs in a park results in a larger number of spin-offs from tenants. The networks among tenants also affect entrepreneurship. The weak synergies of the science park result in fewer spin-offs. The third factor that affect the regional economy is a park's external network with academics, researchers, entrepreneurs and policy-makers.

Academic-industry links would draw to the region new R&D activities and boost growth of spin-offs. The innovation diffusion between park firms and firms in the region is of great benefit to the latter. Technology transfer from tenants to the region's existing businesses can improve the productivity of the latter.

2.3 SCIENCE PARK COLLABORATION NETWORK

Collaboration can be seen as an interactive process that all participating parties are involved in that relationship (Wood and Gray, 1991). Collaborative relationships involve joint problem-solving and decision-making process in which all stakeholders have a commitment (Graham and Barter, 1999; Gray, 1989). Considering the acceleration of technological change, firms cannot depend exclusively on internal development of knowledge and resources. Access to complementary resources is the fundamental basis for collaboration (Austin et al., 2012).

Science park collaboration network refers to firms' interactions with different collaborators, namely academic institutions, co-located firms, technology intermediaries and financial institutions for innovation and growth purposes. Inter-organisational and cross-sector collaboration facilitates knowledge flows between different actors of science park ecosystem. Science park collaboration network allows firms to obtain quick access to complementary skills, knowledge and resources essential to their innovation activities. Collaboration with different science park actors improves the process of knowledge creation and dissemination by tenant firms, expanding tenants' knowledge base and in turn enhances innovation capabilities. Working together with diverse external actors can lead to knowledge generation, creativity and innovation improvement. Gray (1985) regards collaboration as an approach to share resources and solve a problem. Sharing of knowledge and resources between different science park firms and different parties and science park firms and solve a problem.

Although collaboration and cooperation are often used as synonyms in previous studies, there is difference between those two concepts. Cooperation simply aims to look for answers while collaboration is related to looking for the right people to generate next great ideas (Ashkenas, 2015). Cooperation is characterized by separated resources and independent value creation by various participants while collaboration is pooled and shared resources as well as jointly problem-solving and decision-making (Mattessich and Monsey, 1992; Schottle et al., 2014). The major goal of science park collaboration network is to foster knowledge sharing, collective learning and joint innovation activities. Thus, the term of collaboration is used in this study rather than cooperation.

Close spatial proximity and frequent interactions between science park actors enables faster access to relevant knowledge and deeper understanding of new knowledge or technology (Schilling and Phelps, 2007). Greater access to external knowledge expands the knowledge base of firms, which in turn leads to superior innovativeness. Collaborative network is seen as a conduit that channels knowledge flows between network members. Universities is a source of specialised talents. They provide access to talented scientists and graduate students who conduct fundamental research (Arza, 2010; Bishop et al., 2011). They are important sources of new ideas, knowledge and technology (Massey et al., 1992). Co-located firms can share complementary resources with focal firms. Science parks attract service providers that provide valuable resources including marketing skills or market information, connections to other partners, and information about technology developments. The intermediary institutions promote the free flow of technology information and market information among network members (Lin et al., 2016; Parker and Hine, 2014). They improve the possibility to commercialise new technologies successfully. Financial institutions provide access to finance, which supports the risky and costly innovation process.

Collaboration and interaction with different partners is a way to access external knowledge and resources, creating competitive advantages (Segarra-Blasco and Arauzo-Carod, 2008). With the increasing complexity of technology and increasing costs of innovation, cooperative projects are increasingly popular with innovative firms. Faced with acceleration of technological change, more and more businesses seek to acquire external skills, technology, equipment, and machinery, to complement in-house R&D programs. Engagement in cooperation with external agents is an increasingly important element of innovation strategy of firms in China. Companies in high technology industries is faced with serious challenges in rapidly changing competition rules, which drives companies to recombine their resources or capabilities continuously (Peters et al., 2018). They encounter challenges in their quest of survival in these dynamic and unprecedented industries. They confront difficulties in gaining access to assets or competencies required for developing innovation. It is a costly, complex and time-consuming process to accumulate a variety of technological capabilities. Firms need to develop relationships with other firms or institutions to compensate for their weaknesses of resources and skills.

Potential negative effects also exist in knowledge-intensive regions. Increasingly homogenous knowledge base challenges innovative capacities of firms in the long run (Grillitsch and Nilsson, 2017). Shortage of extra-regional knowledge pipeline in knowledge-dense regions enhance the likelihood of lock-in and reduced creativity (Breschi and Lenzi, 2013). Clustering of firms may increase the risk of knowledge leakage and labour poaching (Combes & Duranton, 2006). Knowledge is partly embodied in labour. Labour flows are accompanied by leakage of knowledge. Firms can get access to competitors' knowledge by poaching from its workers. Location close to rivals in similar sector involves both the benefits of labour pooling and the costs of labour poaching. Negative externalities may deter multinational corporations (MNCs) from agglomerating with domestic firms as knowledge outflow is likely to be higher than knowledge inflow (Grillitsch and Nilsson, 2017). Knowledge base of MNCs can benefit and upgrade local companies. Labour poaching negatively affects firms with higher level of knowledge particularly.

2.3.1 Government

The government can play a planner role in the creation and development of science parks (Sun et al., 2019). It can act as a facilitator by providing indirect incentives for driving innovation and entrepreneurship. It also enricher that promote connections among different stakeholders of science park, involving universities, research institutions, technology-based firms, intermediary institutions, regional public agencies. The provision of government-led infrastructure creates opportunities for knowledge agglomeration and self-renewal through continuous creation of start-ups (Phan et al., 2005). The government support is the major growth mechanism for innovation ecosystem by encouraging sustained R&D and the formation of new businesses.

Government agencies create science parks for the purpose of the boom of local innovation ecosystems (Sun et al., 2019). The local government can support the transition of a region from traditional industrial base to innovative entrepreneurial hub (Link and Siegel, 2007). Science parks are viewed as a policy initiative for driving regional economic growth. Government institutions support and encourage the growth of science parks in order to knowledge and innovation base of the local economy (Matt and Wolff, 2004). Science parks can create high-level job opportunities, attract high-quality talents, improve location image and further facilitate regional economic revitalisation (Link and Scott, 2007).

The government agencies can provide incentives for technology transfer and public subsidies for R&D activities (Matt and Wolff, 2004). Most of science parks receive some form of direct government subsidies (Goldstein and Luger, 1991). Government intervention exerts substantial influences on Silicon Valley. The impacts of R&D investment by the government on innovation and start-ups cannot be underestimated (Bell et al., 2008). Apart from provision of finance, the federal government provides necessary infrastructure and remove institutional barriers for Silicon Valley. Liberal visa policy of USA leads to the emergence of successful immigrant entrepreneurs, such as Elon Musk of Tesla and Sergey Brin of Google. The Bayh-Dole Act of 1980 intellectual property policy that facilitates technology commercialisation (Hyde, 2017).

Chinese government has put a lot of efforts to transform from manufacturing-based economy to knowledge-intensive economy (Sun et al., 2019). Torch Program is one of the key government projects for speeding up technological innovation and entrepreneurship of China. A series of science parks have been set up through government planning in order to bridge the gap with developed countries in scientific and technological fields. “Thousand Talents Plan” and “Chun Hui Program” are initiated to attract overseas Chinese scientists and entrepreneurs to return from abroad (Hu, 2007). The government plays a vital and proactive role in fostering university-industry linkages to achieve technological upgrading within industrial sector.

Sun et al. (2019) identify two approaches of government involvement in fostering regional innovation ecosystem, including top-down approach and bottom-up approach. In top-down approach, the governments directly involve in formation and development of science parks. In bottom-up approach, the government fosters innovation ecosystem indirectly through market mechanisms. Chinese science parks are government dominated to promote the transition from labour-intensive economy to knowledge-intensive economy (Hu, 2007). The Chinese government obviously adopts a top-down approach to supporting science parks. It is difficult to distinguish different levels of strength with regard to network with the government. Therefore, the role of government in fostering innovation and business growth has not been taken into account in this research.

2.3.2 Academic institutions

Science parks are established mainly for encouraging technology transfer from academic organisations to industrial ones. Nowadays, universities have gone beyond their traditional roles in terms of education and research. The role of universities has evolved from ivory towers to the vehicle for driving economic development (D'Este and Perkmann, 2011). They present an orientation towards undertaking a "third mission", which is to pursue connection with industrial environment and generation of knowledge directly related to economic growth (Etzkowitz and Leydesdorff, 2000; Segarra-Blasco and Arauzo-Carod, 2008; De Fuentes and Dutrenit, 2012). The role of universities have evolved from focusing on basic research solely to finding solutions to practical problems. A series of studies discuss the important role of universities and research institutions in fostering economic benefits for firms. There is an increasing tendency of university academics' engagement with industry to commercialise their scientific discoveries. The differences between the scientific and commercial community are becoming ambiguous. Policy-makers in China have put lots of effort in facilitating partnerships between universities and innovative firms. The benefits generated by interaction are different for academics and firms (Arza, 2010). From the perspective of academics, they can obtain funding for their research though collaboration with industry. For another, interaction with industry enables testing the practical application of academic research and may inspire new ideas or perspectives for their academic research. As this research explores the impacts of collaboration on firms, the emphasis is put on the perceived benefits for firms.

Science parks provide a framework for knowledge exchange and collective learning between firms and local organisations or institutions (Love and Roper, 2001). Science parks provide a platform for generation and dissemination of knowledge between businesses and academic institutions. The establishment of start-ups by universities is considered as a key driver for regional economic development (Petruzelli, 2011). They serves as important mechanisms for facilitating transfer of knowledge and technology from universities or public research institutions to industrial corporations. Science parks boost business sector's propensity to develop collaborative arrangements with universities. There is no doubt that universities are key sources of new scientific and technological knowledge. Their capability with regard to integration and combination of knowledge from multiple technological domains make them ideal partners for businesses that aim to realise sustainable competitive advantages in the markets (Petruzelli, 2011). Considering the increasing role of innovation in driving economic development, researchers show a growing interest in building a clear picture of technology transfer and R&D collaboration between industry and academia. Many empirical studies reveal that short geographical distances favour linkages and interactions between academic environment and industrial one (Antonelli, 2000). They provide evidence that firms benefit from geographical proximity to academic organsiations. Spatial closeness promotes higher rates of innovation (Jaffe et al., 1993). Close physical proximity fosters knowledge flows from public science to industry, especially tacit knowledge.

A considerable body of studies contribute to classify the channels by which interaction with universities occur. They identify different categories of linkages between academics and businesses in terms of either degree of formality or degree of interaction (Schartinger eta l., 2002; D'Este and Patel, 2007; Bekkers and Bodas-Freitas, 2009; Wright et al., 2008; Perkmann and Welsh, 2009). Contract research involves the transfer of specified formal knowledge (Wright et al., 2008). The knowledge or skills acquired through contract research can not only create increase in profits, but also improve the firm's absorptive capacity of relevant R&D knowledge. Consultancy is related to the engagement of academics in the consulting process with the objective of problem-solving. Licensing is associated with little transfer of tacit knowledge. Mobility of graduates and researchers is another mode of linkages that is largely associated with the transmission of tacit knowledge. It involves little codified knowledge as the skills, knowledge and experience are within the mind of graduates or researchers.

Many studies assert that contract research, joint research and consulting, which involves a higher level of interaction, leading to more fruitful results than licensing and patenting (Perkmann and Walsh, 2009; Cohen et al., 2002). Close linkages foster interactive learning across organisational boundaries. Face-to-face interactions in interorganisational contexts facilitates the transfer of tacit knowledge. Academics can provide direct support with problem solving, idea generation and technology development. Not limited to offering basic ideas, university scientists can provide direct support with regard to assessing feasibility of projects, translating theories from academic publications. Different modes of interaction allows for the exchange of different types of knowledge. Firm managers can make a choice regarding types of interaction channels based on the stages of R&D. Joint R&D and consulting are more appropriate for the projects related to applied research, whereas conferences are good choices for projects focusing on basic research. Arza (2010) assert that consultancy, joint R&D and contract research, that involve a high level of interaction, are the most effective channels of facilitating industries' technological upgrading. Bi-directional learning channels promotes the transfer of tacit knowledge.

Knowledge provider

Access to highly skilled scientists and researchers as well as the latest scientific and technological knowledge are major benefits derived from collaboration with academia (Arza, 2010). In terms of R&D benefits flowing from academic institutions to firms, industrial organisations can have a fundamental understanding of state-of-the-art scientific research (Bishop et al., 2011). They have the opportunities to learn about foundations of specific phenomena and to identify sources of new ideas for R&D activities. One mission of universities is to produce highly skilled and highly qualified human resources. Thus, another strength of research linkages is the provision of skilled graduates by universities. They have a knowledge of new research and discoveries and the capacity to conduct research, generate innovative ideas and deal with complex issues. Firms can gain access to star scientists and the latest scientific research (Soh and Subramanian, 2014). They can exploit novel discoveries and knowledge generated by the latest scientific research. Integration of scientific knowledge of academic community into their internal knowledge base can lead to creation of new knowledge and technologies. Universities provide an environment for stimulating the exploration of unknown territory. Although scientific research is not generally carried out for achieving commercial goals, it enlarges firms' knowledge base.

Interaction with universities or research institutions is of importance for firms to gain insights into the latest progress in their ongoing research, have a good understanding of scientific and technological knowledge, and obtain assistance provided by high-qualified researchers (Bishop et al., 2011). Contacts with academic community is of value to learn about technological advance and scientific discoveries in relevant fields. Access to professionally trained people undertake basic R&D projects. In many industrial sectors, there is a tendency towards scientification of technological development, which is an impetus to cooperating with scientific community (Arza, 2010). In order to keep up with the fast-growing global knowledge industry, more and more firms in emerging markets seek linkages with public research sector for innovation. Linkages with reputable universities or research institutions can improve a firm's legitimacy among its stakeholders (George et al., 2002). Linkages with reputable organisations give companies possibility to gain access to various resources at lower costs. Firms achieve reduction in overall costs and increase in financial performance. Firms' scarcity of internal knowledge and resources is offsetted by R&D collaboration. Links with universities or research institutes enables knowledge flow and technology transfer, which boosts creativity and innovation (George et al., 2002).

Technology development

The increasing importance of scientific knowledge in many production activities motivate industrial organisations to interact with academic ones (Lee, 2000). Research collaboration is seen as a key element of businesses' innovation strategy. For one thing, university collaboration contributes to technological upgrading of firms. The acceleration of technological change demands a combination of technologies that is difficult for firms to develop on their own. University-industry linkages promotes knowledge exchange between academic scientists and commercial firms, which may lead to increased firm performance (Bishop et al., 2011). Some studies provide evidence that collaboration between academia and industry have positively influence firms' performance (George et al., 2002; Laursen and Salter, 2004). University scientists contribute to technology development of their business partners by engaging in their projects coped with products or process technology (Perkmann and Walsh, 2009). Moreover, scientists can assist firms with idea testing. New ideas emerge within firms are "high risk concepts with commercial potential if successfully translated into a concrete concept, prototype, or technology." Academics have the specialist knowledge to explore the innovative ideas and conduct a feasibility test.

Firms benefit from research partnerships with regard to product development and process improvement (Bishop et al., 2011). Researchers can provide assistance with developing innovative products or processes as well as achieving cost reduction and quality improvement of existing products or processes. Network with knowledge providers is an important strategic asset of producing innovative ideas, products and processes (Peters et al., 1998). Arza (2010) also agree that research linkages facilitates the firms' product development and process innovation. According to Soh and Subramanian (2014), research partnerships with academia allows for transformation of scientific discoveries into commercial innovations. Innovative firms seek to achieve commercial exploitation of cutting-edge scientific research from academic organisations. Collaborative relationships enable firms to get access to state-of-the-art knowledge, technology, facilities and equipment. Soh and Subramanian (2014) present the results that collaborations with universities is positively and significantly related to firms' innovation performance. They find that technological recombination focus reinforces the positive association between collaboration with universities and innovation performance while scientific research focus diminishes the association. Academic-industry collaboration provide opportunities for firms to transform scientific knowledge into commercial applications.

Collaborative arrangements with academic community give companies the opportunities to explore new avenues of innovation (George et al., 2002). They can engage in learning process that improves their ability to master new technology. They can gain a deeper understanding of how to integrate the required technologies and incorporate new information into existing knowledge. Public-private relationships speed up product development cycle of a company. Firms gain access to complementary skills and assets, augmenting their R&D capabilities. Technology development requires multifaceted and heterogeneous knowledge bases, which are not under control of one organisation. By developing close linkages with academics, firms can benefit from the research about emerging technology. Academic institutions employ such linkages to test theories in a practical context, and to acquire opportunities to train and place their students. Hence, public-private cooperation is a "win-win" strategy, where both businesses and academics can benefit from such relationship. Public-private linkages expose firms to different administrative systems and diverse approaches to developing new technologies. Access to valuable resources of academic community lowers a firm's expenditures (George et al., 2002). The sharing of equipment or facilities needed in R&D activities leads to reduction in operating costs. Firms can exploit knowledge and technology obtained from academics to develop innovative products, leading to a firm's good reputation, expansion of market share and business growth.

There is an extensive body of literature highlighting the vital role of universities in the knowledge-based economy. The findings of Eom and Lee (2010) reveal that cooperation with government research institutes has positive impacts on patent performance of innovative firms but has no such impact on sales. Technological turbulence and intense global competition increasingly the significant role of university as a source of novel knowledge. In addition to education and research, the third mission of universities has been stressed, which is aiding in economic development. Guan et al. (2007) present the results that academic-industry collaboration has positive impacts on novelty of industrial innovation. However, the impact is weaker with regard to financial performance such as profit ratios and sales.

Empirical evidence reveals that academic-industry collaboration is positively related to firms' innovation success (Lee, 2000; George et al., 2002; Knudsen, 2007; Un and Asakawa, 2014). Partnerships with scientific community allows for integration and recombination of firms' competencies or capabilities, which lead to generation of new products, processes or systems (George et al., 2002). Continuous innovation is of critical importance for knowledge-based firms to maintain and strengthens their competitive position. Firms proximate to a university has a higher likelihood of producing innovation. The transfer of knowledge from academic community to business community is realised through knowledge spillover from academic research or through formal interactions such as joint R&D and contract research (D'Este and Patel, 2007). Although long duration of basic and fundamental research carried out by universities and PRIs reduces the livelihood of earning immediate economic returns (Knudsen, 2007). However, firms can obtain insights into scientific research and new ideas and knowledge acquired from universities and PRIs open up new opportunities for innovation. Maintaining close ties with universities leads to accumulation of knowledge stock, which contributes to innovation in a long term. Collaborative projects with universities produce long-term benefits, such as enlarging general knowledge base and reinforcing their radical innovation capabilities (D'Este and Patel, 2007). Un and Asakawa (2014) have found positive and significant impacts of collaboration with universities on process innovation. Firms primarily cooperate with universities in performing basic research related to a particular technology. They can gain insights into process improvement and obtain knowledge, skills or methods to achieve cost efficiency. Bishop et al. (2011) argue that collaboration contributes to improvement of firms' absorptive capacity. It enhances firms' ability to identify information relevant to their R&D activities as well as the ability to transform scientific knowledge into applications.

Specialist problem-solving

Researchers can help with problem-solving, quality control, and project management (Arza, 2010). Bishop et al. (2011) emphases on the importance of close contacts with academic community. Involvement of university scientists in R&D projects improve the businesses' capability to interpret, transmit and exploit the knowledge acquired. They can provide direct advice in problem-solving, which is a major contribution of academic partners to industrial R&D activities. They can help with assessment of project feasibility, finding solutions to specific technical problems, proposing ideas for product or process innovation, and improving awareness of opportunities and challenges associated with technological development. Conferences, workshops, and formal partnerships such as collaborative R&D and contract research are appropriate ways to promote close and personal interaction with university academics.

They absorb external knowledge in order to tackle technological bottlenecks or create knowledge for production activities (Lee, 2000). Academics play a supportive role in problem solving (Perkmann and Walsh, 2009). Firms consult academic scientists when they encounter problems in their design, R&D, or production activities. They can exploit expertise of academics to get the problems solved. Innovation involves integrate existing knowledge in new ways and create novel knowledge, which is a highly demanding problem-solving process (Bodas Freitas et al., 2013). Collaboration with academic community helps firms improve the solutions or develop new ways to create innovations. Firms aim to broaden their knowledge base and gain scientific support for innovation projects. Academics can provide support in terms of advising on project feasibility, positioning specialist knowledge and translating scientific knowledge into easy-to-understand language (Perkmann and Walsh, 2009).

Challenges in academic-industry collaboration

There are some studies exploring the challenges related to the relationships between academia and industry (Bruneel et a., 2010; Muscio and Vallanti, 2014; Al-Tabbaa and Ankrah, 2016). Different orientations of academics and practitioners is a major barrier to developing effective relationships. It is difficult to achieve alignment of research objectives between public research sector and industrial sector (Muscio and Vallanti, 2014). There is distance between academic research and market demands. Academic research might be of limited interest to businesses due to its low applicability. The university system is associated with Mertonian norms of science, which advocates the values of universalism, disinterestedness and communalism (Bruneel et al., 2010; Merton, 1973). It is likely that conflicts arise from different attitudes towards research topics and research disclosure. Public research sector has their own competitive mechanism which is separate from market transactions. Academics prefer to publicly disclose the results of their research in order to improve reputation through publications. They pursue an open approach to the dissemination of knowledge and information (Al-Tabbaa and Ankrah, 2016). On the contrary, business sector adopts a closed approach to knowledge creation. Businesses do not wish their knowledge or resources to be available to their rivals to create competitive advantage. Moreover, academic-industry collaboration can be hampered by transaction-related barriers as well, which refer to conflicts over intellectual property rights (Bruneel et al., 2010). Al-Tabbaa and Ankrah (2016) pointed out opportunism is also a challenge of interaction between academia and industry. Some partners pursue their individual interests, which affects the effectiveness of networking relationships.

2.3.3 Co-located firms

It is increasingly difficult for firms to compete alone due to dispersion of technological competencies and speeding up of technology change (Goes and Park, 1997). Increasing knowledge intensity and growing uncertainty in technical business environment makes it increasingly difficult for independent firms to maintain a competitive advantage. Since an independent firm are unable to generate all essential resources for innovation, they need to develop linkages with other firms to acquire required technology. Inter-firm linkages allow for resource sharing, knowledge exchange and technology transfer. Lin and Lin (2016)'s study shows that long-term network relationships have positive impacts on firm performance. In the rapidly changing environment, it is vital for firms to develop and maintain relationships with partners to survive and grow (Lin and Lin, 2016). Network relationship is regarded as a crucial variable that enhances firm performance. It is a source of competitive advantage. More and more companies are aware of benefits associated with engagement in external knowledge network, including cost saving, knowledge sharing and technology transfer (Barnir and Smith, 2002). Firms can compensate for resource scarcity, reduce risk and transaction costs through partnership with external organisations (Lin and Lin, 2016). Given that firms can share risk and overcome weaknesses in resources, network relationships help firms reduce transaction costs and speed up innovation process (Xie and Gao, 2018). Some studies have found support for the positive relationship between inter-firm linkages and innovation performance of firms (Goes and Park, 1997; Tomlinson, 2010; Najafi-Tavani et al., 2018).

Knowledge and resource sharing

Inter-organisational network is a facilitator of technology flow and knowledge sharing between member organisations (Huggins et al., 2012). Network provides firms with access to complementary skills, knowledge and technology (Lin and Lin, 2016). Such relationships contribute to the success of firms by offsetting firms' resource deficiencies in capital, information, knowledge, skills, facilities and equipment. Knowledge sharing is facilitated through collaborative network. Combined knowledge and skills could be generated in the process of knowledge sharing with business partners. Research shows that knowledge sharing through network relationship has positive impacts on firm performance. Inter-firm network is complementary to a company's internal capabilities (Tomlinson, 2010). Network enables the sharing and coordination of knowledge and resources possessed by partners within network. Resource sharing and knowledge exchange provide opportunities for them to overcome their initial weaknesses.

Development of new products requires the combination of a diversity of specialised techniques and skills (Calia et al., 2007). Inter-firm network involves the integration of multiple knowledge bases to create new knowledge and develop new products. Synthesis of knowledge domains through cooperative agreements allow firms to achieve rapid solutions to specific problems and fast access to suitable technology. Close ties with other firms enable firms to obtain tacit knowledge, which is difficult to interpret and exchange (Song et al., 2016). Tacit knowledge is knowledge embedded in human minds through experiences, observations, and emotions. It is difficult for competitors to imitate, which drives firms to create a competitive advantage. The increasing knowledge intensity of high-technology industries stimulates the formation of inter-firm partnerships, which limitations knowledge. .

Firms regard inter-firm collaboration as a mechanism to embrace rapid technological shift through exploitation of complementary resources (Rothaermel, 2001). They can draw upon resources of their partners to expand their own resource base. Baum et al. (2000) find that forming alliances network has positive impacts on performance of startups. Many firms suffer from lack of sufficient resources and uncertainty in marketplace (Baum et al., 2000). Engagement in cooperative agreements with other firms provides access to social, technological, and marketing resources at lower costs. Diverse knowledge and technology required for new product development usually take years to accumulate.

Product development

Cooperative arrangements allow for sharing of knowledge and strengthen firms' knowledge base, leading to improvement of their innovative capabilities (Najafi-Tavani et al., 2018). Involvement of other firms in innovation process shortens new product development cycle and opens up new avenues for technological development (Knudsen, 2007). Business network provides firms quick and prompt access to relevant complementary resources, which can result in immediate economic payoffs (Knudsen, 2007). Firms can enhance access to novel ideas or knowledge available through external innovation network and benefit from the process of joint problem solving. Network relationships allow for the flows of richer and broader range of knowledge and technology among business partners (Schilling and Phelps, 2007). The synergies in R&D, production, marketing and managerial systems accelerate the process of innovation, which in turn enhances the likelihood to introduce innovative products to market (Tomlinson, 2010). Inter-firm linkages combine the strengths of firms with different assets, competences, strategies and market power (Goes and Park, 1997). Firms can explore new technologies and improve their existing technologies in a more cost-efficient way (Song et al., 2016).

Innovation process is increasingly shaped by social routines and institutional norms as well as the degree to be embedded in inter-organisational network (Love and Roper, 2001). The innovation process is not a process internal to the company. Creating a new product or developing a new technology involves high risk and requires long-term financial investment (Barnir and Smith, 2002). Uncertainty in business environment makes it difficult to innovate in isolation (Huggins et al., 2012). Firms should have an awareness of external ideas, market demands and technology trends (Rogers, 2004). Development of collaborative arrangements has become increasingly critical for creating competitive advantage. The interactions provide opportunities for firms to expand their market reach and reduce the possibility of market failure (Goes and Park, 1997). Firms can better identify and respond to rapid changes in business environment. Firms can capture emerging market demands and acquire information about state of art of the market (Song et al., 2016). They can produce products that better satisfy market needs by integrating acquired information into their existing product portfolios. Firms can master market needs more rapidly and turn them into innovations more efficiently through linkages with other firms. Collaborative relationships help firms create new business and market opportunities and build market knowledge. Network relationships help firms achieve greater market power. The collaborating firms can exploit network resources to manage the risks and challenges brought by expanding into new markets (Goes and Park, 1997).

Previous studies have identified inter-firm network are positively related to firms' innovation capacity. Not all of companies have sufficient resources to develop innovation individually. Firms engage in collaborative arrangements are more likely to enhance their ability to develop new products. Firms engage in cooperative agreements are more advantaged in innovation efforts. Sharing of asymmetric resources through cooperative arrangements mitigate defects leading to innovation failures. Medda et al (2006) investigate the relationship between R&D activities and productivity growth. The results indicate that significantly higher return has been generated by external R&D than internal R&D. Najafi-Tavani et al. (2018)'s study demonstrates positive impacts of collaborative arrangements with research organisations or competitors on product innovation capability. Huggins et al. (2012) find support for the positive and significant impacts of inter-firm linkages on innovation performance. Inter-firm interactions has become an increasingly important aspect of new product development. Ritter and Gemunden (2003) provide evidence that network competence, which is the ability to develop network relations, has significant impacts on innovation success. Companies can involve others in process of technological development to achieve innovation success. Rogers (2004) has found the positive association between network relationships and innovation performance. Innovation is a critical ingredient in achieving competitive advantage. Love and Roper (1999) has provided evidence for the positive association between network intensity and innovations. The research findings of Xie and Gao (2018) demonstrate positive relationship between strategic network and innovation performance. Cooperative partnerships allow firms' access to novel idea, knowledge and technologies, and create innovations based on combination of multiple knowledge bases. Tomlinson (2010) has found that a firm's innovation capacity is positively and significantly associated with strength of cooperative ties. Close and intense ties with other firms lead to higher level of innovation. The study of Shan et al. (1994) and Ahuja (2000) indicates that a firm's patent is positively related to the amount of formal collaborative linkages developed with other firms. De Propis (2002) finds the positive association between cooperative ties a firm establishes and product innovations. Song et al. (2016) suggest that exploratory alliances induce higher level of radical innovation while exploitative alliance induce higher level of incremental innovation. They find that simultaneous use of exploratory and exploitative alliances has synergy effects on firms' innovation.

Process improvement

Cost reduction, process flexibility, and broader product portfolio associated with inter-firm collaboration has been recognized by more and more businesses (Najafi-Tavani et al., 2018). Firms spread the costs and risks associated with R&D and product development projects through embeddedness in cooperative network. Network relationships lead to benefits associated with reduction in transaction costs and increase in supply-chain efficiency. Collaborative partnerships lead to benefits associated with building of mutual trust, which behave in the best interest of the partnership. Process integration allows collaborating firms to achieve minimization of transaction costs and efficiency maximization. Inter-firm collaboration generates economies of scale and synergistic effects through efficient recombination of firms' competencies and assets (Belderbos et al., 2004).

Fast access to complementary resources and knowledge allows for more cost-efficient technology commercialization (Song et al., 2016). Engagement in joint R&D projects with other firms enable them to shorten development periods (Knudsen, 2007). R&D cooperation helps firms speed up their innovation process (Lin and Lin, 2016). Inter-firm cooperation speeds up learning by identifying and correcting errors early in the process of new product development (Goes and Park, 1997). Time and cost required for innovation process can be offset by collaboration between multiple companies. In fast-growing industrial sectors, common language is necessary to accelerate problem-solving process. Innovation is a problem-solving process in which insights into problems are gained via continuous search and efforts (Schilling and Phelps, 2007). Intense science park business network facilitates collective problem-solving, which improve process efficiency.

2.3.4 Technology intermediaries

A growing body of studies have paid attention to the role of technology intermediaries in creating value for their clients (Howells, 2006; Lin et al., 2016; Inkinen and Suorsa, 2010). They are "organisations that provide a supportive role for collaboration between two or more parties during various stages of the innovation process. (Howells, 2006)" Howells (2006) provide a wide range of functions of them, including information scanning and processing, knowledge processing and generation; gatekeeping and brokering, testing, validation and training; intellectual property protection; commercialization; and technology assessment and evaluation.

Technology intermediaries play a critical role in creating and developing an innovation ecosystem. They function as knowledge brokers between actors of science park ecosystem. They integrate knowledge bases of innovation actors and introduce new combinations of knowledge (Goes and Park, 1997). As business environment becomes increasingly open and networked, firms rarely innovate on their own and they increasingly rely on external sources to improve their innovation process. Technology intermediaries are increasingly regarded as key actors in the innovation system, speeding up and improving efficiency of innovation-related activities (De Silva et al., 2018). Technology intermediaries perform a wide array of tasks within the innovation process (Lin et al., 2016). Their functions range from supporting and facilitating collaborations for technology transfer, to bridging a variety of knowledge and capability gaps (Goes and Park, 1997). They collect and disseminate knowledge or technology as well as distribute technical and institutional resources within the innovation system of science parks (Lin et al., 2016).

Knowledge reservoir

Hargadon and Sutton (1997) regard intermediaries as a knowledge repository that brings together multiple sources of knowledge and provides new combinations of knowledge as technology solutions for their clients. The functions of technology intermediaries are diverse and complex. For one thing, they develop and maintain network relationships with different actors of the innovation system, including firms, financial organisations, higher education institutions, research centres etc (Lin et al., 2016). The extensive network allows them to help enterprises get access to a large pool of information, knowledge and resources. As they sit at the intersection of various organisations or institutions, they can process knowledge more professionally and locate targets more promptly. Howells (2006) highlight the role of intermediaries in provision of knowledge processing. This function goes beyond just gathering technical knowledge and forwarding it to firms. It also involves the combination of scientific and technological knowledge and the clients' knowledge. Intermediaries have more a complete pool of knowledge about diverse domains. They can combine available resources in new ways and adapt existing solutions on the market to individual firms' needs.

In a rapidly changing, highly complex business environment, businesses are confronted with intense competition and severe resource scarcity (Lin et al., 2016). Even firms with an extensive range of internal capabilities cannot internally develop and commercialise all technology across diverse domains. Close ties with intermediaries allow them to obtain knowledge more easily. The companies' weak areas in technology portfolio can be offsetted by information scanning services provided by intermediaries, which in turn fosters advance in innovation (Hargadon and Sutton, 1997). They are able to search for and explore external knowledge and resources more broadly and deeply. No firm possess all essential knowledge and resources and can undertake all innovative activities internally (Lin et al., 2016). As business environment becomes increasingly open and networked, firms rarely innovate on their own and they increasingly rely on external sources to improve their innovation process (Goes and Park, 1997).They provide professional services in terms of training, law, market research, talent search, commercialisation of technology etc.

Networking facilitator

Science park network consists of knowledge providers including universities together with research institutions, as well as knowledge users including private enterprises and public agencies (Inkinan and Suorsa, 2010). Technology intermediaries of science parks contribute to facilitating inter-organisational linkages and collaboration as well as innovation culture, interactive learning, and mutual trust among different actors. They foster networking and collaboration by means of conferences, seminars, meetings, or exhibitions. They encourage firms to engage in collaborative relationships with universities for innovation. The problem confronts firms is that they need the information about external technology sources in order to assess the value of the technology (Lichtenthaler, 2013). Firms always find it difficult to identify suitable technology and right partners. However, there is no need for transaction if relevant information is disclosed. High costs of technology transactions pose a barrier to potential transactions in technology markets. Firms can cooperate with technology intermediaries to overcome the obstacles associated with market inefficiencies. This goal can be channeled through services provided by intermediaries, such as partner identification, negotiation support etc. They are devoted to customizing specific solutions for their clients. Their function of information scanning and technology intelligence helps firms identify suitable technology or resources.

Innovation is a cooperative process, which strengthens the supportive role of intermediaries in networking and cooperation (Inkinan and Suorsa, 2010). Technology intermediaries play an important role in linking different organisations within an innovation system (Inkinen and Suorsa, 2010). They provide private sector R&D activities with support related to technology transfer and scientific knowledge commercialization. These organisations include public funded institutions and regional agencies in support of knowledge generation, technology dissemination and collaboration building. They translate the knowledge from academic domain to industrial sector, overcoming the cultural and cognitive factors that hinder the efficiency of technology markets (Parker and Hine, 2014). They provide an interaction platform which allows their clients to overcome cultural barriers arising from different language and cognitive distance. They develop a common language that facilitate communication between companies and external innovation network. They develop a single format by which their clients and other actors in the knowledge network could exchange and communicate knowledge or information without barriers. Besides, intermediary institutions are of critical importance for extension of knowledge networks, which opens up opportunities for firms to get access to suitable technology solutions.

Technology intermediaries support technology transfer or commercialisation by providing expert services regarding R&D, marketing, business management, together with access to workforce, equipment and facilities (Inkinen and Suorsa, 2010). Intermediaries support transfer of technology from universities to businesses by identifying relevant research undertaken by university scientists and "pulling" the technology generated from the research into the business (Hine et al., 2010). On the other hand, they "push" university research projects out to private sector, usually in the form of IPR. Intermediaries build a bridge for knowledge exchange. They bring together knowledge bases of parties, providing clients with rapid access to target technology. They integrate different sets of knowledge created by different parties and minimize the knowledge gap between parties. Linkages with intermediaries strengthen clients' capabilities and competences to cope with challenges in technology transfer activities (Lichtenthaler, 2013). Such relationships serve as a key enabler for maximizing the efficiency of technology markets. However, interaction between firms and intermediaries has received limited attention from researchers. It is hard to find prior evidence that specifically explore how cooperation with technology intermediaries enhances innovation of firms. Lichtenthaler (2013) find that if companies actively collaborate with intermediaries, transaction costs in technology markets could be reduced.

It is a challenge for firms to identify technology commercialization opportunities due to the complexity and context-dependency of technological knowledge (Lichtenthaler and Ernst, 2008). If the firms lack sufficient internal capabilities or resources, they can rely on intermediary services to overcome managerial difficulties. Intermediary institutions can help them analyse and assess potential of new markets. There is a trend that firms seek commercialization of technology outside boundaries, which strengthen the importance of technology intermediaries. However, identifying opportunities of technology applications is a major challenge for firms seek commercial exploitation of technology. Intermediary institutions, which are specialised in technology intelligence, can extend firms' resources for identifying technology applications opportunities (Knockaert and Spithoven 2014). Firms can draw on intermediary services to extend their market knowledge. Intermediaries can support the identification of commercialisation opportunities by technology assessment and evaluation, analysis of potential technology customers. Intermediary institutions offer firms the opportunities to gain access to multiple sources of technology, contributing to mitigating the imperfections in technology markets.

The technology transfer services that intermediaries provide for companies are channeled through the identification of opportunities regarding knowledge commercialisation, and search, acquisition and exploitation of external technology (Parker and Hine, 2014). Mutual trust and common knowledge are cultivated by improving interaction and communication between firms and institutions within the network. Intermediaries provide a search function with regard to identification of knowledge or technology solutions, matching of knowledge users and producers, as well as assistance in negotiation and contracts involved in technology transfer process. Watkins and Horley (1986) identify the role of intermediaries in partner identification, technology package, supplier selection, and contract negotiation support. They utilize their expert knowledge to help firms formalise contractual arrangements of collaborative relationships. They provide compensatory links to firms that have poor knowledge network.

Innovation accelerator

Close communication with technology intermediaries to mitigate transactional inefficiency in the marketplace (Goes and Park, 1997). Businesses that have close linkages with intermediaries can not only reduce external search costs, but improve efficiency and flexibility of innovation process (Lin et al., 2016). Lin et al. (2016) have found out that innovation performance of firms could be significantly enhanced by cooperating with technology intermediaries. Firms can transform knowledge obtained from intermediaries into tangible advantages, which contributes to achievement of superior innovation. In addition to technology transfer, they contribute to mutual learning that is conducive to improvement of innovation capabilities and generation of new ideas and knowledge (Lin et al., 2016). Cooke et al. (1997) regard collective learning process between geographically proximate organisations as a basis for innovation in knowledge-based sectors. Collaboration, interaction and cooperation between enterprises and institutions in a regional context is seen as “soft institutional infrastructure for localised interactive learning (Parker and Hine, 2014).

Technology intermediaries offer the possibility to enhance the ability to appropriate benefits from innovation activities (Knockaert et al., 2014). Intermediary intervention helps to cope with the market failures of R&D investments. In order to identify suitable technology external to the firms, they must where and how to gain access to it, and how to assimilate it and distribute it throughout the firms (Knockaert and Spithoven, 2014). The functions of intermediary institutions are much broader than the facilitation of linking firms and institutions within high-technology regions (Parker and Hine, 2014). Intermediaries are able to assess the relevance and importance of the technology embodied in external network to their operations. Knockaert and Spithoven (2014) find that intensity of interaction with technology intermediaries has positive influences on innovation speed of firms. Firms need to interact frequently with intermediaries to improve their innovation speed.

Case studies of Parker and Hine (2014) suggest that technology intermediaries influence firms in terms of organizational capabilities for problem-solving in innovation process. Interactive learning processes in the innovation system enhance problem-solving skills and ability to interpret knowledge. Considering their environmental scanning function, close links with intermediary institutions enable firms to get early insights into technological development and market demands which are key to innovation. Technology intermediaries are important knowledge disseminators about trends in technological development (Howells, 2006). Intermediary institutions provide assistance in the creation of mechanisms for codifying tacit knowledge that supports interpretation and exploitation of knowledge (Parker and Hine, 2014). They improve their clients' ability to understand and analyse knowledge. Their provision of a supportive function contributes to improved problem-solving skills that serves as a foundation of error detection and correction. The intermediary intervention allows for better capability to identify existing problems and to pool or exploit knowledge to more sort out those problems.

2.3.5 Financial institutions

Science parks can provide assistance in ensuring financial support for survival and growth of firms (European Commission, 2013). They can attract financial institutions to locate in the vicinity of parks, supporting the innovation activities of firms. The availability of technology finance enables firms in emerging markets to mitigate technological and economic risks to a large degree (George and Prabhu, 2003). They complement the limited internal resources available in firms of emerging markets. Financial institutions are equipped with rich skills in assessment of investment projects. They help their clients not only build technological resources, but also improve internal resource allocation. Knowledge accumulation of financial institutions is translated into reliable advice for clients in investment decisions and utilisation of available resources. Their support for firms' innovation goes beyond providing finance that relax investment constraints. Clients can also benefit from their industry-specific expertise (Bertoni and Tykvova, 2015). Many firms with innovative technologies are short of financial resources, expertise in market knowledge and entrepreneurial expertise.

Science parks play an important role in overcoming finance gaps of resident firms. Financial institutions provide not only finance tenants require, but also assist in investment decisions, business plan development, financial information processing etc (Lahr and Mina, 2016). The functions of financial institutions go beyond the provision of finance. They can also offer a wide range of value-adding services. Financial agencies play a vital role in financing companies' innovation activities and introduction of new products to markets (King and Levine, 1993). King and Levine (1993) identify four types of financial services, including evaluation of investment projects, resource mobilisation for investment projects, risk diversification, and valuation of expected profits from innovation activities. Due to high costs associated with project evaluation, it is important for financial sector to perform this task. Innovation projects of firms necessitate mobilisation of sufficient funding by financial agencies (Hsu et al., 2014). They pool financial resources to support innovation process of firms. It is essential for financial agencies to provide assistance for firms to manage and diversify risk involved in uncertain innovation process. Financial institutions provide a means for entrepreneurs to value the expected rewards from engaging in innovation activities (King and Levine, 1993). Good-quality financial services are critical to expanding scope of innovation activities and enhancing innovation efficiency. Both creation of innovative products or services and introduction of innovations to the market are costly processes.

Three factors lead to large costs of innovation, including uncertainty, timing and resources

(O'Suillivan, 2005). Innovative activities are risky, unforeseeable and idiosyncratic (Chemmanur and Fulghieri, 2013; Zhu et al., 2012). It is difficult to predict the costs and profits due to uncertainty of innovation process. Many contingencies are hard to predict during innovation process. Innovative projects usually involve a high likelihood of failures. The length of time from concept development to introduction of new products to markets is an issue for firms (O'Suillivan, 2005). Finance must be sustained during the innovation process. Science parks can function as brokers by advising resident companies how to get access to funding support from private or public sector sources. Innovation is a complex process ranging from concept development to launch to market, going through multiple phases (O'Suillivan, 2005).

Lack of financial resources is one of the most frequently mentioned barriers to innovation (Zhu et al., 2012; Freel, 2012; Yigitcanlar et al., 2018). Innovative activities involve high financial risk to a large degree (Yigitcanlar et al., 2018). Finance is a crucial part of high-risky innovation activities. Freel (2012) regard access to finance and supposed equity gaps as the most common barrier to innovation. A large proportion of firms on science parks are small firms. There is market failure associated with provision of finance to small companies. Difficulty in attracting or securing finance is one of the major barriers to product innovation. Aghion et al. (2005) propose a hypothesis that financial constraint is a major barrier to technology development in poor countries, making them get far away from the global technology frontier.

The role of finance in business growth has been discussed in previous research (Fowewe, 2017; Yigitcanlar et al., 2018). Finance is significant for expansion of operations and product line, recruitment of high-skilled talents, and investment in equipment and facilities. Many companies are faced with finance constraints as they find it difficult to acquire finance from financial institutions. A group of studies examine the impacts of finance on firm performance (Demirguc-Kunt and Maksimovic, 1998; Beck et al., 2006; Ayyagari et al., 2011; Fowowe, 2017). Demirguc-Kunt and Maksimovic (1998) show that business growth slows down as a result of reduced access to external funding. The findings of Ayyagari et al. (2011) show that external finance is associated with greater innovative activities, which is manifested in the introduction of new products to market, upgrading of existing products, and creation of new plants. The survey of African firms conducted by Fowowe (2017) has found that finance constraint imposes negative and significant effects on growth of firms.

Bank loan is the most common channel to get access to funding to support R&D and innovation process (Yigitcanlar et al., 2018). Venture capital invests in new businesses with innovative technologies, which is featured as high-risk and high-return funding. Venture capitalists add value to firms by providing expertise for firms with regard to policies of investment in knowledge-specific and intangible resources. They can assess new technology or products with their prior experience and expertise. The research findings of Faria and Barbosa (2014) reveal that venture capital helps firms enhance innovative performance in terms of patents. Celikyurt et al. (2010) find evidence that the presence of venture capital directors on the board leads to improved innovative outcomes in terms of patents and R&D expenditure. Business angels are usually funders of ventures in early stage. They make significant investments in start-ups (Chemmanur and Fulghieri, 2013). The study of Kerr et al. (2011) provides evidence for financing by angel investors improves the possibility of firm survival and improved level of employment.

Another group of studies explore the relationship between a developed financial systems and firm growth in a broader consensus (King and Levine, 1993b; Hsu et al., 2014). The study of King and Levine (1993) reveals that financial intermediaries contributes to improvement in efficiency of resource allocation, reduction of information costs, the acceleration of technological innovation and business growth in the long run. It is difficult to nurture and stimulate innovation (Hsu et al., 2014). Innovation plays a crucial role in economic growth and competitiveness of a nation. Innovation process is not only unforeseeable and idiosyncratic, but also entail a high likelihood of failure. A well-functioning financial market is required for facilitating the improvement of innovation process. They play a key role in reduction of financing costs, assessment of technology projects, allocation of scarce resources, and risk management. Financial sector provides services that allow for the allocation of resources and finance to the highest value use. It helps firms mitigate risk or losses brought by adverse selection and moral hazard. Financial institutions support development prospects of firms. Financial sector allows for risk diversification, which is critical for technological innovation (King and Levine, 1993b; Hsu et al., 2014). Technology-based firms are usually engaged in design and development of innovative products or processes. High-tech firms design, develop and introduce new products with systematic application of scientific and technological knowledge. Innovative activities are associated with both high expected returns and high risk. Innovation process with high level of novel technological contents is highly risky and unpredictable. Financial sector can provide a range of risk management tools, which motivate firms to engage in innovative projects with high risk and high uncertainty.

2.4 LITERATURE REVIEW OF INNOVATION CAPABILITIES

An innovation is "a new idea, which may be a recombination of old ideas, a schema that challenges the present order, a formula, or a unique approach which is perceived as new by the individuals involved." (Van de Ven, 1986). Innovation serves as a foundation of firms' survival in the fast-changing business environment (Yang, 2012). Innovation performs an enabling function for firms to respond flexibly to rapid changes in customer markets and technology trends. Scarcity of innovative capabilities is regarded as a barrier to business growth (Lawson and Samson, 2001; Wright et al., 2008). Innovation is more than the generation of creative ideas, but a process that involves the transformation of ideas into competitive products or services in the market. A firm’s ability to achieve a sustained competitive advantage largely depends on its capacity to produce inimitable innovations. Innovation involves the process in which the firm identifies problems and create new knowledge to cope with the problems (Nonaka, 1994). Innovation is a process that involves design, production activities associated with the introduction of new products or processes (Chiesa et al., 1996).

There is no general formula for specifying innovation capabilities (Lawson and Samson, 2001). Technological innovation is often developed based on a combination of various assets, processes, resources and capabilities (Christensen, 1995, Guan and Ma, 2003). According to Guan et al. (2006), it is a complex and multi-faceted concept which is difficult to measure directly. In addition to R&D capabilities, successful innovation also depends on other types of capabilities that support and accelerate the process of transforming R&D into products (Wang et al., 2008). Businesses should integrate, mobilize and deploy a wide range of resources in order to achieve success of industrial innovation. Various researchers have developed a wide range of approaches to evaluating innovation capability of a firm, such as the asset approach (Christensen, 1995; Adler and Shenbar, 1990), the process approach (Chiesa et al., 1996), the functional approach (Yam et al., 2004; Guan and Ma, 2004; Guan et al., 2006; Wang et al., 2008), and the systems approach (O’Connor, 2008). The process approach is employed by Chiesa et al. (1996) to develop a technical innovation audit. Chiesa et al. (1996) identify four core elements of their process model of technological innovation, including concept generation, product development, process innovation, and technology acquisition. This work can serve as a foundation for producing a checklist of innovation practices. Concept development is the process of creating new concepts of products; product development reflects the process of turning new concepts into new products; process innovation is to develop innovations in production processes; and technology acquisition reflects the ability to develop and manage technology.

Christensen (1995) developed an asset-based model for defining technological innovation, which encompasses scientific research assets, process innovative assets, product innovative application assets, and aesthetic design assets. The author pointed out that the success of technological innovation depends on the access to relevant innovative assets. Scientific research assets are comprised of the stock of scientific knowledge and new research. Both pure scientific research and industrial research generate this type of asset. Process innovative assets involves not only "hardware" process innovation that is associated with manufacturing, quality control, and logistics, but "systemic" organizational and managerial assets related to production. Product innovative application assets refer to the resources and capabilities required for developing new products. Finally, aesthetic design assets focus on the design of products and packaging, which play an indispensable role in marketing promotion. It provides the links between the product and advertising and promotion activities. The asset approach is also adopted by Adler and Shenber (1990). They identified four components of a firm's technological innovation capability, which are technological assets, organizational assets, external assets and projects. Technological assets embrace three main areas, including product, process and support technologies possessed by the firm. Organizational assets are skills, procedures, strategy, culture and organizational structure that enable the firm to develop technological assets. External assets refer to the links and network developed by the firm with different types of partners, such as customers, suppliers, competitors, etc. Projects are the means by which technological, organizational, and external assets are mobilized, deployed and transformed.

Guan and Ma (2003) and Yam et al. (2004) have introduced a functional approach to defining technological innovation capabilities (TICs). They have developed an innovation audit framework for the relationship between TICs and enterprise competitiveness. TICs are classified into seven capability dimensions that are associated with innovation success, including learning capability, R&D capability, resource allocation capability, manufacturing capability, marketing capability, organizing capability, and strategic planning capability. Each dimension represents a function of a firm. Guan and Ma (2003)'s study examines the relationship between innovation capabilities and export performance based on a survey of Chinese industrial firms. They have found significant impacts of innovation capabilities on export performance, except for manufacturing capability. The results of Yam et al. (2004)'s survey of innovative manufacturing firms in Beijing reveal that R&D capability is closely related to innovation rate and product performance. They also found a strong relationship between resource allocation capability and sales growth. Wang et al. (2008) provide a quantitative measurement tool for evaluating the performance of TICs of high-tech firm by adopting a fuzzy method. They assess TICs in terms of five aspects, including R&D capabilities, innovation decision capabilities, marketing capabilities, manufacturing capabilities, and capital capabilities.

Some authors conceptualise innovation capabilities from a dynamic capability perspective. Lawson and Samson (2001) apply a dynamic capabilities approach to generate a conceptual model of innovation capabilities. It provides a framework for firm managers to adapt innovation process to rapidly evolving market needs and technology trends. The "innovation capabilities" construct they proposed is composed of seven major elements, including vision and strategy, organizational intelligence, organizational structure and systems, harnessing the competence base, creativity and idea management, technology management, and culture and climate. Lee and Kelley (2008) also conceptualize innovation capabilities from a dynamic capabilities perspective. Innovation management deployment of entrepreneurial resource, and providing relational and decision support. This study highlights the role of innovation project leaders in promoting close communication and collaboration between employees. Such entrepreneurial support facilitates mutual trust and collective understanding among employees, which is a key element in developing innovation.

2.5 CONCLUSION

This chapter identifies the research gap through the review of literature related to science parks. The impacts of science parks on tenant firms have been extensively researched by comparing performance of firms located inside and outside science parks. Nevertheless, how knowledge sharing and collaborative innovation process occurs within science park ecosystem influence tenants' performance has not been fully investigated. Due to complex nature of science parks, there are difficulties inherent in evaluating the effectiveness of science park in creating value for tenant firms. The mixed results shown by prior literature indicates that whether science parks successfully sustain tenants' performance remains doubtful. The availability of statistical data sources allows for comparison between performance of firms located inside and outside science parks. Some authors have found out positive impacts of science parks on tenants indicated by significantly better performance of on-park firms than off-park firms (Lofsten and Lindelof, 2002; Ferguson and Olofsson, 2004; Lamperati et al., 2015). However, some studies did not demonstrate positive effects of science park location on hosted firms (Westhead, 1997; Liberati et al., 2016). There is no guarantee superior performance is associated with location on science parks. Conditions are similar for firms located on a science park. Tenants' performance depends not only on their location, but also their ability to exploit the location benefits. Network relationships they develop with other science park actors can be a key determinant for competitive advantage of tenant firms.

This study will extend the literature by examining how collaborative network explain or facilitate science park firms' innovation achievement and commercial value. In this chapter, the identification of elements in science park ecosystem clarifies and unpacks different types of network relationships that might affect tenant firms' outcomes. A diversity of actors involved in science park ecosystem are categorized into four groups, including academic institutions, companies, technology intermediaries and financial institutions. Review of literature regarding innovation capabilities summarises different approaches employed by previous studies to assess firms' innovation capabilities. It provides a basis for conceptualization of innovation capabilities.

In addition, previous studies have provided rich evidence on how science parks influence performance of affiliated firms in developed countries (Lindelof and Lofsten, 2003; Ferguson and Olofsson, 2004; Lamperati et al., 2015; Liberati et al., 2016). However, there is relatively limited literature examines the impacts of science parks on tenants in developing economies. This study will focus on investigating how science park ecosystem exerts influences on hosted firms in China context, which is the largest developing country in the world. The following chapters aim to fill in gaps identified in review of science park literature.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 INTRODUCTION

The major aims of this study are to develop a scale of ESPCN (engagement in science park collaborative network), and examine the impacts of ESPCN on innovation capabilities and financial performance of on-park firms. Quantitative approach will be applied to conducting the research. It is widely agreed that quantitative and qualitative research are two streams of research methodologies (Bryman and Bell, 2015). Quantitative research is based on objectivist epistemology while qualitative research is informed by constructivist epistemology (Yilmaz, 2013). Compared with quantitative research, qualitative research is more context specific. Quantitative research can reflect facts and reality that qualitative research is unable to It focuses on the measurement and examination of causal relationships between different variables (Choy, 2014). Qualitative research allows researchers to generalise research findings from a large size of sample (Yauch and Steudel, 2003). The results of closed-ended questions enable researchers to obtain generalisable findings towards a phenomenon. Quantitative research is suitable for research that looks into a phenomenon based a priori theory (Yilmaz, 2013).

Quantitative research is more appropriate for this research than qualitative research. It can statically measure reality, which can provide an objective understanding of ESPCN and its impacts on science parks. Firstly, in order to identify ESPCN practices that can be used by tenant firms to exploit the benefits of science park location, a large-scale sample size is required for validation of the proposed dimensions of ESPCN. Moreover, quantitative method can be adopted to measure and analyse causal relationships between constructs. The effects of ESPCN on science park firms can be identified by statistical tools. Quantitative approach is widely used in studies on measuring the effectiveness of science parks in contributing to firm performance. The hypothesised model demands a considerable amount of sample to generalise the results. In addition, the results of quantitative research are more reliable for policy makers which is based on a considerable amount of statistical data.

This chapter is structured as follows. 3.2 justifies the reasons for selecting survey as research strategy for this study. 3.3 explains why questionnaire is adopted for collecting data. 3.4 presents the advantages of structural equation modeling over other statistical methods. 3.5 provides a step-by-step research design for developing and validating the conceptual framework. Six steps of scale development are identified in this chapter including model specification, Q-sort, questionnaire design, large-scale survey, test of measurement model, and test of structural model.

3.2 SELECTION OF RESEARCH STRATEGY

Research strategy is a general plan of how you will go about answering the research questions you have identified. There are different strategies can be employed in research. The possible research strategies, including case study, survey, ethnography, action research, and experiment, are discussed. The reasons for selecting survey as the major approach in this study are justified.

3.2.1 Case study

Case study provides the researchers with the opportunity to conduct a more in-depth investigation of a particular setting in comparison with other research strategies (Griffis and Goldsby, 2003). Maylor and Blackmon (2005) identify the underlying logic behind case study strategy, which is “the intensive examination of a single situation, and the focus on unique features of one setting.” The social units under study might be one or a small number of individuals, programs, companies, or events. The objective of case study researcher is not to generalise the findings, but to deeply learn about one or a few cases. It is used for justifying, illustrating and describing the phenomenon of interest. Siggelkow (2007) believes that even limited number of cases can provide the researchers with very convincing tests of theory. It is likely to inspire the emergence of new ideas.

Case study method is not considered for this study as it is not conducted for the purpose of generalising research findings to other situations. Such method is useful especially for conducting an exploratory study (Maylor et al., 2005). It concentrates on exploring descriptive or analytic research questions, e.g. “how” and “why” questions. However, the focus of this study is to test the hypotheses proposed according to literature, which is confirmatory data analysis.

3.2.2 Experiment

Experiment is concerned with testing influences of varying one or more inputs on one or more outcomes. The researcher has strong control over the experimental design (Hox and Boeije, 2005). The research design involves comparison between an experimental group and a control group. The researcher applies one or more variables to the experimental group in order to assess their effects by comparing with control group who has received no condition or variable (Crowther and Lancaster, 2008).

Experiments would be a good choice for hypothesis-testing that involves cause-and-effect relationships (Maylor et al., 2017). Nevertheless, one issue associated with experimental approach is that they are applicable to the measurements on a small number of variables (Saunders et al., 2013). They are inappropriate for examining a study with a large amount of variables. Each additional independent variable brings considerable extra difficulties, both practical and technical, to your research design. The current research involves a wide array of variables, which is difficult for experiments to test. Maylor et al. (2017) argue that experimental design not suitable for research that concerns complex business situations and human behaviours. It is considered as an appropriate method of studying a limited part of a phenomenon or context. This study investigates firms’ exploitation of science park social network that involves various types of parties. It is too complex for experiments to deal with.

Therefore the experimental method is not taken into account.

3.2.3 Ethnography

The key principle of ethnography is the personal involvement of researchers with the subject under study. The researchers should engage in a particular organisation and become part of the group with the objective of building the richest picture of the context (Maylor and Blackmon, 2005). An ethnographic research investigates the culture of the organisation or group under study in order to gain insights to what the meanings and significance people give to their behaviours (Griffis et al., 2003).

Ethnography is not considered suitable for the present research. This research aims to explore the impacts of science park social network on firms' innovation, it is unlikely to generalise the results from ethnographic research with a few cases of science park firms. Considerable time spent in the situation under study is required by such type of research. In order to derive rich knowledge from the experience of ethnography study, the researchers should immerse himself/herself in a particular setting (Griffis et al., 2003). Preparation work for ethnography is considerable, for example, you need to gain support from the organisation prior to your investigation. Data collection usually takes place over a long time period. Additionally, there is a large amount of data to be assimilated and analysed (Maylor et al., 2017). Generally, the researchers develop new thoughts constantly during the research process, requiring flexibility and responsiveness to changes in a timely manner.

3.2.4 Action research

Action research put an emphasis on the management of a change (Saunders et al., 2003). The difference between action research and ethnography is that an action researcher learns about an organisation through trying to change it, not just observing and analysing the circumstance (Griffis and Goldsby, 2003). The key feature of action research is the involvement with members of organisations under study. The researcher is a part of the organisation. Action research is close collboration between researchers and practitioners in some way. Crowther and Lancaster (2008) regard action research as “a consultancy or rather at least an approach to conducting consultancy”. Action research is related to practical hands-on field research in the organisation of interest. Identification of problems in organisations and solving the problems is the objective of action researcher.

For one thing, the researcher often conducts action research with the purpose of addressing issues in organisations. The objective of this research is to examine how science parks support firms’ innovation rather than address practical issues in science park firms. For another, the focus of action research is active participation in change process of an organisation. It is not possible for the author to participate actively in making a change to on-park firms and assess the consequences of any change. Hence, action research is not taken into consideration.

3.2.5 Survey - Chosen research strategy

Researchers use surveys to data from large numbers of respondents by asking well-chosen questions. Surveys can be also known as cross-sectional research as they are concerned with different individuals, groups, organisations, or situations (Griffis and Goldsby, 2003). The cross-sectional surveys allows simultaneous measurement of multiple factors and examination of underlying relationships between the factors. The underlying theory is critical to survey design, the hypotheses developed regarding the relationships between different variables should be based on a strong a priori theory.

Survey is considered as the most appropriate research strategy for this study. Large sample size is dictated by the SEM approach employed in the present study. Compared to other types of research design such as case study, ethnography and action research, survey is the best choice for the study that requires relatively sizeable samples (Crowther and Lancaster, 2008). Besides, considering large number of variables specified in this study, experimental research, which can just accommodate a few variables, is impractical for this study. Surveys allow researchers to collect data on a wide array of variables, making it suitable for examination of complex models. This study involves a relatively complex model which embraces 9 factors measured by 45 indicators. Survey is an ideal approach to collecting a large amount of data from a large sample in a timely manner. It tends to be more efficient as information needed can be collected by a well-designed questionnaire. The data gathered is standardised, which is easy for researchers to compare and analyse (Saunders et al., 2013). In addition, by means of survey, the researcher can achieve generalised research findings, which is impractical for other approaches.

3.3 DATA COLLECTION METHODS

3.3.1 Secondary data

Secondary data is pre-existing data that has been collected by some else. For one thing, some official documents may be produced by the government departments in the forms of White Papers, yearbooks, survey reports and so on (Saunders et al., 2013). For another, companies provide private sources of secondary data such as annual reports, press releases etc. Besides, mass media, such as newspapers, journals, is also an important source of second-hand data. It is a time-saving and economic method to collect data. It is inevitable for researchers to use secondary data as literature review provides an indispensable theoretical supporting the research.

However, this method is not suitable for this research as primary data is what this research intends to collect. Firstly, secondary data was collected with other objectives rather than generated specifically for purpose of your research (Maylor et al., 2017). The researchers need to assess the extent to which the data sources is relevant to their own research questions. As for as this study is concerned, it is impractical to collect documentary data with regard to how science park firms interact with other parties. Secondly, the researchers should take into account confidentiality issue. In this study, it is possible to collect data regarding financial performances of science park firms from their annual reports. However, gaining their permission to access such data is necessary. It is difficult to get access to hundreds of annual reports that meets the large-size sample demands of SEM method.

3.3.2 Observation

In general, observation is a method to collect data by looking, noting and analysing events of interest. This method relies on actual observations of what people do, not on what people say or how they feel. It allows for the generation of richer and more in-depth data and findings than other means such as questionnaires (Crowther and Lancaster, 2009).

Nevertheless, as a result of the limitations associated with observational research, it is excluded from being used in this study. The first issue with observation lies in their situation-specific nature. The research findings obtained cannot be generalised to other circumstances. It generally focuses on limited amount of cases, which fails to achieve the goal of deductive development of theory in this study (Crowther and Lancster, 2009). According to Lee and Lings (2008), another issue is that it is not an easy task to get access to the context or situation that researchers want to study. The researcher needs to gain support from managers to get the opportunity to study the organisation of interest. It is suggested that the process of observational research is time-consuming and costly (Emroy and Cooper, 1991). Constraints of time and resources make the method of observation impractical for this study.

3.3.3 Interview

Interview is a popular method of data collection in social sciences. The researchers can obtain richer and more in-depth information by taping deeply into the experience, thoughts and behaviours of interviewees (Lees and Lings, 2008). Interviews enable researchers to capture the most detail, both verbal and non-verbal. Besides, interview is popular with researchers due to its flexibility with regard to both content and time. It is a two-way conservation. The researcher and the respondent can directly react on words or body language of each other.

In spite of several advantages provided by interview, it is inappropriate to use it in this study owing to the issues in terms of cost, time, bias and generalisation. Interview is time-consuming activity. The respondents you target might be hard to reach. It takes time to get access to interviewees, conduct interviews, transcribe the tape recorded, and analyse the detailed data (Opdenakker, 2006). Interviews may bring a lot of costs. If the research project covers a wide geographic area, the cost is inevitably high. Moreover, it is difficult to generalise the results from interviews because of the small samples chosen and non-random sampling method Another pitfall related to interviews is that it is prone to bias (Boyce and Neale, 2006). Responses from participants of a program are likely to be biased as they want to prove their program is working. In addition, if the researcher is not trained appropriately in interview skills, he/she may fail to acquire rich data from respondents. They should grasp the techniques to motivate the respondents to provide detailed and valuable information.

3.3.4 Questionnaire – chosen data collection method

Questionnaire is one of the most widely used methods to collect data in business and management research. Achieving a wide coverage is one of the advantages of questionnaire over other means of data collection. By means of questionnaire, the researchers can collect sizeable amount of data in a cost-efficient way. It provides opportunities to generalise the research findings of questionnaire survey to the wider population. Marshall (1993) maintain that high-quality data and good response rate can be achieved by questionnaire when the questions are well-designed and carefully thought-out.

Questionnaire is identified as an appropriate method of data collection for this study. Firstly, the use of questionnaire allows the researchers to reach large samples of population, meeting the large sample requirement of SEM method. Secondly, it is a less time-consuming way to collect data in comparison with interviews, observation etc. The researchers can question a large amount of respondents in a relatively short time. Questionnaire is used by this research given time constraint of PhD study. Thirdly, the data collected by questionnaire is easier to analyse. The rapid improvement of statistical software packages enables the researchers to analyse questionnaire results in an efficient way. The researchers do not need to spend a lot of time transcribing data, which is an inevitable task for interviews and observations. Moreover, the highly formalised and structured questionnaire consists of pre-determined, standardised set of questions, providing a reliable means of data collection (Crowther and Lancaster, 2009). The researchers can carry out a test to examine its reliability. According to Parahoo (1993), self-completed questionnaire can reduce the possibility of interviewer bias effectively. Without direct contact, the answers are not influenced by the attitudes or behaviours of interviewer. Questionnaire provides the respondents with confidentiality, which encourage respondents to provide honest and frank answers.

3.4 STRUCTURAL EQUATION MODELLING

Structural equation modelling (SEM) is also referred to as causal analysis, causal modeling, and simultaneous equation modeling etc (Ullman and Bentler, 2013). SEM is a growing family of statistical methods for providing a parsimonious and meaningful account of the observed data. The last few decades have witnessed the increasingly wide application of SEM as an important statistical tool in the area of social sciences such as economics, psychology, business management etc. SEM integrate methods from psychometrics, sociometrics, econometrics, and multivariate statistics. SEM is also known as causal modelling as the goal of SEM is to test causal effects among a set of factors (Hoyle, 2012). It enables the examination of a set of relationships between one or more independent variables and one or more dependent variables. SEM allows the testing of hypotheses at a construct level, whereas the other tools test construct-level hypotheses at the level of a observed measure. SEM consists of a collection of statistical techniques that allows simultaneous examination of a series of relationships among measured variables and latent constructs (Ullman and Bentler, 2013). SEM analysis is conducted with the objective of examining the extent to which the hypothesized model is supported by the observed data (Schumacker and Lomax, 2004). It the model is not supported by the data, the researcher can modify the initial model or develop alternative models. There are two major types of variables: latent variables are variables that cannot be directly observed or measured. The observed or measured variables are variables that are used for defining the latent variable or constructs.

The core strength of SEM is that it enables the simultaneous test of relationships between observed variables and latent constructs as well as relationships among latent constructs (Hoyle, 2012). The concepts that the researchers are interested cannot be directly observed in many instances (Schreiber et al., 2006). The term latent variables or constructs are used to describe unobserved variables, which are depicted graphically with circles or ovals. Observed variables are depicted graphically with a square or rectangle. The issues or phenomenon that researchers are interested in are often complex and multidimensional in nature. Phenomenon of interest to researchers is not observable and tangible. Hence, a set of item scales are developed to measure latent variables. Noar (2003) argue that multiple items can better capture the complexity of a construct. Weston and Gore (2006) consider SEM as the combination of factor analysis and path analysis. SEM aims to identify the interrelationhips among variables, which is similar to the goal of factor analysis. It also aims to explore hypothesised relationships between factors, which is similar to the goal of path analysis.

The major motivation for application of SEM is to model constructs that cannot be observed or assessed directly (Anderson and Gerbing, 1988). Basic statistical tools can only deal with a limited amount of measures, which is unable to test sophisticated theories (Schumacker and Lomax, 2004). By contrast, SEM allows for the examination of a sophisticated theoretical model. Thus, the researchers can model and test complex phenomena by means of SEM. Another reason for employing SEM method is that it takes measurement error into account when analyse the model. Latent variables can be referred to as "factors", representing what multiple indicators have in common. Many authors regard latent variables as theoretical or hypothetical constructs or concepts in social science. Latent variables can also be defined as the means of reducing the complexity or dimensionality of a set of data. They provide a parsimonious way to test the relationships between variables. Besides, latent variables can serve as a linear function of the observed variables in the model. Hoyle (2012) asserts that latent constructs can be seen as observed "if their values can be derived through the linear manipulation of model equations given values of observed variables."

SEM has a distinct advantage over other statistical methods, that is able to simultaneously test a set of dependence relationships as well as analyses multiple dependent variables (Shook et al., 2004). Both multiple regression analysis and ANOVA can test multiple dependent variables. However, variables could be both independent or dependent variables in a SEM model (Hoyle, 2012). The researcher can identify a set of variables for predicting correlated or uncorrelated outcomes. Dependent variables can be identified as independent variables for predicting other dependent variables. SEM provides synergy among many other multivariate statistical techniques (Bagizzu and Yi, 2012). Bagizzu and Yi (2002) provide an distinction between first-generation statistical tools (i.e., regression analysis, correlation analysis, exploratory factor analysis, ANOVA etc.) and second-generation methods (i.e.,SEMs). SEM is a combination of the former and is able to perform most of classical statistical analyses. One of SEM's advantages over other statistical techniques is that it can correct errors confronting first-generation tools. It can estimate and model random or measurement error as well as systematic or method error in items chosen for measuring latent constructs. SEM also provides a broader and more in-depth approach to assessing construct validity than other tools. Furthermore, SEM is likely to generate novel hypotheses that are not identified in previous studies, leading to. new paths for research.

The complexity of SEM results in statistical and interpretation challenges (Werner and Schermelleh-Engel, 2009). SEM is a large sample method. In SEM approach, maximum likelihood is most often adopted in parameter estimation, which is based on the assumption of large sample size. Hundreds of samples are required in most cases. Small sample size results in unreliable results. In addition, SEM is often used as a means to examine causal hypotheses. Nevertheless, if two or more alternative models which make different hypotheses about causal relationships between factors demonstrate almost the same model fit, it is difficult to make a decision solely on statistical criteria. Moreover, the most difficult part of SEM is to specify and identify a correct model. The researcher must specify a model a priori and know the number of items. Due to the problems with specification, test and interpretation of structural equation models, there are many points at which the process would fail (Fergusson, 1995).

3.5 DEVELOPMENT AND VALIDATION OF CONCEPTUAL MODEL

In order to develop and a valid conceptual model, a strict process will be conducted step by step in this study, ranging from model specification based on literature review to test of structural model.

Considering the large sample size dictated by SEM approach adopted, questionnaire-based survey is adopted in this study. Questionnaire design for this study was carried out in two steps. In the first stage, when completing the extensive review of literature review, the initial list of question items has been generated for measuring the constructs proposed. As for the second stage, interviews were conducted with two academics and two practitioners for the purpose of assessing the validity and reliability of the question items. In the next stage, the questionnaire is sent out for a large-scale survey.

3.5.1 Specification of a conceptual model

The first step in the modeling process is specifying a model, which is to specify a set of hypotheses to be tested (Ullman and Bentler, 2013). Anderson and Gerbing (1988) developed a two-step approach. The measurement model specifies the relationships between manifest variables and their underlying factors that are intercorrelated freely (Anderson and Gerbing, 1988). The structural model specifies the causal relationships among the factors. The researcher should specify a model, which is the mechanism for which involves development of variables, relationships between the variables, and identification of parameters (Weston and Gore, 2006). The researchers should determine the observed and latent variables included in the scale, as well as specify how they are related, whether direct or indirect. Each parameter in a model can be identified as either fixed or free. The value of fixed parameters is set by researchers while that of free parameters are estimated from observed data.

Development of a conceptual model is usually based on theories and empirical results from prior studies (Shreiber et al., 2006). Theories should serve as a guide for the researcher through the process of scale development from items selection, identification of latent constructs to specification of relationships between items and factors (Noar, 2003). This process would be easier with an explicit theory in mind. Some researchers want to develop a theory or a construct that has not been measured by previous studies. They should consider more about critical thinking, literature review, as well as examine whether a measure is both unidimensioal and multidimensional. When develop a scale, the researcher should consider other developed items for measuring the construct, other developed items for measuring similar constructs, and other items for measuring the related theories or constructs. Model specification is driven by the theoretical relations between observed variables and latent constructs (Schreiber et al. ,2006). The researcher specifies a hypothesised model to estimate a population covariance matrix that is compared to the observed covariance matrix. A direct effect represents an independent variable has direct effects on a dependent variable. An indirect effect indicates an independent variable influence a dependent variable through a mediating variable.

The researcher must determine how many items to specify. Different researchers have different views about the number of indicators of a construct. Hoyle (2012) believe that three items offer just enough degree of freedom for estimating parameters. Adding a fourth item offers degree of freedom to test model fit. Mulaik and Millsap (2000) argue that each latent variable should comprise at least four observed items. Bagizzu and Yi (2002) clarify trade-offs related to number of items per factor. Unstable solutions and failure to converge will be results of factors with two few indicators. Thus, a construct with at least three indicators is advocated by many researchers. However, there are also risks associated with specifying a construct with a greater number of indicators. It is harder to obtain convergent and discriminant validity with more indicators per factor. The sample size required to test the model and the parameters to be estimated increases as the number of items per factor increases.

Hoyle (2012) identify four approaches to specifying a model. First of all, the researcher just proposes a single model, which is referred to as strictly confirmatory approach. The researcher makes a decision to either reject or accept a model depending on the results of test. Secondly, the researcher can propose additional models without adequate knowledge of the target model under alternative models approach. The target model that is of greatest interest to the researcher can be evaluated in two ways. It is assessed with reference to the sample data first, and then assessed with reference to the alternative models. The best fitting model is selected among multiple models as the most appropriate to represent the observed data. In the model-generating approach, when the initially specified model shows poor fit to the observed data, the researcher can transform from hypothesis-testing approach to an exploratory approach to generating additional models for future test. However, the risk associated with this approach is that the model yielded may exploit the idiosyncrasies of the current data but not applies to another set of sample. The final approach is model discovery approach, in which SEM software program is used to automatically search all possible models given a set of constructs. It is feasible to use such automated search strategies for a modest number of variables. However, one issue associated with this approach is that a wide range of models may be yielded. This study proposes two conceptual models. The researcher will decide to accept or reject two models based on sample data.

3.5.2 Q-sort

In the second stage, the scales were validated using Q-sort method. Developed by Stephenson (1953) as an alternative measurement technique to existing scales and tests in psychology, the method can be used in any situation in which subjectivity is at issue, including attitude measurement. Q-sort is a cost efficient and simple approach to providing insights into potential problem areas in the questionnaire items (Nahm et al., 2002). It is done by examining the instrument items that are sorted by knowledgeable people in the field of study into corresponding categories defined by the researcher (Stephenson, 1953). The objective is to assess the reliability and validity of those items before the final data collection.

3.5.3 Questionnaire design

The unit of analysis is resident firms on science parks. All of the question items are designed at the level of science park firms. The target respondents of questionnaire are Chinese managers.

Forward and backward translation will be applied to translation of question items into appropriate language for respondents (Brislin, 1983). Two versions of questionnaire are listed in appendix, including Chinese and English versions. Furthermore, a pilot test will be undertaken to obtain feedback about questionnaire design from expert. Pilot study aims to ensure that firm managers can understand the question items clearly.

The question items are measured in terms of respondents' level of agreement for each item. 7-point Likert scale will be adopted to questionnaire design (1=strongly disagree – 4=neutral – 7=strongly agree). Since the emergence of Likert scale, there has been debate among researchers regarding the reliability and validity of number of points on the measurement scale (Dukes, 2005). In terms of reliability of respondents' answers in a survey, it is likely that 7-point scale performs better than 5-piont scale due to more choices on the scale (Joshi et al., 2015). 7-point scale is adopted rather than 5-point scale as it not only permits the measurement of direction and neutrality but can distinguish three levels of attitude intensity as well. The 7-point scale provides more varieties of options which in turn increase the probability of meeting the objective reality of people. As a 7-point scale reveals more description about the motif. 7-point scale may address this issue by avoiding the dilemma of choosing between the two undesirable points on 5 point to some degree. On the other hand,. beyond 7 categories, the scale points would mean less and the increases in reliability would be tiny. Symonds (1924) implied that the optimal reliability is with a 7-point scale. It is not worth it to develop a scale with more than 7 points.

3.5.4 Large-scale survey

In survey research design, the researchers have various methods to collect data, either through face-to-face interview, telephone interview, postal survey and online survey. An online survey will be undertaken. With the improvement of information technology over the last few decades, online questionnaire has become increasingly popular with survey researchers. Compared with face-to-face interviews, the respondents have more confidence with regard of confidentiality online survey (Emroy and Cooper, 1991). Besides, online questionnaires can be significantly cheaper than hard-copy questionnaires. You can send out large numbers relatively cheaply. Doing online survey is convenient to reach as many respondents as possible in short time. More importantly, online questionnaires allow you to make sure that respondents answer the key questions by stopping them from progressing until they have answered the appropriate questions.

Although the researchers can improve the quality of answers through some interview techniques, structured interview survey is infeasible due to its high cost in both money and time (Emroy and Cooper, 1991). Costs are associated with the study that covers a wide geographic area. The sample population of this study are managers of firms located within Beijing and Shanghai science parks. Time spent in science parks, costs related to transport to those places, and hotel expenses are all included in the costs of personal interviews. Personal interview is more appropriate for studies that require a smaller set of sample. There is no doubt that conducting interviews with more than hundreds of respondents face-to-face is highly costly and time-consuming. Moreover, personal interviews bring the issue of bias when the behaviours of researchers make the respondents feel not comfortable.

Telephone interview is not uncommon method of data collection owing to its combination of interactivity of personal interview and low cost of mail survey (Easterby-Smith et al., 2008). You can contact with respondents from all over the globe. It brings savings to the researchers, which come from cuts in travel expenses. Additionally, compared to other channels of survey such as post survey or online survey, telephone interview allows for a quicker completion of the questioning. However, the limitation of telephone interview preclude it from being used in this study. Emroy and Cooper (1991) identify the limit on interview length as one of the drawbacks of such approach. It is unlikely to question the respondents with complex scales in telephone interview. The questionnaire designed for this research comprises of a large number of question items, which is impractical to ask for answers to all of them on telephone.

Postal surveys is less time-consuming compared to interviews, which rarely takes less than half an hour. Besides, the cost of postal survey is typically lower than face-to-face interviews with sample members, especially when they are geographically dispersed (Easterby-Smith et al., 2008). However, it requires postage and the fee of envelopes. Another drawback of such method is very low response rate without personal contact with the respondents. It is generally believed that the respondents are reluctant to answer a long and complex mail questionnaire (Emroy and Cooper, 1991). The researchers may receive returned postal questionnaires with many questions left blank.

According to above analysis of various means to distribute questionnaire, online survey is adopted in this study. Wenjuanxing is a widely used questionnaire platform in China. It is a Chinese website platform which provides a tool for creating online questionnaire. Firstly, it is free for all users. Secondly, it does not limit the amount of questions and respondents. The data collection of firm managers in Beijing Zhongguancun science parks would take one month. The link of questionnaire will be shared in WeChat groups of managers of science park firms every week. WeChat is a mobile instant messaging service, developed by Tencent Holdings Ltd in 2011, which is the biggest social media company in China. WeChat is the most widely used social networking service in China, which has more than 1 billion users. Its broad coverage makes it easier to get access to almost all of firm managers on science parks. Four waves of data collection will be conducted towards firms on Zhongguancun Science Park. A market research company is considered to be used for distributing the questionnaire to firm managers on Shanghai Zhangjiang Science Park by email. The company is responsible for sending out the questionnaire the researcher provides to target respondents. The ethics of research has been approved by relevant committee. In order to ensure the quality of data, unengaged responses and responses that take very short time to finish will be screened out. Some tests will be undertaken to ensure the reliability of dataset, which are justified in the following.

3.5.5 Validation of measurement model

According to Joreskog (1974), “many investigations are to some extent both exploratory and confirmatory, since they involve some variables of known and other variables of unknown composition”. EFA is generally employed in the early phase of scale development, while CFA is employed when the factor model has been specified on the basis of concepts and theories (Chen et al., 2012). EFA is conducted with no previous identification with regard to the number of constructs and the indicator-factor relationship. EFA is an exploratory or descriptive to identify the number of factors, and to determine reasonable indictors for measuring various latent variables. EFA reduce the number of observed variables into a smaller number of latent factors by examining the covariation among the observed variables (Schreiber et al., 2006). A CFA model is usually established on prior exploratory studies that have identified the correct pattern of item-factor relationship (Hoyle, 2012). CFA allows the examination of higher-order factors, which can explain correlation between lower-order factors.

3.5.5.1 Exploratory factor analysis

Factor analysis allows the covariances between a series of indicators to be explained by a few underlying latent variables (Hox and Bechger, 1998). Exploratory factor analysis (EFA) has long been used for exploring the structure of a set of variables. On the one hand, unidimensionality is tested to determine whether a set of indicators reflect only a single underlying factor or not (Segars, 1997). Three criteria are applied to measure unidimensionality, including factor loading, eigenvalue of subscale, and variance of the items extracted in commonality. On the other hand, cross-loading issues will be solved as it results in the problem of factor intercorrelations (Worthington and Whittaker, 2006). The items that do not measure a priori factor or strongly load on multiple factors will be dropped. Moreover, the author also tests Cronbach's alpha to measure the reliability of subscale (Cronbach, 1951). The constructs that fail to reach targeted alpha value will be removed. Cronbach's Alpha is the most common measure for assessing the reliability of a construct, which refers to internal consistency of a set of items (Cronbach, 1951). High alpha suggests the set of items are highly correlated while low score suggests the sample of items fail to capture the construct. The value above 0.70 is considered as an acceptable threshold for composite reliability, with reliability of each indicator higher than 0.50 (Shook et al., 2004).

At the preliminary stages of analysis, EFA is a statistical tool to reduce data to a small number of factors by combining the highly correlated items into the same factor (Rubio et al., 2001). It helps to determine the key dimensions of interest and identify poor-quality indicators. The factors are "used as variables in data analyses by generating composite scores with the items that measure each factor". They are latent variables that account for the variation and covariation among a series of observed variables (Hoyle, 2012). The observed variables are influenced by a common underlying construct. The relationships among latent variables and indicators as well as the number of latent variables are not specified. EFA estimate the number of factors and factor loadings. However, EFA is criticised by Rubio et al. (2001) as correlation between variables may exist for reasons in addition to serving as measures of the same concept. EFA is unable to test models with higher-order factors because correlation between factors could be explained in two ways. SEM allows researchers to conduct confirmatory factor analysis (CFA) which enables analysis of higher order factors. Higher-order constructs account for correlation between lower-order factors.

3.5.5.2 Confirmatory factor analysis

CFA provides a parsimonious way to estimate the covariation among a range of observed measures. Hoyle (2012) regard each indicator as a linear function of one or more common factors and one unique factor. CFA provides a more rigorous approach compared with EFA. CFA assesses construct validity based on chi-square test and other fit indexes. CFA deals with the measurement model specifically, which specifies the relations between observed variables and latent variables (Hoyle, 2012). In CFA, specification is made with regard to the number of factors and relationship between observed measures and factors. CFA hinges on a strong empirical or theoretical basis that guides the specification of the hypothesized model. CFA contributes to the development of a model in several ways. It plays an indispensable role in construct validation (Tompson, 2004). It verifies the convergent and discriminant validity of latent variables. CFA also compensate the limitation of EFA by specifying correlated errors. In EFA, the correlated errors that is not explained by latent variables may be manifested as additional factors. CFA is a precursor to structural model that specifies how various constructs are related to one another. It is critical to ascertain that the measurement model is acceptable prior to estimation and evaluation of structural relationships among various factors (Marsh et al., 1988). It is more likely that poor fit of model is owing to misspecifications in measurement component than in structural model.

Hoyle (2012) summarises that a measurement model might be misspecified in three ways. Incorrect design of the item-factor relationships is a major source of misspecification of CFA model (Yang-Wallentin et al., 2010). This occurs when the indicator was specified to load on the wrong factor; the indicator has loadings on more than one factors; and the indicator is not related to any factor. The model fit can be seriously affected by only one misspecified item-factor relationship. The researcher needs to modify the item-factor relationship or remove the bad item from the model in order to obtain an acceptable model. Another source of misspecification is the incorrect number of constructs specified. Overfactoring occurs when factors are highly correlated. The remedy is either to collapse factors or drop a redundant factor. Underfactoring is reflected by the CFA model's failing to adequately reproduce the observed relationships among the indicators. Hoyle (2012) identify the relationships among the indicator residual variances as the source of CFA model misspecification. The correlated errors that are not due to latent variables result from exogenous common causes, including similarly worded and reverse-worded items, response set, reading difficulty etc.

Construct validity

Construct validity represents the ability of indicators to measure constructs. It reflects the notion of convergence, which indicates the degree to which items chosen measure the factors they are hypothesised to measure as well as discrimination between those items and items of a different factor (Schimitt, 2011). In order words, construct validity could be achieved when multiple indicators of the same construct are highly correlated and not relate highly with indicators of other constructs. Convergent validity indicates high correlations between items measuring the same construct (Chuchill, 1979). Construct validity reflects convergent validity and discriminant validity of theoretical constructs. In this study, average variance extracted (AVE) value and composite reliability (CR) value will be used to assess convergent validity of first-order constructs. Discriminant validity indicates "low correlations between the measure of interest and other measures that are supposedly not measuring the same variable or concept" (Heeler and Ray 1972, p.362). This study uses two criteria to assess discriminant validity, (i) inter-correlation value and (ii) AVE value should be higher than square of inter-correlation value among constructs.

Second-order factor model

Second-order constructs are examined to test whether they can explain the covariances among first-order constructs (Marsh and Hocevar, 1985). Target coefficient is the index that is used for validating second-order factor model, which reflects the ratio of chi-square of first-order factor model to chi-square of second-order factor model. Higher-order models can relate the observed indicators to first-order constructs that can then be related to their higher-order constructs (Koufteros et al., 2009). A set of first-order factors can be represented by a single common underlying second-order construct. Second-order constructs account for the relationships between first-order variables that are measured by multiple indicators (Chen et al., 2005). For one thing, the feasibility of a second-order model depends on substantially correlated first-order variables. For another, it is practical when the relationships between first-order variables could be accounted for by one second-order construct. Compared with bundling all measures together in a single composite score, second-order models allow the researchers to examine the contribution of each first-order factor to the final scale score. Path coefficients enable researchers to estimate and evaluate both substantive and statistical contributions of each lower-order factor.

Higher-order models can deal with the issues related to "bloated specifics" factors, referring to factors that are composed of a narrow content span of items (Marsh and Hocevar, 1988). In order to meet unidimensional criteria of multiple items, the researchers often formulate items that more or less restate each other. Even though these items can satisfy unidimensionality concerns and meet reliability criteria, it is inevitable that their theoretical contribution and explanatory power are diminished. The content domain of such factors are too narrow to define concepts or constructs of multi-dimensional nature. Koufteros et al. (2009) treat such lower-order variables as "building blocks" of higher-order variables. They can be defined as facets of the higher-order variables. Higher-order constructs can embrace the meanings of various lower-order factors.

Chen et al. (2005) discuss that higher-order modelling provides the researcher with a more interpretable and parsimonious model compared with first-order models with several related factors. In comparison to first-order models, higher-order models have some advantages over them. First of all, higher-order models provide a more parsimonious method to interpret sophisticated measurement structures (Marsh and Hocevar, 1988). They allow the researchers to explain the covariance between first-order variables in a more simplified way. In addition, higher-order models enable the theoretically error-free estimates of specific factors by separating variance from measurement error. It is able to identify variance of each first-order variable.

Model fit

The evaluation of model fit is concerned with whether the hypothesized model provides an acceptable account of the observed data (Hoyle, 2012). This step is to measure the discrepancy between observed and estimated covariance matrix. Absolute fit indexes evaluate the degree to which the proposed model reproduces the sample data, including measures such as chi-square (x), GFI (Goodness-of-Fit Index), RMSEA (root mean squared error of approximation), and SRMR (root mean squared residual) (Hooper et al., 2008). Incremental fit indexes determine the degree of improvement when compare the proposed model with a more restricted, nested baseline model (Kenny, 2015; Marsh et al., 1996). These include measures such as CFI (Comparative Fit Index), NFI (Normed Fit Index), and NNFI (Nornormed Fit Index), TLI, (Tucker-Lewis Index), and AGFI (adjusted goodness of fit index).

Gerbing and Anderson (1993) discuss that an ideal fit index meets three expectations: is sample-size independent; confined to a precise range between 0 and 1, with 1 indicating perfect fit while 0 indicating complete lack of fit; has known distributional properties to assist interpretation. No single index meets all the criteria. The core of the model analysis is to test the coefficients of hypothesised relationships as well as whether the hypothesised model fit the observed data well. Schreiber et al. (2006) suggest that RMSEA, TLI, CFI not only have a confined range of acceptable score, but also work well with different sample size, and different types of data. Bagizzu and Yi (2002) identify the widely recognised fit indexes. RMSEA is the average amount of misfit for a model per degree of freedom; CFI indicates relatively noncentrality between the specified model and the null model; SRMR is the square root of the average squared residuals. CFI, NNFI, RMSEA and SRMR will be used to assess fitness of structural model in this study. Hu and Bentler (1998) argue that relying on two indexes (CFI and RMSEA) is adequate for assessing model fit.

There has been growing interest in how measures of fit are affected by sample size and number of variables. Kenny et al. (2003) examine the effects of number of variables on model fit, which refer to number of observed variables rather than latent variables. Their results suggest that in correctly specified models, RMSEA tends to increase as more variables are added to the model. They find negative relationship between the number of variables and the measures of CFI and TLI. The value of CFI and TLI seem to decline as the number of indicators increase. That is to say, CFI and TLI get worse in models with a large number of variables. The authors suggest that if CFI and TLI values of models with many variables are slightly less than expected, but RMSEA seems satisfactory, it is not a big concern. However, the model is truly poor with both poor CFI or TLI and poor RMSEA. The study of Fan et al. (1999) explore how model is influenced by sample size, estimation methods and model misspecificiton. The authors believe that the variation of an ideal index contributed by sample size and estimation methods should be as small as possible. Conversely, model misspecification should be the major contributor to an index's variation. Their results show that RMSEA, CFI and NNFI are indexes that are minimally affected by sample size. GFI and AGFI exhibit worse performances because sample size contributes to over 10% variation of them. Secondly, GFI, AGFI, and RMSEA are indexes that are not highly influenced by estimation methods. Thirdly, RMSEA is good choice for researchers desires indexes that are sensitive to model misspecification.

Table 3.1 Recommended value for acceptable model fit

Measures of fit	Statistics measures	Recommended values for acceptable model fit
Absolute	Chi-square test	NA
	Root mean square error of approximation (RMSEA)	⩽0.08
	Standardised root mean square residual (SRMR)	⩽0.10
Incremental	Tucker-Lewis index (TLI)	⩾0.90
	Normed Fit Index (NFI)	⩾0.90
	Comparative fit index (CFI)	⩾0.90
Parsimonious	Normed χ^2 (χ^2/d.f.)	⩽3.0

3.5.6 Test of structural model

After the confirmation of the measurement model, two structural models proposed in Chapter 4 will be tested, which is the final phase of validation of hypothesised models. The overall fitness of the two models will be examined. Both absolute fit indices (RMSEA) and incremental fit indices (NNFI and CFI) will be used for measuring model fit. The rule-of-thumb for fitness measures are CFI>0.90, NNFI>0.90, RMSEA<0.08, and SRMR<0.010. Hypotheses proposed in the theoretical model will also be tested to check whether they are supported by survey data. Furthermore, mediation effect of innovation capabilities between ESPCN and financial performance will be examined. The approach developed by Sarkis et al. (2010) will be applied to measuring of mediation effect. Steps of conducting test of mediation effect will be detailed in Chapter 5.

Since the emergence of the first SEM software in 1974 (i.e. LISREL), there has been an increasing tendency to develop alternative SEM programs and improve their functionality (Hoyle, 2012). Now researchers have a series of choices of SEM software programs, including LISREL, Amos, Mplus, EQS, etc. Even though they share lots of similar features and functions, they are distinct in various ways. The major advantage of Amos over other programs is that you can create a path diagram to graphically demonstrate a SEM model through using simple drawing tools provided by Amos Graphics. Hoyle (2012) stress the broad range of bootstrapping capabilities of Amos, which facilitate beginners to manipulate the software package. The users' choice of approach to structuring model input depends on their preference to work within a graphical or a text-format framework (Hair et al., 2014). Amos is more appropriate for the researchers who prefer to work graphically rather than textually and do not have a solid understanding of SEM. LISREL, Mplus, and EQS are more suitable for the researchers who are more skilled and experienced in application of SEM analysis. Compared with other types of programs, Amos is more suitable for PhD candidates who test a SEM model for the first time.

3.6 CONCLUSION

This chapter clarifies research methods and research design employed by this research. It justifies the reasons for selection of survey as research strategy and selection of questionnaire as data collection method in this study. Besides, this chapter also demonstrates how to develop the measurement model and validate the structural model step by step. Structural equation modeling is the major approach applied to analysis of sample data collected from firms located on science parks in Beijing and Shanghai. This study adopts two statistics software packages to development of theoretical model. SPSS 23 will be used for undertaking exploratory factor analysis (EFA). Amos 26 will be adopted to examine the validity of measurement model through confirmatory factor analysis (CFA). It is also used to validate the structural model.

CHAPTER 4 CONCEPTUAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

4.1 INTRODUCTION

This chapter firstly justifies three theories that underlie this study, including resource-based view (RBV), knowledge-based view (KBV), and dynamic capabilities. Resource-based view (RBV) indicates that firms can create competitive advantage with valuable, rare, non-imitable and non-substitutable resources and capabilities. Science park ecosystem can be seen as a bundle of resources that mitigates resource deficiencies of affiliated firms. Knowledge-based view (KBV) regards knowledge as the source of competitiveness. Proximity to diverse science park actors makes it easier for tenants to access knowledge or information required in their innovative activities. (Grant, 1996; Kogut and Zander, 1992). However, RBV theory is criticised for its static nature and it fails to explain how to integrate resources to cope with fast-changing environment (Kraaijenbrink et al., 2010; Wang and Ahmed, 2007). Dynamic capabilities is associated with firms' ability to integrate and reconfigure external and internal resources to address dynamic environment (Teece et al, 1997). Dynamic capabilities approach overcomes the limitation associated with RBV theory and it puts emphasis on how firms deploy resources to adapt to rapid changes in business environment.

In order to fill in the gap identified in science park literature, this chapter develops two conceptual models which aims to explore the impacts of science park ecosystem on tenant firms. One model focuses on the overall impacts of "engagement in science park collaborative network" (ESPCN) on tenant firms. ESPCN impacts on tenants will be assessed in terms of tenants' innovation capabilities and financial performance. The other model examines the effects of four dimensions of ESPCN separately. Four dimensions of ESPCN reflect tenant firms' relationship with four types of science park actors identified in literature review chapter. Four dimensions of innovation capabilities are proposed based on the literature review of innovation capabilities. Question items of the two multi-dimensional constructs are generated on the basis of measures adopted by previous studies. In addition, the hypotheses are proposed in terms of the relationships between constructs in the conceptual models.

4.2 UNDERLYING THEORIES

Resource-based view (RBV) theory comes up with a framework that addresses how firms achieve and sustain competitive advantage (Wernerfelt, 1984; Barney, 1991). RBV posits that sustainable competitive advantages depends on valuable, rare, inimitable and non-substitutable firm resources (Barney, 1991). Knowledge-based theory provides a basis for analyzing knowledge diffusion and sharing within science park ecosystem (Grant, 1996; Kogut and Zander, 1992). They can get quick access to suitable knowledge by developing linkages with actors on science parks. Dynamic capabilities approach is an extension of RBV theory. RBV is a static theory and inadequate to explain how firms maintain competitive advantage in dynamic environment (Teece et al., 1997; Kim et al., 2015; Eisenhardt and Martin, 2000; Wang and Ahmed, 2007). Dynamic capabilities approach enhances RBV by justifying how firms integrate internal and external resources and competences to deal with rapid and unpredictable changes in markets (Teece et al., 1997; Eisenhardt and Martin, 2000). Dynamic capabilities is critical for technology-based firms operate in high-velocity markets to survive and grow. Science parks provide assistance for resident firms in addressing rapid environmental changes. Resident firms are supposed to synthesise and recombine their internal resources and external resources to cope with dynamic environment.

4.2.1 Resource-based view (RBV)

This study draws on resource-based view (RBV), which views companies as a bundle of resources or capabilities that contribute to the creation of competitive advantage (Barney, 1991). RBV is one of the most influential theories in the field of strategic management. RBV regards firm-specific resources and capabilities as the critical determinant of competitive advantage of firms (Wernerfelt, 1984; Teece, 1997). In the science park context, RBV implies that the environment of science parks provides a resource base necessary for the success of resident firms. Science parks allow firms to mitigate deficiencies in resources. This study explores how firms maintain competitive position through exploiting resources provided by science park ecosystem. From the resource-based perspective, each firm is a bundle of resources. It is difficult to develop new competencies rapidly for firms as business development process is complex. Penrose (1959) first provided insights into the resource-perspective of companies. A broad range of resources can be applied to studying companies. Wernerfelt (1984) put forward the concept of resource-based view (RBV). His work in terms of resources. He introduced the idea that resources can be considered as the source of competitive advantage. The seminal work of Barney (1991) popularise RBV concept by proposing VRIN framework. It posits that firms with valuable, rare, inimitable and non-substitutable resources can create sustainable competitive advantage. Firm resources with these four features allow firms to achieve superior performance and sustain competitiveness in the market. Barney define resources as "all assets, capabilities, organisational processes, firm attributes, information, knowledge, etc. controlled by a firm (Barney, 1991).", which enable firms to execute strategies that enhance efficiency. Firms that implement value-creating strategies that are rarely implemented by rivals and difficult for rivals to imitate can deliver sustained competitive advantage.

According to RBV theory, science park ecosystem can be seen as a bundle of resources or capabilities, which are valuable and difficult to imitate and enables science park firms to achieve a competitive advantage (Barney, 1991). Firms that can better exploit the resources provided by science parks is expected to achieve superior performance. Considering rapid changes of markets and technology, it is difficult for firms to possess all resources or develop all capabilities required for innovative activities. Science park ecosystem can be seen as resource network that mitigate resource deficiencies of affiliated firms. Co-localisation of firms and institutions is associated with easy access to appropriate resources in the vicinity (Maskell, 2001)

Resources and capabilities are at the heart of firms' competitive advantage (Peteraf, 1993). Imperfect resource mobility and resource heterogeneity across firms underlie competitive advantage of firms (Peteraf, 1993). Resources can be classified into three categories, including tangible resources, intangible resources and personnel-based resources (Grant, 1996). Tangible resources encompass financial resources and physical capital such as land, factories, and equipment; intangible resources include knowledge, information, reputation etc; personnel-based resources entail organisational culture, employee loyalty, technical know-how, etc. Barney (1991) categorises resources into human capital, physical capital and organizational capital.

4.2.2 Knowledge-based view (KBV)

Knowledge-based view regards knowledge as valuable resources that create and sustain competitive advantage (Caloghirou et al., 2004). Caloghirou et al. (2004) regard interaction as the key to acquisition and production of new knowledge. Firms can interact with various actors to get access to knowledge beyond their boundaries. Increasing variability and complexity of markets and technology stimulates firms to seek and develop relationships with external partners. Knowledge-based view facilitates the analysis of how science park ecosystem contributes to firms' achievement. More and more companies seek to develop relationships with external actors to access knowledge and resources beyond their boundaries (Grant and Baden-Fuller, 2004). Knowledge-based theory provides a basis for exploring how science park network influences tenant firms. This study provides insights into the effectiveness of science park network in promoting the growth of resident firms.

Science parks allow firms to get quick access to state-of-the-art information and knowledge about markets and technology. Knowledge-based theory views firms as dynamic and evolving system of knowledge creation (Spender, 1996). External flows of knowledge are opportunities for firms to existing knowledge base and produce new knowledge (Aranda and Molina-Fernandez, 2002). Geographical proximity between firms and institutions facilitates knowledge spillover and interactive learning that is critical to innovation (Malmberg and Maskell, 2002). The combination of diverse and specialised knowledge is required for developing innovations. Considering increasing knowledge intensity of business sector, knowledge-based view is applied to this study. Knowledge-based perspective considers knowledge as the key resources of companies. The idea of Grant (1996)'s work is that firms can be seen as a body of knowledge. Market and technology knowledge are critical for firms in knowledge-intensive sectors. It is likely that small firms lack information-gathering and processing capabilities (Spender, 1996).

Knowledge acquired from different actors involved in science park ecosystem allows firms to create new knowledge, which provides a basis for achieving innovation success. The concentration of firms and institutions allows tenant firms to gain easier access to knowledge and technology required by their R&D or innovative activities. By developing linkages with different science park actors, firms are able to absorb new knowledge and apply it to their own use. Recombination of existing knowledge base and external sources of knowledge leads to creation of difficult-to-imitate knowledge, which contributes to achievement of sustainable competitive advantage. Kogut and Zander (1992) provide a foundation for knowledge-based theory by putting an emphasis on knowledge as a source of competitive advantage. Knowledge stock of firms leads to development of capabilities that improves possibility of survival and growth. Kogut and Zander (1992) argued that creation of new knowledge strengthens competitive position of firms. New knowledge is recombination of current stock of knowledge and incremental learning. Some studies provide a distinction between tacit knowledge and explicit knowledge (Grant, 1996; Kogut and Zander, 1992). Tacit knowledge cannot be transferred directly while explicit knowledge can be easily communicated and articulated (Grant, 1996). Tacit knowledge (know-how) is slow to transfer and costly to duplicate. The transfer of tacit knowledge is relatively slow and costly. Knowledge is crucial input in production and source of advantage. Knowledge is embedded in processes, procedures, and rules of firms (March, 1991).

Knowledge-based resources play a crucial role in creating sustained competitive advantage due to their inherently difficult-to-imitate nature (Wiklund and Shepherd, 2003). Knowledge has the greatest potential to create sustainable competitive advantage owing to its immobility. Knowledge allows firms to predict and respond to environmental changes more accurately. Knowledge-based resources facilitate sustainable differentiation as it is difficult to imitate, articulate and transfer (Wiklund and Shepherd, 2003). Co-location with various actors within science parks enables tenants to access market and technological knowledge quickly, which enhance firms' ability to identify and exploit new opportunities (Wiklund and Shepherd, 2003). Diverse knowledge sources improve firms' ability to identify and exploit new opportunities. Firms are able to capture market opportunities and respond rapidly to advancements made by rivals (Cohen and Levinthal, 1990). Knowledge acquired from external actors makes it easier to assess market value of new products or services (Wiklund and Shepherd, 2003). New knowledge can be associated with technological breakthroughs. Although firms do not possess considerable knowledge-based resources, they can discover, assess and respond to potential opportunities quickly with the assistance of science parks.

4.2.3 Dynamic capabilities

Science park firms that compete in dynamic environment require a paradigm beyond RBV. Dynamic capabilities allow firms to adapt, recombine and integrate their internal and external resources and capabilities to align with the dynamic markets (Teece et al., 1997). Development of network with external actors is dynamic capability that is difficult to imitate. It involves the integration and recombination of external and internal resources and competencies to create a competitive advantage in dynamic environment.

RBV theory is static and unable to explain how technology-based firms on science parks respond to fast changes in markets and technology. Dynamic capabilities approach allows the researcher to explore how science park firms integrate external resources into their operational processes to adapt to dynamic environment. Technology-based firms operate in dynamic business environment, which stimulates them to interact with different external actors. Science parks function as growth poles that help resident firms deal with rapid technology developments and unpredictable market trends. Long-term competitive advantage of tenant firms depends on not only their internal resources and capabilities but also their ability to exploit external resources provided by science park. They need to integrate internal and external resources to address environmental changes and maintain long-term survival. Real-time information provided by actors in science park ecosystem allows firms to quickly identify and adapt to market changes or technology developments (Eisenhardt and Martin, 2000).

In the field of strategic management, how to obtain and sustain competitiveness is a critical issue for firms. RBV is criticised for being static and unable to address how to integrate resources to cope with market dynamism (Kraaijenbrink et al., 2010; Wang and Ahmed, 2007). Since the 1990s, the fast-changing business environment has challenged RBV theory which fails to address market dynamics. The static nature of RBV theory results in failure to explain competitive advantage in highly dynamic environment. Kim et al. (2015) argue that it is essential to go beyond resource-based perspective to justify competitive advantage. Teece et al. (1997) develop a dynamic capabilities approach to safeguarding competitive advantage of firms in rapidly changing environment. It takes market dynamism and firm evolution into consideration (Wang and Ahmed, 2007). Dynamic capabilities are defined as a firm's ability to "integrate, build and reconfigure internal and external competences to address rapidly changing environments (Teece et al., 1997)."

Tenant firms can integrate external resources obtained from relationships with different science park actors and their internal resources and capabilities to address dynamic environment. Dynamic capabilities approach links firms' resource and capabilities with external environment, which is seen as the extension of resource-based perspective (Barreto, 2010). An evolutionary economics perspective is applied to addressing fast-changing environment. They emphasise firms' ability to defend their competitive position in environments of rapid change. RBV views firm-specific capabilities and assets as the source of competitive advantage. Dynamic capabilities approach stresses newer sources of competitive advantage beyond traditional boundaries of strategy (Teece et al., 1997). It focuses on the integration of internal and external resources for creation of defensive market position. It justifies how to develop, integrate and recombine difficult-to-imitate managerial, operational and technological skills to deal with shifting environment.

This approach stresses the ability to renew and reconfigure management capabilities, organisational skills and technological assets to address fast-changing environment (Teece et al., 1997). It offers insights into how firms develop their capacity to adapt to rapid technology developments and unpredictable market trends. It reflects firms' capability to identify new or innovative sources of competitive advantage, which is difficult to imitate. Easy imitation indicates quick dissipation of competitive advantage. The more tacit knowledge the firm possess, the more difficult it is to imitate by its rivals. Teece et al. (1997) identify three categories of determining factors for dynamic capabilities, including processes, positions and paths. Integration of external knowledge and resources is critical for creation of strategic advantage. Managerial and organizational processes shaped by asset position and evolutionary path is the essence of dynamic capabilities of firms.

Dynamic capabilities involve a firm's ability to identify possible technological change, as well as its ability to cope with changes through innovation (Rothaermel and Hess, 2007). Teece et al. (1997) regard dynamic capabilities as the heart of firms' ability to innovate. Eisenhardt and Martin (2000, p.1107) define dynamic capabilities as firms' ability to integrate and reconfigure resources and competences to adapt to or even create market changes. It highlights the importance of achieving new resource configurations in addressing rapidly changing markets (Eisenhardt and Martin, 2000). Firms' ability to create situation-specific new knowledge is important in high-velocity environment. Dynamic capabilities approach put an emphasis on accessing outside knowledge or resources to gain superior firm performance (Eisenhardt and Martin, 2000). In-house R&D is not enough for firms to able technological development (Rothaermel and Hess, 2007). Powells (1996) posit that innovation success depends on not only R&D activities within organizational boundaries, but also a network of interactive learning composed of both external and internal actors.

4.2.4 Links to the study

In summary, RBV theory indicates that accessing strategic resources is major factor that drives creation and development of competitive advantage (Barney, 1991). Interaction and networking with other science park actors improves tenants' accessibility to scarce resources that they might be short of internally. Science park collaborative network offers a means for dealing with such limitation (Najafi-Tavani et al., 2018). In order to expand their resource base and strengthen their internal capabilities, firms seek to explore and search essential resources beyond the organizational boundaries. Collaboration with diverse science park actors enables firms to increase firm-specific resources and capabilities, thereby improving competitive position. Rare, valuable and difficult-to-imitate nature of relationship-specific assets allow firms to improve competitiveness.

As RBV theory suggested, strategic resources are drivers for reaching a sustained market advantage. One of strategic resources is knowledge. Knowledge-based view (KBV) provides a basis for studying knowledge-based firms on science parks. Knowledge and resources necessary for innovative activities are not always available inside the companies. Co-location with diverse entities on science parks allows firms to obtain easy access to market and technological knowledge. Firms can quickly identify and exploit new opportunities to adapt to rapid changes in business environment.

Teece and Pisano (1994) define dynamic capabilities as the “subset of capabilities which allow the firm to create new products and processes and respond to changing market circumstances”. As a major mechanism for business growth and renewal, innovation is central to dynamic capabilities theory. Innovation is a critical factor for firms’ survival and evolution. Innovation capability is a key component of dynamic capabilities, which underpins firms’ ability to recombine and renew its resources in line with external changes (Wang and Ahmed, 2007).. Nevertheless, firms cannot create and develop all resources and knowledge that are critical for innovation improvement. Another component of dynamic capabilities is adaptive capability, dealing with firms’ weaknesses in resources and knowledge (Wang and Ahmed, 2007). It stresses the importance of combination of external knowledge with internal knowledge to adapt to environmental changes Firms can take in knowledge from science park collaboration network and exploit it for internal use.

4.3 CONCEPTUAL FRAMEWORK

This study examines how benefits derived from inter-organisational interactions can be channeled to enhance innovation capabilities and financial outcomes of firms. Firstly, three underlying theories have been identified, which are resource-based view, knowledge-based view, and dynamic capabilities. Secondly, four components of “engagement in science park collaborative network” (ESPCN) construct, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial intermediaries. This construct refers to tenant firms’ network relationships with four different types of organisations or institutions that are involved in science park ecosystem. Both overall effects of ESPCN and its individual dimensions are expected to exert positive impacts on innovation capabilities and financia performance of science park firms. The next part shows that innovation capabilities of firms consist of organizational learning, idea generation, product and process development capabilities.

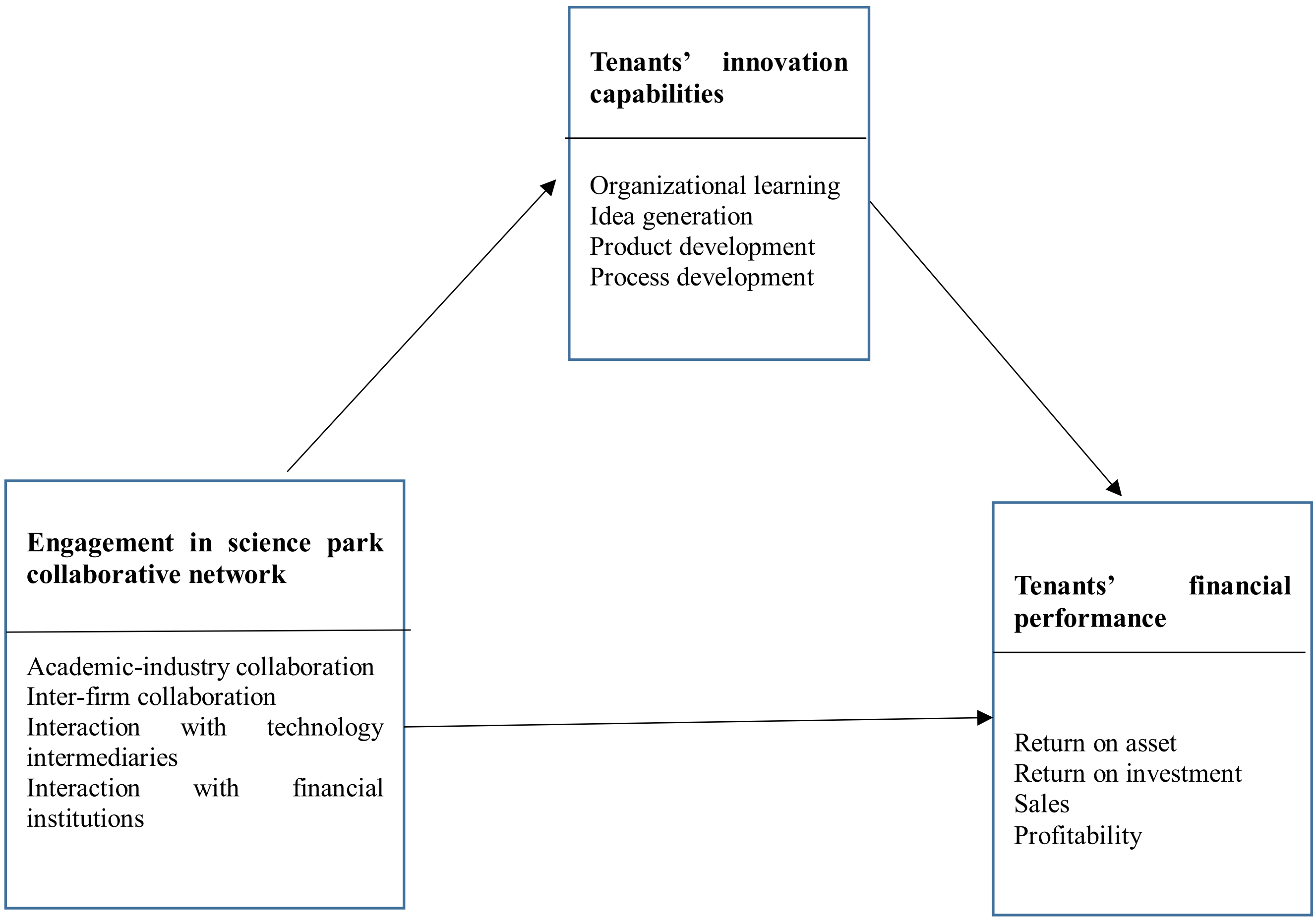


Figure 4.1. Conceptual framework

4.1.1 Engagement in science park collaborative network

4.1.1.1 Academic-industry collaboration

Science parks are designed and created for stimulating interactions between academic institutions and commercial enterprises (UKSPA, 2019; IASP; 2019). Academic institutions, including higher education institutions and research institutions, are ideal partners for commercial enterprises to sustain competitive advantage in the market (Petruzelli, 2011). There is a tendency that universities pursue a “third mission”, which is to develop connections industrial sector (Etzkowitz and Leydesdorff, 2000). They can provide direct support in terms of idea generation, technology development and problem-solving (Perkmann and Walsh, 2009; D’Este and Perkmann, 2011). They are key sources of high-skilled scientists and researchers, which provide ideas or expertise for technological development of firms (Bishop et al., 2011). They are key providers of the latest scientific and technological knowledge, which facilitate businesses to make innovative breakthroughs. Close links with academics is an effective way to facilitate industrial sector’s technological upgrading (Arza, 2010). Linkages with academia help firms explore the unknown territory. Firms can collaborate with academics to create new knowledge and cope with technological bottleneck (Lee, 2000). Academics can provide assistance in problem-solving, which is a major contribution of academic partners to R&D activities of businesses. Academic-industry relationships help firms explore new avenues of innovation and accelerate innovation process (George et al., 2002).

4.1.1.2 Inter-firm collaboration

Science parks provide a favourable environment for knowledge sharing and technology flow between innovation-based firms (Parker, 2010; Gwebu et al, 2018). Geographical proximity allows for interpersonal, face-to-face and frequent linkages, which is conducive to the creation of collective learning milieu (Rodriguez-Pose and Hardy, 2014). Business network mitigates firms' deficiencies in resources. Firms can get access to complementary knowledge, skills and resources through inter-firm network (Lin and Lin, 2016). They can capture information about emerging market demands and state-of-the-art of the markets more quickly (Song et al., 2016). Synergies in R&D, managerial, production and managerial systems enhance their ability to develop innovative products (Tomlinson, 2010). Joint problem-solving speed ups innovation process and maximises process efficiency (Lin and Lin, 2016). Process integration generates synergy effects (Goes and Park, 1997). Firms can get insights into improvement of product quality, process efficiency and cost reduction (Un and Asakawa, 2014). It is believed that inter-firm relationships enable firms to share risk and challenges associated with developing new products or expanding into new markets (Najafi-Tavani et al., 2018). Cooperative arrangements allow firms to spread the costs and risks.

4.1.1.3 Interaction with technology intermediaries

Technology intermediaries work as knowledge brokers between geographically proximate actors (Lin et al., 2016). They contribute to the creation of collective learning region by linking different organizations involved in innovation ecosystem of science parks (Cooke et al., 1997). They diffuse and disseminate knowledge or technology, as well as distribute technical and institutional resources within science park ecosystem (Lin et al., 2016). The search function of intermediaries provide assistance in identification of suitable knowledge, technology, talents, and partners. Their role in facilitating linkages between different actors within innovation system has been extensively discussed in previous studies (Inkinen and Suorsa, 2010; Lin et al., 2016; Parker and Hine, 2014). They help clients overcome barriers arising from negotiation involved in technology transfer process (Parker and Hine, 2014). Close ties with intermediaries allow firms to improve the efficiency and flexibility of innovation process, as well as mitigate inefficiencies of technology markets (Knockaert and Spithoven, 2014; Goes and Park, 1997). Not limited to facilitating networking and collaboration, technology intermediaries also provide direct services that support tenants' innovation-related activities. Technology intermediaries play a supportive role during various stages of innovation process (Howells, 2006). Firms that develop network relationships with intermediaries can get access to a wide range of services, including training, talent search, technology assessment, intellectual property rights protection, technology commercialization, market research etc (Howells, 2006; Lin et al., 2016).

4.1.1.4 Interaction with financial institutions

Innovation process involves high risk and requires long-term financial investment (Barnir and Smith, 2002). Financing issues are of importance for every business, especially technology-based start-ups. Financial institutions help science park firms cope with risk involved in innovation process. As far as we know, the major barrier to innovative activities is to attract or secure finance (Freel, 2012). Innovation involves high level of risk and costs. There is a high likelihood of innovation induces an unacceptably high perception of risk (Hsu et al., 2014). Science park management can act as brokers advising affiliated firms how to gain access to finance from private- and public-sector sources. Various types of capital, including governmental funds, venture capital, loans, foundations and project funds, are available to support innovation activities within firms. A wide range of financial services are provided by science parks, such as technology funding, technology guarantee, technology lease, technology credit, online financial services, investment services etc.

Table 4.1. Measurement items for construct of engagement in science park collaborative network (ESPCN)

Construct	Items	References
Academic-industry collaboration	AIC1 Scientists or students are often involved in our R&D projects. AIC2 We maintain close ties with universities or research institutions to obtain information about the latest technological trends. AIC3 We have close cooperation with universities or research institutions to develop new product technologies. AIC4 We involve academics actively in product development. AIC5 We have close cooperation with universities or research institutions to solve technical problems. AIC6 We have close cooperation with universities or research institutions to speed up product development process. AIC7 We have close cooperation with universities or research institutions to generate creative ideas.	Brettel and Cleven (2011); D'Este and Patel (2007); Schartinger et al. (2002); Perkmann and Walsh (2007); Arza (2010)
Inter-firm collaboration	IFC1 We maintain close ties with other tenants on science parks.	Lau et al. (2010); Brettel and Cleven (2011); Diez-Vial and Montoro-Sanchez (2016);

	IFC2 We regularly share and exchange information about the latest technological trends with other tenants. IFC3 We regularly cooperate with other tenants to develop new product technology. IFC4 We regularly cooperate with other tenants to solve technical problems. IFC5 We regularly cooperate with other tenants to speed up product development process.	Bakouros et al. (2002); Narula (2004); Carson et al. (2003); McEvily and Marcus (2005)
Interaction with technology intermediaries	ITI1 We have close ties with technology intermediaries of the science park. ITI2 We regularly involve technology intermediaries in our innovation process. ITI3 We regularly participate in conferences or meetings organised by technology intermediaries of science park. ITI4 We usually find collaborative partners through technology intermediaries of science park. ITI5 We regularly search talents through technology intermediaries of science park. ITI6 We regularly use technology assessment services provided by technology intermediaries. ITI7 We regularly use training services provided by technology intermediaries.	Rush et al. (2007); Lichtenthaler and Ernst (2008); Nilsson and Sia-Ljungstrom (2003); Zhu and Tann (2005)
Interaction with financial institutions	IFI1 We have close ties with financial institutions of the science park. IFI2 We regularly use financing services provided by financial institutions on science parks. IFI3 We regularly use investment decision-making services provided by financial institutions on science parks.	Wonglimpiyarat, 2016; Smith, 2011; Hsu et al., 2014; King and Levine, 1993

	IFI4 We regularly use capital management services provided by financial institutions on science parks. IFI5 We regularly use financial information consulting services provided by financial institutions.	

4.1.2 Innovation capabilities

Innovation is a process that put opportunities into practical application (Koc and Ceylan, 2007). Innovation is considered as key to the creation of competitive advantage and thereby improving performance. It equips firms with flexibility to meet market demands on a sustainable basis and thereby enhancing the possibility of long-term survival. DTI (1994) defines innovation as "the successful exploitation of new ideas." It is believed that firms that are better able to exploit new ideas superior innovation capabilities (Francis and Bessant, 2005). Firms with superior innovation capability demonstrate better capability to recognize opportunities for profitable changes (Francis and Bessant, 2005). Innovation capabilities reflect firms' ability to transform new ideas into new products, processes and services (Lawson and Samson, 2001). Innovation capabilities play a vital role in enhancing the chances for survival and growth of firms (Frishammar et al., 2012).

By integrating the previous literature, this study conceptualises innovation capabilities as four sub-components: organisational learning, idea generation, product development, process development and innovation strategy. First of all, organisational learning is an important source of innovative ideas. Second, it is suggested that the companies which are successful innovators have a source of creative ideas, and a means to process new ideas. The ability of an organisation to grow is dependent upon its ability to generate new ideas and to exploit them effectively for their long-term benefit of the organisation. Innovative ideas can originate from a broad spectrum of sources. Besides, many studies on evaluating a firm's innovation capability believe that product development and process development are core processes through which a firm converts its innovative ideas or concepts into deliveries to external customers (Chiesa et al., 1996; Christensen, 1995). Product development is primarily associated with innovative functions while process development is recognised as routine-based process improvement (Christensen, 1995).dea generation, product development process development can result from gradual learning process (Rush et al., 2007).

4.1.2.1 Organisational learning

Learning is a key dimension of building technological innovation capabilities (Rush et al., 2007). A series of studies regard learning capability as one of important components of innovation capabilities (Yam et al, 2004; Guan and Ma, 2005; Lawson, 2001). Learning process plays an important role in continuous improvement of innovation process. Some authors believe that partnering relationships contribute to learning process or firms (Barlow et al., 1998; Kale et al., 2000; Perez, 2013). Learning capability depends on exchange process between organisations (Lim et al., 2013). Close relationships promote exchange of existing knowledge and creation of new knowledge through regular interactions and information sharing (Uzzi, 1996). Partnership fosters learning as learning is a two-way process (Barlow et al., 1998). Collaborative relationships promote flexibility and provide opportunities for learning. Close ties with partners allow firms to find out problems and weaknesses quickly as well as identify opportunities for improvement. Partnership provides learning benefits as it involves regular meetings with partners. Discussions and dialogue involve the sharing and exchange of divergent thoughts, which makes learning more likely to be achieved.

Organisational learning capability refers to the firms' capability to identify opportunities for improvement as well as to learn from previous experience of successes and failures (Kogut and Zander, 1992; Spender, 1996; Calantone et al., 2002). Learning process leads to continuous improvement in effectiveness and efficiency. It sustains long-term technology development of organisations (Peter, 2012). Organisational learning involves ability to capture knowledge about dynamic environment and to identify opportunities to innovate (Duffield and Whitty, 2015). Firms that are committed to learning are more likely to possess state-of-the-art, which is associated with creation of innovative product and processes. It is less likely that they miss the opportunities brought by dynamic environment due to their capability to identify market demands and technology trends (Calantone et al., 2002). For another, organisational learning capability also involves the capability to learn from experience and integrate them into the organisations. Learning is a process of experiencing and analysing (Spender, 1996). Firms create innovative products or processes through trail-and-error learning process (Kogut and Zander, 1992). Innovation can be seen as a "probe and learn" process. Learning organisations can identify the strengths and weaknesses of competitors and learn from their successes and failures (Calantone et al., 2002).

4.1.2.2 Idea generation

In order to keep up with rapid changes of technology trends and market needs, firms need to make more efforts to manage idea generation process (McAdam and McClelland, 2002). Firms are motivated to produce new ideas to meet the acceleration of technological advancement (Kornish and Hutchison-Krupat, 2017). In order to catch up with the pace of technology development, firms need to continuously generate creative ideas to survive. Innovation process involves idea generation and transformation of ideas into marketable products or services (McAdam and McClelland, 2002).

Creative ideas provide a basis for creative products (Cooper, 2019). Ideation is usually described as “fuzzy front end” of innovation process (Holahan et al., 2014; Cooper, 2019). Frequent interactions and knowledge exchange enhance the changes to generate breakthrough ideas. innovation starts with ideas (Koc and Ceylan, 2007). Ideas are the main source of technological innovation. Idea generation is a key variable of companies’ innovation capabilities. Sowrey (1990) argue that a successful product developer is supposed to first become a successful idea generator. Knowledge exchange and technology flow is conducive to effective idea generation (Koc and Ceylan, 2007). The integration of diverse knowledge and skills leads to generation of creative ideas (Cohen and Levinthal, 1990). Science parks are external support instruments that serve as an important source of creative ideas. Ideas can be defined in different ways in different innovation areas (Drucker, 1985). Ideas might be solutions to technical problems, new concepts for product development, new techniques to improve operation process, and methods to deal with managerial issues. Kornish and Hutchison-Krupat (2017) define ideas as “discrete, or enumerated, descriptions of solutions to a problem posed.”

4.1.2.3 Product development

Product development is associated with exploitation of creative ideas (Alegre and Chiva, 2006). Intensified global competition and dynamic business environment provide a stimulus for firms to engage in product development activities. Firms develop new products to adapt to intense competition, rapid market changes and technology development (Lawson and Samson, 2001). Product development capability is the lifeblood of firms survive and compete in dynamic markets (Slater et al., 2013). Long-term survival and competitive position of firms depends on its ability to successfully develop new products and introduce them to the market (Cooper, 1998). It provides a basis for the development of innovative products or services that performance benefits. Well-integrated process of product development allows firms to achieve competitiveness in the market (Holahan et al., 2013). Innovative products lead to fast entry into the marketplace, which is associated with higher commercial value. Product innovation refers to incorporation of new ideas and concepts into products (Un and Asakawa, 2014). It is more associated with radical innovation, with incorporation of innovative ideas into products. Process innovation refers to "the introduction of a new method of production", which aims to improve quality, features, and production efficiency of products. Process innovation focus more on incremental innovation with the objective of cost reduction and efficiency improvement. Process innovation tends to improve existing concepts and methods of producing products.

Creating differentiated products that have more unique benefits than rivals enables firms to greater market share and higher profitability (Cooper, 2019). Superior products can better satisfy the needs of users, offer features, benefits or attributes that not available in rivals' products, can be easily perceived (Cooper, 2019). Technologies that improve product performance offers a foundation for creating differentiation advantage (Kerin et al., 1992). A clear understanding of market demands and competitive position is an indispensable component of innovation success. Alegre and Chiva (2006) summarise two dimensions of product innovation performance, including innovation efficacy and innovation efficiency. Innovation efficacy refers to the degree of innovation success and innovation efficiency is the effort made to achieve innovation success. This study focuses on innovation efficacy, which reflects the success of product innovation. Firms are driven by the desire to create new markets by new product development and adaptation of existing products (Boer and During, 2001). Chuang et al. (2015) measure new product capability in two dimensions, new product development competence and new product creativity. New product development competence involves capabilities associated with planning and implementation of new products. New product creativity captures novelty and meaningfulness of new products.

With shortening lifecycle of products rapid technology changes, product development capability plays an increasingly crucial role in long-term survival of businesses (Cooper, 1998). Product innovation can provide “first mover advantage”, which refers to competitive advantage of being first entering the market (Kerin et al., 1992; Cooper, 2019). First mover status is associated with higher market share than followers (Kerin et al., 1992). Speed reduces the possibility that market conditions change. It is likely that reduced cycle time of product development leads to quicker realisation of making profits (Cooper, 2019).

4.1.2.4 Process development

Process innovation has been paid less attention than product innovation in the literature as it is an intermediate outcome that lead to better firm performance (Piening and Salge, 2015). However, it remains a focal component of innovation theories, which allows firms to sustain competitive advantage (Reichstein and Salter, 2006). Process development can be considered as the introduction of new elements to firms' production or operations process, such as equipment, input materials, work practices, project management techniques etc (Reichstein and Salter, 2006). Improvements in the creation of and distribution processes of existing products or services are an important means by which organisations can respond to market changes such as growth and decline of demand, new market entry, and price adjustments by competitors (Frishammar et al., 2012).

Process development aims to improve operational flexibility, diminish costs, and improve operational efficiency and flexibility (Boer and During, 2001). It is associated with production technology, quality control, logistics, and plant design (Christensen, 1995). It is the capability to develop new or substantially improved manufacturing, supply chain and administrative processes (Piening and Salge, 2015). It involves both "hardware" assets (plants, equipment and facilities) and "systematic" assets (organisational and managerial resources in developing manufacturing or operational system). It involves developing methods or techniques that improve production or operational process (Frishammar et al., 2012). It refers to firms' ability to resources and competencies for process improvement purpose. Process improvement enables firms to reap benefits by reducing costs and increasing process efficiency. It allows firms to modify and reconfigure its operational capabilities or processes efficiency improvement (Piening and Salge, 2015). Reconfiguration of organisational processes results in superior competitive advantage and market position. Process development is increasingly seen as an important source competitiveness and organisational renewal (Frishammar et al., 2012).

Process development involves small-scale changes in processes of production and distribution. It is associated with routine operational improvements and increase in productivity (Reichstein and Salter, 2006). Positive outcomes from process development include time and cost saving, product quality improvement, process error reduction, improved productivity and increased operational efficiency and effectiveness (Bunduchi et al., 2011; Piening and Salge, 2015). Product development and process development are closely related to each other. Most new products cannot be developed and manufactured without innovation in new process technology (Frishammar et al., 2012). While product innovation refers to new end products or services introduced by a firm, process innovation reflects changes in the way firms create and deliver such products and services. Process innovation can create value by improving quality and reliability of products, enhancing process efficiency, and saving time and costs (Frishammar et al, 2012; Piening and Salge, 2015). The potential benefits of process innovation include cost and time savings, quality improvement, and productivity gains. Implementing cost-reducing production or supply chain technologies enables a firm to either retain a higher profit margin or to pass on cost savings to consumers in the form of price reductions, which may lead to higher sales and market shares.

Table 4.2. Measurement items for construct of innovation capabilities (IC)

Constructs	Items	References
Organisational learning	OL1 The basic values of this organisation include learning as key to improvement. OL2 We are skilled at identifying opportunities for improvement. OL3 Our employees can quickly detect problems or mistakes in the process of innovation OL4 We are skilled at capturing lessons learned from previous innovative activities. OL5 We are skilled at applying lessons from past experience to future innovative activities. OL6 Our employees are skilled at collaborating each other to solve problems. OL7 Our employees share information and learn from each other.	Yam et al. (2004); Rush et al. (2007); Hull and Covin (2010); Calantone et al. (2002); Jerez-Gomez et al. (2005); Chiva et al. (2007); Alegre and Chiva (2008); Hult (1998); Hult et al. (2000)
Idea generation	IG1 Creative ideas are encouraged and rewarded. IG2 Both quantity and quality of ideas generated are high. IG3 Ideas come from different departments and areas in organisations. IG4 There are policies for idea generation including all levels of organisations and supported by a reward system. IG5 Many of the ideas generated were new to the company. IG6 Many of the ideas generated were new to our existing customers. IG7 Many of the ideas generated were new to the market.	Koc and Ceylan (2007); Schulze and Hoegl (2008); Kornish and Hutchison-Krupat (2017
Product development	PD1 Our company continuously introduces new products and develops new market. PD2 Our company brings new and innovative	Lau et al. (2010); Brettel and Cleven (2011);Acur et al. (2010); Leskovar-

	products more often to market than our rivals. PD3 The percentage of new and innovative products in the product portfolio is higher than our rivals. PD4 We target a certain portion of revenue growth to come from product development. PD5 Our new product development cycle has been shorter than our rivals. PD6 Our products have more unique features than our rivals. PD7 Our products are more creative than competitors' products. PD8 Our product development use technologies never used in our industry before. PD9 Our products show an unconventional way of solving problems.	Spacapan and Bastic (2007); Im and Workman (2004); Chuang et al. (2015); Hsu and Fang (2009); Chen et al. (2014); Su et al. (2013); Lin (2007)
Process development	PcD1 We have more efficient production or operation process than our rivals. PcD2 We have lower cost of operation than competitors. PcD3 Our product development process stays within our budgeted costs. PcD4 Scheduled time is in line with development time. PcD5 We continuously generate new methods or skills for improving the efficiency of production or operation process. PcD6 We continuously generate new methods or skills for cost-saving. PcD7 We are creative in methods or skills for managing operational process. PcD8 We are flexible to capacity changes than competitors	Acur et al. (2010); Ning and Li (2016); Dyler and Song (1998); Su et al. (2009); Slack and Lewis (2008); Kessler and Chakrabarti (1996)

There are some potential threats and limitations related to the constructs identified in this study. It is hard to capture the full breadth of networking activities with academic institutions, co-located firms, technology intermediaries and financial institutions. Many studies employ only published measures to ensure construct validity. However, if only published measures are adopted, the research area does not move forward in new directions. New items are designed for measuring interaction with technology intermediaries and financial institutions. The existence of risk associated with development of new scales cannot be ignored. Some studies design multi-dimensional models for measuring organisational learning capability. This study just measures it as a first-order construct. As for idea generation, some firms can generate creative and commercially valuable ideas, but they are unable to transform them into new products or services. The correlation between idea generation and other dimensions of innovation capabilities might be not high enough, which is a challenge to convergent validity of higher-order construct. Moreover, the measures underlying the constructs of product development and process development are likely to be highly correlated with each other, which may do harm to construct validity.

4.2 HYPOTHESES DEVELOPMENT

4.2.1 Hypotheses for overall-effect model

4.2.1.1 The impacts of ESPCN on innovation capabilities and financial performance

Engagement in science park collaborative network (ESPCN) is expected to exert positive impacts on innovation capabilities and financial performance of tenant firms. The measurement scale has been generated already. In this study, the indicators for measuring financial performance of science park firms include return on asset, return on investment, sales and profitability. Those four measures have been adopted by previous studies (Cao and Zhang, 2011; Flammer, 2015; O'Neil et al., 2016). This study develops a multi-dimensional construct for measuring innovation capabilities of firms instead of common innovation performance indicators such as patents, R&D investment and R&D intensity. It also examines the impacts of science park collaboration network on financial performance, which how science parks create commercial benefits for tenants apart from innovation benefits. The role of science park ecosystem in generating economic value for resident firms can be identified. The study can extend the literature by examining the relationships between science park collaboration network, innovation capabilities and financial performance of firms.

Science park can be seen as an integrated network connecting industrial firms, academic institutions, and other types of institutions. A hybrid network of public or private organisations with the provision of information, expertise and capital is the seedbed for local innovation success (Etzkowitz and Klofsten, 2005). The provide foundations for interactive synergies and collaborative network between individuals or organisations involved in science park ecosystem (Rodriguez-Pose and Hardy, 2014). They nurture an environment conducive to innovation by providing financial support, assistance in technological development, value-added business services, access to high-qualified talents etc. Teece (1986) stress the importance of complementary capabilities for firms' innovation. Firms may confront the problems related to lack of knowledge regarding production and marketing of innovations. Science parks, which are technologically dynamic areas, allows for the combination of diverse and complementary resources. Location on science parks solves the liability of "newness" and "smallness" due to the availability of intensive resource network (Gwebu et al., 2018). Based on resource-based view (RBV), valuable, rare and inimitable resources are sources of competitive advantage (Barney, 1991). Engagement in science park network can be seen as scarce, valuable and non-imitable resources, that can create sustainable competitive for tenant firms. Co-located organisations or institutions can provide tenant firms with complementary resources including information, knowledge, skills, customer market etc (Gwebu et al., 2018). Technological breakthroughs can be generated through the integration of existing knowledge based and knowledge acquired from external actors (Rodriguez-Pose and Hardy, 2014).Science parks provide resource-rich and opportunity-rich environment that allows resident firms to achieve sustained competitive advantage (Gwebu et al., 2018).

Resource-based view indicates that valuable, rare, non-inimitable resources can lead to creation of competitive advantage (Barney, 1991). Science park collaborative network can be seen a bundle of resources which helps tenants achieve competitiveness in the market. Network relationships with other science park actors enable tenants to access resources that are inimitable to some degree and as are context-specific and difficult to replicate. Knowledge-based view suggests that knowledge is the source of competitive advantage (Grant, 1996). Firms can get quick access to knowledge, information or technology required by development of new products or services by closely interacting with different organisations on science parks. According to dynamic capabilities theory, the ability to integrate and reconfigure external and internal resources to respond to environmental dynamism (Teece et al., 1997). Resource and knowledge accumulation of science parks allows tenant firms to cope with threats associated with dynamic environment (Gwebu et al., 2018). Science parks offer tenants opportunities to adapt to fast-changing business environment. Camagni (1991) regards collective learning as the heart of an innovative milieu. Science parks can be seen as an innovative milieu in which a coherent set of territorial relationships involving different actors are developed.

Knowledge-based firms benefit the most from location on a science park in terms of knowledge spillover (Lawson and Lorenz, 1999). Science parks are innovative milieu that depend on knowledge spillover, resource sharing and technology transfer (Gwebu et al., 2018). A single site agglomerates academic institutions, SMEs and large firms, young and established companies, and knowledge-intensive business services, financial agencies, building an innovative community (Benneworth, 2014). Science parks are spaces that function as a bridge between academic community and business community. Academic institutions on science park ecosystem are important sources of high-skilled workforce and scientific and technological knowledge (Benneworth, 2014). Science park contribute to the formation and development of high-technology business network. Technology intermediaries, such as industrial associations, business alliances, technology assessment centres, talent resource centres, training institutions etc., In China, science park attract the influx of financial institutions to locate on science parks, which ensure continuous financial support for innovation activities of tenant firms.

Geographical proximity plays an important role in creating synergy effects, which arise from common cultural, psychological, social context (Keeble et al., 1999). Geographical proximity contributes to constructing commonly accepted rules and procedures, which is conducive to seeking solutions to common problems (Keeble et al., 1999). According to Porter (1998), geographical proximity and repeated interactions between actors in one region foster more efficient collaborations. It is essential to create a common language to discuss technological issues (Keeble et al., 1999). Camagni (1991) stress the emergence of common language which helps firms translate external knowledge into information that the firm an understand. Common language is necessary for coordination of decision making. The success of R&D linkages requires spatial proximity and a common language (Breznitz, 2011). Relationships of trust and reciprocity are the basis for technology and knowledge diffusion as well as technological innovation development. Trust-based relationships reduce the risk associated with innovation activities. Shared cultural background and geographical closeness provide a foundation for collaborative innovation (Breznitz, 2011).

Geographical proximity provides firms easy access to tacit knowledge, which is important for sustainable competitive advantage (Lawson and Lorenz, 1999). Tacit knowledge is difficult to transfer without informal and personal contacts. Transfer of tacit knowledge is concentrated within technology-intensive regions (Lawson and Lorenz, 1999). According to knowledge-based theory, knowledge is the core of firms' competitive advantage (Kogut and Zander, 1994). Science parks are institutional frameworks that play an important role in facilitating knowledge transfer and dissemination (Shearmur and Doloreux, 2000). High-technology sectors rely on the knowledge and information related to rapid response to fast-changing markets and technology to a larger degree (Shearmur and Doloreux, 2000). Spatial proximity is a contributing factor to network formation (Ter Wal and Boschma, 2009). It allows for face-to-face interactions, frequent contacts and close interpersonal linkages, which reduces the transaction costs of technical knowledge (Rodriguez-Pose and Hardy, 2014). Localised knowledge network allows firms to identify new knowledge and innovation opportunities with diminished transaction costs (Ter Wal and Boschma, 2009). Therefore, the following hypotheses are proposed:

H1: Engagement in science park collaborative network have positive and significant impacts on innovation capabilities of science park firms.

H2: Engagement in science park collaborative network have positive and significant impacts on financial performance of science park firms.

4.2.1.2 The impacts of innovation capabilities on financial performance of tenants

In order to adapt to rapid technological change, firms need to have control of essential resources and capabilities to cope with such adaptations (Rothaermel, 2001). Innovation capabilities provide firms with first mover and lead market advantages. Firms have a preferential position in achieving competitive superiority, leading to long-term profitability. New product development allows firms to acquire technological leadership, which lead to high profits in the long run. Innovation is valuable, rare, difficult to imitate and difficult to substitute resources, which is a source of firms' competitive advantage (Barney, 1991). Innovation is valuable as it satisfies market demands. Innovation is difficult to imitate, as the underlying tacit knowledge is difficult to transfer and replicate. Innovation is difficult to substitute because of its path-dependent and context-specific nature.

Although innovation is a risky process, it leads to long-term business growth. The development of new products and technology can lead to generation of economic value and has been viewed as engine of business growth. Innovation activities are expected to generate new products and create new markets (Damanpour et al., 2009). A series of studies provide evidence that innovations have positive influences on firm performance (Parisi et al., 2006; Kostopoulos et al., 2011; Beers and Zand, 2014). Bigliardi (2013) the study of Kostopoulos et al. (2011) shows the positive linkage between innovation performance and financial performance of firms. Innovations permit firms to achieve first-mover advantage, target premium market segments, and keep ahead of the rivals (Wiklund and Shepherd, 2003). The benefits for first movers are larger than their competitors in high-technology sectors (Banburry and Mitchell, 1995). First-mover advantage can lead to dominant market position of firms. They can achieve brand recognition and dominate distribution channels. Speed of product development is important for firms as a result of shortened product lifecycle and intensified business competition (Langerak and Hultink, 2006). Thus, the hypothesis is proposed as below.

H3: Innovation capabilities have positive and significant impacts on financial performance of science park firms.

4.2.2 Hypotheses for individual-effect model

4.2.2.1 The impacts of academic-industry collaboration

Science parks provide a platform for transfer of technology from academic institutions to industrial firms. They are regarded as mechanisms for facilitating knowledge diffusion and dissemination between public and private community. Innovation competencies are enhanced through dense network between public and private sectors (Peters et al., 1998). The industrial sector stimulates public sector research to develop knowledge for technological innovation that meet market demands. Several studies support the view that firms can benefit from geographical proximity to universities (Jaffe et al., 1993; Antonelli, 2000). Maietta (2015)'s research implies that spatial proximity is positively related to firms' innovation. Technology transfer can be realized formal collaborative research or knowledge spillover. Geographical closeness enables science park firms to develop close linkages with universities, which is associated with transmission of tacit knowledge. Entrepreneurs can maintain face-to-face contact with academics or researchers, allowing for communication of useful information that is tacit and has not yet been published. Tacit knowledge is difficult to interpret and exchange, which is difficult for competitors to imitate

The major benefit of developing close relationships with universities or research institutions is access to highly skilled and highly qualified scientists or researchers (Arza, 2010). Universities or research institutions are important sources of scientific and technological knowledge. They are ideal partners for businesses to achieve and sustain competitive advantage because of their ability to integrate knowledge of different fields. In order to cope with acceleration of technological change, firms are increasingly aware of the importance of developing partnerships with academic world. Businesses can get access to state-to-the-art research, which strengthens their knowledge base (Bishop et al., 2011). Firms can exploit new knowledge and discoveries generated by the latest scientific research. They can identify sources of innovative ideas for R&D activities. Universities encourages the exploration of the unknown territory. Collaborative projects with universities explore new avenues of innovation (George et al., 2002). R&D partnerships with academia promote technological upgrading of business community. Firms can seek commercialization of cutting-edge research from academic institutions, which contributes to firms' technological upgrading (Soh and Subramanian, 2014).

Collaboration with academic community fosters product development and process innovation. Firms can benefit from joint R&D projects with regard to both product-oriented research and exploratory "blue sky" research (Lee, 2000). Combination of academia and businesses' knowledge base can lead to generation of innovative products and processes (George et al., 2002). George et al. (2002)'s study implies that linkages between industry and academia is positively associated with innovative output of firms. The research of Belderbos et al. (2004) reveals that academic-industry linkages have positive impacts on sales from innovative products. Firms can exploit knowledge or technology obtained from their academic partners to improve their ways to innovate. Face-to-face interactions with academics provide direct support with problem solving, which accelerate product development of companies (Perkmann and Walsh, 2009). Academics can provide assistance with tacking technological bottlenecks when develop new products or processes. Firms can seek advice from academic researchers with regard to specific problems in R&D and production process.

More and more scholars pay attention to the "the third mission" of universities in addition to education and research (Etzkowitz and Leydesdorff, 2000). Universities have evolved from focusing on fundamental research to seeking connections with commercial community. They play an increasingly important role in fostering economic benefits for firms. However, compared with impacts on innovative performance, the evidence with regard to the positive impacts of academic-industry linkages on financial performance is limited. The findings of George et al. (2002) indicate that academic partnership is not positively related to firms' financial performance. The results of Guan et al. (2007) demonstrate weaker impacts of linkages with academics on profit and sales compared to impacts on innovation. Eom and Lee (2010) have not found positive impacts of cooperation with research institutions. Conversely, Bishop et al. (2011) argue that linkages with scientific community can boost the improvement of firm performance. Sharing of valuable resources or assets decrease firms' expenditures. Collaboration with academics enables industrial firms to get access to state-to-the-art equipment and facilities required in R&D activities, which lead to reduction in overall costs and increase in profits. Support regarding problem solving and technological development, provided by academic experts, allowing firms to speed up their innovation development cycle. Firms can achieve "first-mover" advantage in the marketplace. As a result, expansion of market share and business growth can be realized by firms. Integration of scientific knowledge obtained from academia facilitates the generation of new products or processes, which is the key to maintain and strengthen competitive advantage. Thus, the impacts of academic-industry collaboration on financial performance of science park firms is expected to be positive. The following hypotheses are proposed.

H4a: Academic-industry collaboration has positive and significant impacts on innovation capabilities of science park firms.

H4b: Academic-industry collaboration has positive and significant impacts on financial performance of science park firms.

4.2.2.2 The impacts of inter-firm collaboration

Considering the increasing complexity of technology and knowledge intensity of high-tech industries, it becomes more and more difficult for firms to develop innovation on their own. Geographical proximity encourages firms to open up certain activities that foster technological innovation and technology commercialization (Benko, 2000). Science parks provide a supportive environment for the development of long-standing relationships between tenant firms. According to Lorenzoni and Lipparini (1999), spatial proximity and long-term and stable relationships are determinants of benefits derived from external network. Science parks ecosystem provides opportunities of interactive learning and collaborative innovation for firms. Firms that have insufficient resources to conduct R&D activities individually can seek linkages with other firms in similar sector located on science parks. Intense inter-firm network in science parks favours knowledge dissemination, technology diffusion and collective learning. Spatial closeness and frequent contacts foster mutual trust, which contributes to the ideal results of collaborative relationships to a large degree. Common knowledge and common background allow them to have a better understanding of the knowledge they share (Bell, 2005).

Not all of firms have all required resources for developing new products or processes. Firms can gain access to complementary resources, skills and knowledge through developing relationships with other firms (Lin and Lin, 2016). They can employ network relationships to compensate for their resource deficiencies in knowledge, technology, equipment and facilities. Inter-firm relationships allow for sharing of knowledge and enlarge firms' knowledge base. Such relationships help firms overcome the scarcity of internal resources. Access to partners' novel ideas or technology fosters generation of new knowledge or technology relevant to product or process innovation. The synergies in R&D and production systems accelerate innovation speed, which enhances the likelihood of achieving technological leadership in the market (Tomlinson, 2010). The coordination of resources and knowledge speeds up problem-solving process. Synthesis of knowledge domains allows for rapid solution to specific problems and fast access to appropriate technology. The integration of multiple knowledge bases through business network facilitates the creation of new knowledge and new product development. Firms can combine knowledge acquired from their partners with existing knowledge. The new combinations lead to superior innovativeness. They can capture and respond to market changes rapidly and produce products which better satisfy market needs. Love and Rogers (2004) have found evidence that inter-firm network is positively related to growth rates of innovation. The study of Najafi-Tavani et al. (2018) shows that collaboration with competitors has positive impacts on innovation capabilities. Shan et al. (1994) and Ahuja (2000) provide evidence for the positive relationship between patents and collaborative relationships with other firms.

It is vital for firms to develop and maintain relationships with partners to survive and grow in modern fast-changing markets. Inter-firm relationships help firms identify emerging market opportunities promptly and expand market knowledge (Lin and Lin, 2016). Creation of innovative products and expansion into new markets always involves high risk. Firms can reduce and manage the risk and challenges through collaborative arrangements with partners. Collaborative partnerships bring together firms with bundles of distinctive resources and assets (Konsti-Laakso et al., 2012). Thus, engagement in inter-firm cooperation can help firms identify and adapt to rapid market changes and technological changes, reducing the possibility of market failures. Network relationships provide opportunities for firms to expand market reach (Goes and Park, 1997). In a short, inter-firm collaboration allow for the achievement of greater market power and superior competitive position.

In addition, business network is associated with reduction in costs and increase in supply chain efficiency. Firms can spread costs involved in R&D and innovative projects through embeddedness in partnerships. They can access suitable technology or resources at lower costs (Baum et al., 2000). Song et al. (2016) suggest that inter-firm alliances improve cost-efficiency when develop new product technologies. Firms can transform knowledge into innovations in a more cost-efficient way. In the context of rapid technological change, Integration of operation process induces minimization of transaction costs and efficiency maximization, contributing to sustainable competitive advantage (Lin and Lin, 2016). Synergy benefits are generated and economies of scale are achieved by integration of core competencies (Goes and Park, 1997). Costs, risk, and time associated with innovation-related activities are shared with partners. In summary, firms can gain competitive superiority by building close ties with partners. Benefits derived from collaboration between science park firms are hypothesized to enhance their financial outcomes, which is shown as below.

H5a: Inter-firm collaboration has positive and significant impacts on innovation capabilities of science park firms.

H5b: Inter-firm collaboration has positive and significant impacts on financial performance of science park firms.

4.2.2.3 The impacts of interaction with technology intermediaries

Technology intermediaries is a key actor within innovation ecosystem of science parks. They sit at the intersection of various actors, which are able to locate knowledge more promptly and process knowledge professionally (Lin et al., 2016). Innovation is a cooperative process, which strengthens the role of intermediaries in collaboration building (Inkinen and Suorsa, 2010). Technology intermediaries play an important role in facilitating networking and collaboration between firms and institutions within high-technology regions (Inkinen and Suorsa, 2010). They contribute to mutual learning process, which is favorable for generation of creative ideas and new knowledge (Lin et al., 2016) Technology intermediaries develop and maintain linkages with different actors, which enables their clients to get access to a large pool of knowledge from different sources.

Intermediary institutions can be regarded as a knowledge repository that collects and integrates various sources of knowledge (Hargadon and Sutton, 1997). Interaction with technology intermediaries increases the likelihood to speed up innovation process (De Silva et al., 2018). Many of firms on science parks are small and medium sized, which lack sufficient knowledge or resources to develop innovation. Intermediary intervention can bridge a variety of knowledge and resource gaps (Goes and Park, 1997). Identification of suitable technology and right partners is always difficult for firms. The support of intermediaries helps them locate suitable knowledge or technology more easily. The combination of knowledge bases of different actors allows for the prompt identification of knowledge or technology solutions for their clients (Parker and Hine, 2014). Linkages with intermediaries is conducive to the improvement of firms' problem-solving ability. The speed of introducing new products to market can be increased due to faster problem-solving process. Knowledge acquired from intermediaries can be transformed into superior innovation achievement (Lin et al., 2016; Knockaert and Spithoven, 2014). Lin et al. (2016) provide evidence that cooperation with technology intermediaries can significantly improve innovation performance of firms.

Knockaert and Spithoven (2014) have found positive relationships between links with technology intermediaries and innovation speed of firms.

Businesses that develop close network relationships with technology intermediaries can mitigate transactional inefficiency in the marketplace (Goes and Park, 1997). High transaction costs pose a barrier to in potential transactions in technology markets (Lichtenthaler, 2013). Intermediary intervention helps to overcome obstacles associated with market inefficiencies. Their function of technology scanning and information intelligence allows their clients to reduce external search costs. Their access to large pool of knowledge across diverse domains mitigate the imperfections in technology markets (Lichtenthaler and Ernst, 2008). Such relationships can be seen as a key enabler for maximizing the efficiency of technology markets.

Intermediaries improve firms' ability to appropriate benefits from innovation activities (Knockaert et al., 2014) through services such as information scanning, partner selection, market research, training, IPR protection etc. Ties with intermediaries leads to the extension of firms' market knowledge (Lichtenthaler, 2013). Intermediary institutions can identify profitable markets for innovations developed by firms. They can support technology commercialization by market analysis (Lichtenthaler and Ernst, 2008). They can provide assistance in coping with market failures of clients' R&D investments. The integration and recombination of available resources or knowledge adapt their products or services to market changes and technological development (Howells, 2006). Clients to capitalize quickly on market opportunities. It can be expected that interaction with technology intermediaries enable firms to accelerate innovation process and achieve cost savings, which will be transformed into superior profitability and competitive advantage. Therefore, the following hypotheses are proposed as below.

H 6a: Interaction with technology intermediaries has positive impacts on innovation capabilities of tenants.

H 6b: Interaction with technology intermediaries has positive impacts on financial performance of tenants.

4.2.2.4 The impacts of interaction with financial institutions

Innovation is associated with high risk brought by unanticipated market demands and changeable technology markets (Guan et al., 2007). The government and science parks provide various sources of funding in support of R&D and innovation activities of tenant firms through financial institutions, including governmental funding, venture capital, loans, foundation etc. In addition to funding support, financial institutions also provide science park firms with a broad range of financial services, including investment decision-making, asset management, risk management, online financial services, etc. Knowledge stock of financial institutions allows them to provide better advice for their clients regarding their financing, investment and resource allocation decisions (George and Prabhu, 2003).

Support from financial institutions is of critical importance for innovation success, especially technology-based SMEs, as innovation involves high risk and high costs. One of the major obstacles to innovation is shortage of finance (Yigitcanlar et al., 2018). Insufficient finance is a key barrier to firm innovation and firm growth (Fowowe, 2017). The assistance provided by financial institutions is crucial for converting innovative ideas into commercialized innovations, which is key to achieving competitive advantage in the market. Financial institutions play an important role in assisting firm in expanding their technology resources (Geroge and Prabhu, 2003). The expansion of operations, research and development, recruitment of high-qualified talents, and investment in equipment and facilities are unlikely without sufficient funding. O'Suillivan (2005) identify three factors that give rise to high costs of innovation: resources, timing and uncertainty. Innovation process is complex, which requires human resources from different functional departments to be involved in this process. It is widely agreed that innovation is time-consuming process. It is hard for firms to obtain immediate commercial returns from innovation process. Financial support should be sustained from idea generation to introduction of new products to market. Generally, innovation process involves high risk and uncertainty. It is difficult to estimate the funding required for innovation accurately.

Science parks can ensure financial support for tenants by attracting financial institutions to locate on parks, supporting the innovation activities of firms (European Commission, 2013). The functions of financial institutions go beyond provision of finance that relax investment constraints (Lahr and Mina, 2016). Tenant firms can also benefit from a wide range of services, such as evaluation of investment projects, resource mobilization, risk management (King and Levine, 1993). Financial institutions contribute to acceleration of technological innovation, reduction of information cost, and business growth in the long run. Continuous sources of finance improve the likelihood of survival and growth of tenant firms.

Several empirical studies provide evidence that access to finance is an important determinant of innovation performance and business growth. Li (2009) believe that financial institutions and banking system influence innovation and catch-up rate of emerging economies. The results of this study suggest that support from financial institutions have important implications for innovation efficiency. The findings of Girma et al. (2008) indicate that firms with good access to domestic bank loans has superior innovation capacity. Using data of 17 EU countries, Faria and Barbosa (2014) find that venture capital increases number of patent applications. Chemmanur et al (2011) find a positive association between venture capital and total factor productivity. Fowowe (2017) provide evidence that the constraint of access to finance has a negative and significant impacts on firm growth. Therefore, following hypotheses are proposed.

H7a: Interactions with financial institutions has positive and significant impacts on innovation capabilities of science park firms.

H7b: Interactions with financial institutions has positive and significant impacts on financial performance of science park firms.

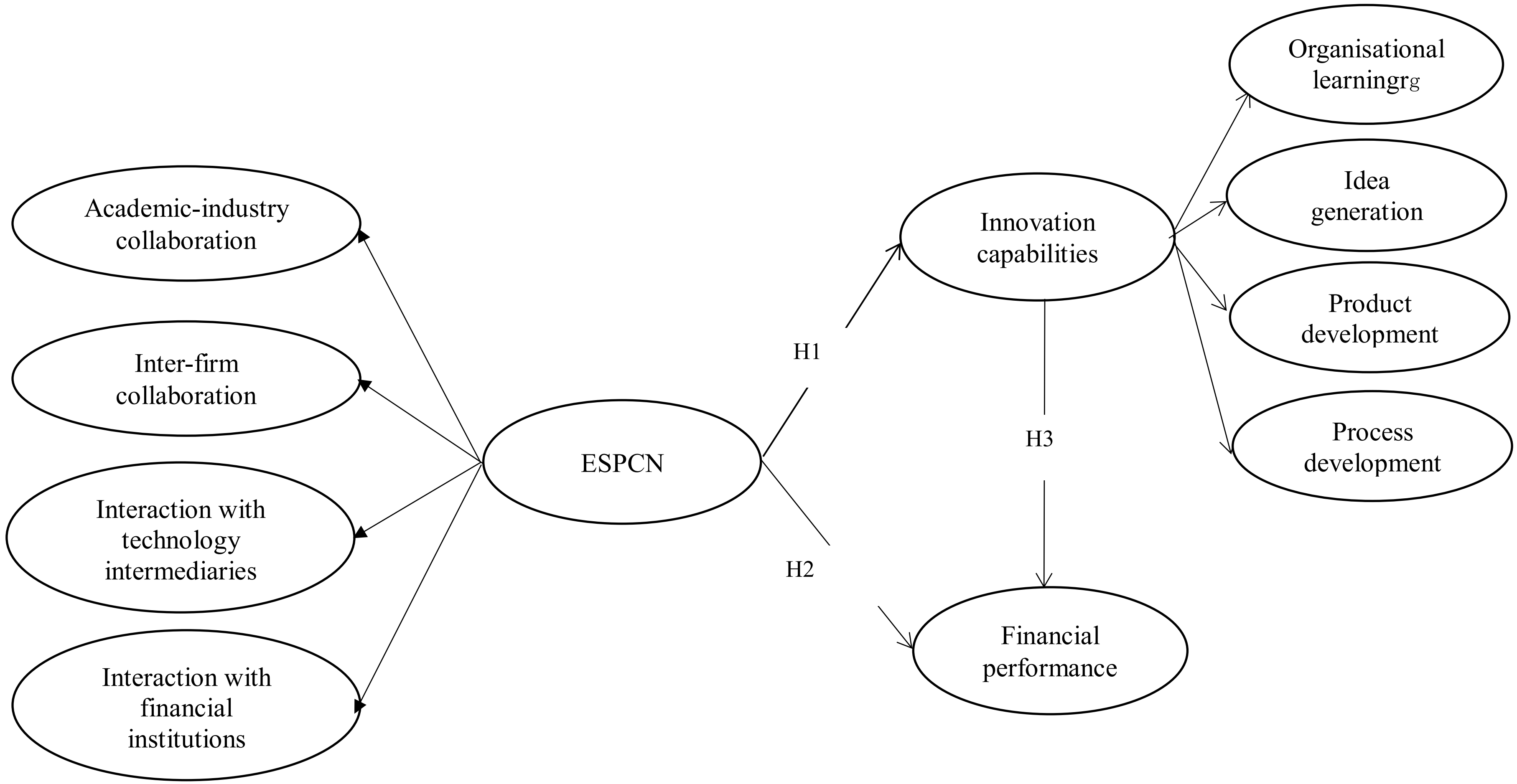


Figure 4.2. Overall-effect model

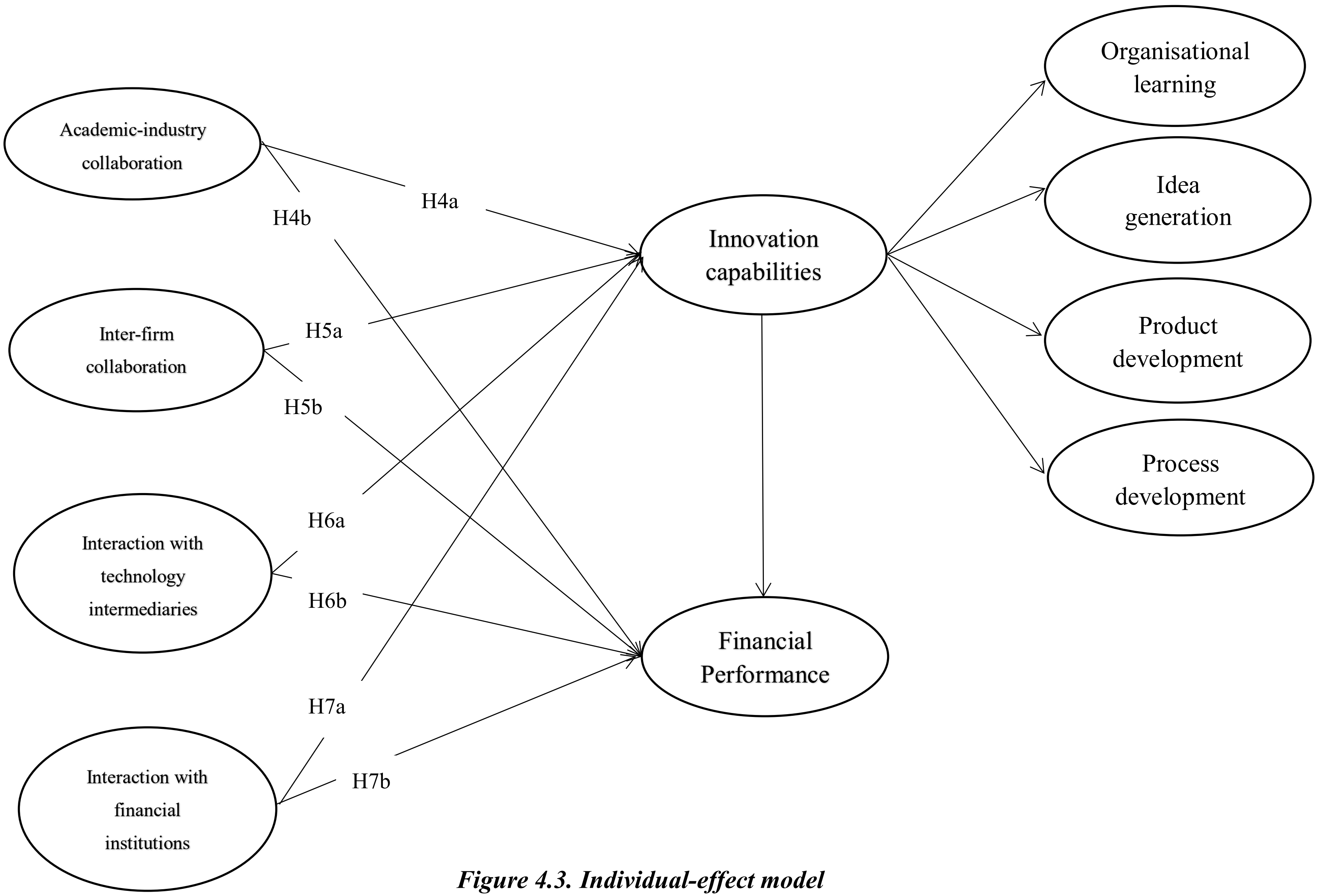


Figure 4.3. Individual-effect model

4.4 CONCLUSION

This chapter has proposed a theoretical model that demonstrates the relationships between ESPCN, innovation capabilities and financial performance of science park firms. ESPCN and innovation capabilities are proposed as two multi-dimensional constructs. ESPCN construct is composed of four dimensions, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, interaction with financial institutions. Four sub-factors constitute innovation capabilities construct, which are firms' capabilities of organisational learning, idea generation, product development and process development. Two structural models are developed in this chapter, including the model that examines the overall effect of ESPCN on innovative and financial outcomes of tenant firms as well as the model that assesses individual effects of ESPCN dimensions on tenants. This chapter has also come up with hypotheses to test the impacts of ESPCN and four dimensions of EPSCN on tenant firms. Next chapter will focus on examining the reliability and validity of the measurement scales of ESPCN and innovation capabilities as well as that of two structural models.

CHAPTER 5 DATA ANALYSIS

5.1 INTRODUCTION

Following the process of data collection, the researchers should move on to the stage of scale validation. Exploratory factor analysis (EFA) is performed in the first place, which involves empirical appraisal of the underlying factor structure. It helps group a large set of items into a smaller number of meaningful latent variables. Researchers usually use EFA to identify items that do not reflect the construct they are designed to measure as well as items that strongly load on more than one constructs.

Confirmatory factor analysis (CFA) is typically used by researchers after the test of the instrument scale using EFA. An alternative method is to conduct a CFA to validate a series of theoretically driven items without the prior test of EFA. However, according to Byrne (2001, p.99), "the application of CFA procedures to assessment instruments that are still in the initial stages of development represents a serious misuse of this analytic strategy". In CFA, the items are constrained to load on only one factor. EFA is able to identify items that measure no factor, one factor, or two or more factors. It is argued that EFA can discover the correct factor structure satisfactorily in most cases (Worthington and Whittaker, 2006). Thus, it is logical to explore the factor structure by means of EFA before performing CFA regardless of how the researcher believe the items reflect the underlying theoretical constructs. The main purpose of CFA is to measure the degree to which the measurement model fits the sample data. And then, structural model will be tested and hypotheses will be examined.

5.2 Q-SORT

After the generation of an initial list of measurement items based on literature review, two academics and two practitioners were invited to participate in the sorting process. In the first round, two academics were requested to sort question items into corresponding constructs and a non-applicable (NA) category. The NA category was included to prevent the respondents from forcing the placement of any item into a particular category. All items were mixed in a common pool. Before the start of the sorting process, the researcher explained the meaning and definition of each of the constructs.

The sorting result was evaluated using three measures. First, inter-judge raw agreement score is the number of items that judges agree to place into a target construct divided by the total number of items. Second, item placement ratio (hit ratio) is number of items that are placed into the target category divided by twice the total number of items. Finally, Cohen's Kappa as a measure of agreement can be interpreted as the proportion of joint judgement in which there is agreement after chance agreement is excluded. The result shows that inter-judge raw agreement score and Cohen's Kappa score have been greater than acceptable level (Landis & Koch, 1977). A score greater than 0.65 has been considered acceptable by several researchers (Landis & Koch, 1977). The score greater than 0.75 is considered as an excellent agreement level (Nahm et al., 2002). The items classified in a construct different from the target constructs were identified, reworded or removed. Two practitioners, who are managers of two York Science Park firms, were involved in the second round of Q-sort. The procedure explained in first round of sorting was repeated. The second-round sorting yielded satisfactory results, which indicates an acceptable level of reliability and validity of constructs. Hence, the Q-sort method was terminated after round two. The results of Q-sort have been presented in Table 5.1.

Table 5.1 Result of Q-sort

Construct	Items	Q-sort result
Academic-industry collaboration	AIC1 Scientists or students are often involved in our R&D projects.	Keep
	AIC2 We maintain close ties with universities or research institutions to obtain information about the latest technological trends.	Keep
	AIC3 We have close cooperation with universities or research institutions to develop new product technologies.	Keep
	AIC4 We involve academics actively in product development.	Removed
	AIC5 We have close cooperation with universities or research institutions to solve technical problems.	Keep
	AIC6 We have close cooperation with universities or research institutions to speed up product development process.	Keep
Inter-firm collaboration	IFC1 We maintain close ties with other tenants on science parks.	Keep
	IFC2 We regularly share and exchange information about the latest technological trends with other tenants.	Keep
	IFC3 We regularly cooperate with other tenants to develop new product technology.	Keep
	IFC4 We regularly cooperate with other tenants to solve technical problems.	Keep
	IFC5 We regularly cooperate with other tenants to speed up product development process.	Keep

Interaction with technology intermediaries	ITI1 We have close ties with technology intermediaries of the science park. ITI2 We regularly involve technology intermediaries in our innovation process. ITI3 We regularly participate in conferences or meetings organised by technology intermediaries of science park. ITI4 We usually find collaborative partners through technology intermediaries of science park. ITI5 We regularly search talents through technology intermediaries of science park. ITI6 We regularly use technology assessment services provided by technology intermediaries. ITI7 We regularly use training services provided by technology intermediaries.	Keep Removed Keep Keep Keep Keep Keep
Interaction with financial institutions	IFI1 We have close ties with financial institutions of the science park. IFI2 We regularly use financing services provided by financial institutions on science parks. IFI3 We regularly use investment decision-making services provided by financial institutions on science parks. IFI4 We regularly use capital management services provided by financial institutions on science parks. IFI5 We regularly use financial information consulting services provided by financial institutions.	Keep Keep Keep Keep Keep
Organisational learning	OL1 The basic values of this organisation include learning as key to improvement. OL2 We are skilled at identifying opportunities for improvement. OL3 Our employees can quickly detect problems or	Removed Keep

	mistakes in the process of innovation OL4 We are skilled at capturing lessons learned from previous innovative activities. OL5 We are skilled at applying lessons from past experience to future innovative activities. OL6 Our employees are skilled at collaborating each other to solve problems. OL7 Our employees share information and learn from each other.	Keep Keep Keep Removed Removed
Idea generation	IG1 Creative ideas are encouraged and rewarded. IG2 Both quantity and quality of ideas generated are high. IG3 Ideas come from different departments and areas in organisations. IG4 There are policies for idea generation including all levels of organisations and supported by a reward system. IG5 Many of the ideas generated were new to the company. IG6 Many of the ideas generated were new to our existing customers. IG7 Many of the ideas generated were new to the market.	Removed Keep Keep Removed Keep Keep Keep
Product development	PD1 Our company continuously introduces new products and develops new market. PD2 Our company brings new and innovative products more often to market than our rivals. PD3 The percentage of new and innovative products in the product portfolio is higher than our competitors. PD4 We target a certain portion of revenue growth to come from product development. PD5 Our new product development cycle has been shorter	Keep Keep Keep Removed Keep

	than our competitors.	
	PD6 Our products have more unique features than our competitors.	Keep
	PD7 Our products are more creative than competitors.	Removed
	PD8 Our product development use technologies never used in our industry before.	Keep
	PD9 Our products show an unconventional way of solving problems.	Removed
Process development	PcD1 We have more efficient production or operation process than our rivals.	Keep
	PcD2 We have lower cost of operation than competitors.	Removed
	PcD3 Our product development process stays within our budgeted costs.	Removed
	PcD4 Scheduled time is in line with development time.	Removed
	PcD5 We continuously generate new methods or skills for improving the efficiency of production or operation process.	Keep
	PcD6 We continuously generate new methods or skills for cost-saving.	Keep
	PcD7 We are creative in methods or skills for managing operational process.	Keep
	PcD8 We are flexible to cope with emergencies emerged in operational process.	Reworded

5.3 QUESTIONNAIRE DESIGN

5.3.1 Questionnaire translation

The questionnaire will be sent to managers of Chinese companies, so it is necessary to translate the questionnaire into Chinese version (Beaudart, 2017). The author got in touch with two

Chinese researchers who has overseas educational background. They translated the Chinese questionnaire back to English. The aim is to ensure that the question items state what the original items express. The author compared the original version and re-translated version of questionnaire. There is no obvious change between the two versions of questionnaire. That is to say, the Chinese questionnaire can demonstrate the meaning of original questionnaire.

5.3.2 Pilot test

Following two rounds of Q-sort, a pilot study was conducted with two practitioners of Beijing Zhongguancun Science Park before sending out questionnaires in a large number. The questionnaire was further modified according to the suggestions given by the experts. Piloting is not solely to do with trying to ensure that survey questions operate well; it also has a role in ensuring that the research instrument as a whole functions well. It may be possible to identify questions that make respondents feel uncomfortable and to detect any tendency for respondents' interest to be lost at certain junctures. Sequencing of questions is important to increase response rate and it is better to start with easy, non-threating non-sensitive questions. According to Marshall (2005), there are sensitive questions to pose, they are best placed towards the end of a questionnaire. Thus, sensitive question items regarding the financial performance of science park firms were placed at the end of the questionnaire. Easy questions regarding the background information about the respondents and the company in which they work at were placed at the start of the questionnaire.

5.4 LARGE-SCALE SURVEY

A questionnaire was distributed to collect responses from managers of firms located on science parks in Beijing and Shanghai. The questionnaire was sent to managers of firms on science parks in Beijing by WeChat while it was sent to firm managers in Shanghai science parks by email. The questionnaire was sent to contacts by email or WeChat (as shown in Appendix 1, p.272). The target respondents are firms in ten industrial sectors.

Apart from the items to measure the constructs, the survey instrument is also designed to collect information about the respondents, characteristics of the companies in which they currently work. Background questions provide demographic and socio-economic information on the individual or firm. At the individual level these include gender, age, and position; while at the level of the firm it includes evidence on the industry in which the firm operates, the number of staff employed, the number of years since the firm established, and the ownership of the firm. Financial performance is measured by return on assets, return on investment, profitability, and sales. The questionnaire just focuses on financial performance over last two years. A large proportion of firms located on science parks are start-ups. It is difficult to collect enough responses if the questions focus on a longer period of performance.

Table 5.2 shows the information about respondents and firms they are affiliated to, including gender, age, and position of respondents, as well as industrial sector, ownership, age, and size of sample firms. Respondents who are not included in those five types of positions and firms that are younger than 2 years old are eliminated. CEOs, R&D managers, production managers, operation management managers and marketing managers are closely associated with innovation activities of firms. They are able to understand and answer the questions.

The questionnaire was sent out on a large scale. The target respondents are CEOs or senior managers of firms located at science parks in Beijing and Shanghai. Since the late 1980s, science parks have been established in major Chinese metropolises under the Torch program, which is an important science and technology initiative by the Chinese government. Through years of investment and effort, more than 100 science parks have been established in China. Science parks in Beijing and Shanghai were selected as the sample. Beijing Zhongguancun Science Park is well known as the most successful science park in China. Many of China's high-technology companies and multinational firms' Chinese headquarters are located within Zhongguancun Science Park (Zhang et al., 2012). Shanghai Zhangjiang Science Park is the Pharmaceutical Hub in China, which is one of China's first state-level high-tech zones approved by the State Council (Ding and Lu, 2010).

In order to improve the response rate, 10 secretary-generals of a range of Zhongguancun's industry alliances have been contacted by telephone to ask for their help in sending out the questionnaire. One of them were very kind to accept my request. In March, the researcher went back to China and made some progress in data collection after meetings with the managers of Industry Alliance. The researcher planned to send out the question items by means of email originally. However, the manager of Industry Alliance said that he can add the researcher to several WeChat groups of managers of Zhongguancun Science Park firms. He suggested that the questionnaire could be shared as a link in the groups. After he added the researcher into three WeChat groups that are composed of Zhongguancun Science Park, the questionnaire has been shared three times in the groups to remind group members to fill in it. There are 1410 members in those four WeChat groups, 155 responses have been collected finally.

In order to collect data from firm managers of Shanghai Zhangjiang Science Park, a Chinese marketing research company EP assisted the data collection process. The company has access to contact details of science park firms' managers and facilitated the data collection process. They distributed the online questionnaire to 2086 managers of Shanghai Zhangjiang Science Park firms via email. 180 responses have been received within three days, which is high-efficient and time-saving. There are 335 responses collected from managers of science park firms in total. In summary, the response rate of the survey towards science park firms' managers in Beijing and Shanghai is 9.6%. After removing unengaged responses which tick the same answer for all of the questions and take short time to finish (less than 3 minutes), 312 were kept for the analysis in the next stage. The effective response rate of the questionnaire is 9.2%.

Table 5.2 Respondent table (N=312)

Gender of respondents	Percentage
Male	71.5%
Female	28.5%
Age of respondents	Percentage
21 - 30	14.7%
31 - 40	58.7%
41 - 50	23.4%
51 - 60	2.2%

61 - 70	0.6%
Over 70	0.3%
Title of respondents	Percentage
CEO	13.1%
R&D manager	27.9%
Production manager	17.9%
Operation management manager	24.0%
Marketing manager	17.0%
Other	0
Industrial sector	Percentage
Electronics and Information Technology	33.7%
Biopharmaceutical	14.7%
New materials	9.0%
New energy	12.5%
Advanced Manufacturing	21.5%
Earth/Space/Marine engineering	1.0%
Environmental protection	5.1%
Aviation and aerospace	1.3%
Automobile	1.3%
Other	0
Firm ownership	Percentage
State-owned enterprises	25.6%
Private enterprises	51.3%
Chinese-foreign joint venture / Foreign direct investment	22.8%
Other	0.3%
Firm age	Percentage
Below 2 years	0
2 - 5 years	18.3%

6 - 10 years	33.7%
11 - 20 years	30.8%
Over 20 years	17.9%
Number of employees	Percentage
Below 10	0
10 - 50	19.6%
51 - 200	36.2%
201 - 500	26.9%
Over 500	17.9%

5.5 EXPLORATORY FACTOR ANALYSIS

Exploratory factor analysis (EFA) is a widely used statistical technique during the initial stage of scale construction. Researchers use it to explore the factor structure with observed data. A large set of items is grouped into subscales measuring different constructs. In the first place, Kaiser-Meyer-Olkin (KMO) test is performed for examining whether the data is suitable for structure detection. According to Norusis (1998), KMO measure close to 1 indicates better performance related to correlations between variables. Kaiser (1974) pointed out that score of 0.60 is mediocre and 0.80 or higher is desirable. Tabachnick and Fidell (2001) argued that the value above 0.60 is considered as suitable for factor analysis. The criteria used in this study is that KMO value should be higher than 0.60.

After measuring the sample adequacy, unidimensionality is tested to determine whether a set of indicators reflect only a single underlying factor or not (Segars, 1997). The measurement items should be strongly associated with the construct they intend to measure. Without specifying the number of constructs prior to the analysis, principal component method is applied to conducting data analysis. With regard to rotation methods, Varimax method is employed as it is the most common choice to clarify factors in previous studies (Costello and Osborne, 2005). This study applies three criteria to the purification of items. The first criteria is that items with factor loadings higher than 0.30 is acceptable (Flynn et al.1994). Second, eigenvalue of subscale should be greater than 1.0. According to Kaiser (1958), eigenvalue below 1.0 indicates that the factor is potentially unstable. Third, the variance of the items extracted in communality should be above 0.50.

On the other hand, the researcher should identify the items that do not measure a priori factor or that strongly load on multiple factors. Cross-loading should be examined as it leads to the issue of factor intercorrelations. If the difference between the loading on the intended construct and the loading on other constructs of the cross-loaded items is less than 0.15, the researcher should remove the items from the scale (Worthington and Whittaker, 2006). Moreover, Chen and Paulraj (2004) argued that nuisance items, those items that do not load on targeted factors should be dropped.

In the next step, Cronbach's alpha test is performed to estimate the reliability of the subscale (Cronbach, 1951). Constructs are considered acceptable if the reliability coefficients exceed 0.70. Researchers should delete the constructs that fail to achieve the targeted alpha value.

5.5.1 Exploratory factor analysis: Engagement in science park collaborative network (ESPCN)

First of all, KMO value for the ESPCN construct is 0.935, which is much higher than cut-off value of 0.60, indicating that the data is suitable for the exploration of factor structure. Furthermore, the SPSS v26 is adopted in the study. four factors are extracted by EFA from the data, which supports the original structure developed by the author. All measurement items for the ESPCN construct meet the three criteria proposed above. First, the factor loadings of items in the scale are larger than 0.30. All items load most strongly on the factor they intend to measure, with the factor loadings ranging from 0.700 to 0.825. Although several items load on two factors, the difference between the factor loadings is greater than 0.15. Thus, they are still kept in the scale. Second, the eigenvalues of the four factors all exceed 1.0. Second, the variance of the items extracted by factors are all above 0.50. In addition, the four factors present a satisfactory level of Cronbach's alpha scores, ranging from 0.852 to 0.915, which are greater than the cut-off value of 0.70.

Table 5.3. EFA results of ESPCN

	Component			
	Factor 1 Eigenvalue=9.472 Percentage of variance=45.104 Cronbach's alpha=0.915	Factor 2 Eigenvalue=2.350 Percentage of variance=11.192 Cronbach's alpha=0.922	Factor 3 Eigenvalue=1.687 Percentage of variance=8.034 Cronbach's alpha=0.907	Factor 4 Eigenvalue=1.494 Percentage of variance=7.115 Cronbach's alpha=0.852
ITI1	0.817			
ITI2	0.741			

ITI3	0.726			
ITI4	0.766			
ITI5	0.768			
ITI6	0.767			
IFI1		0.799		
IFI2		0.759		
IFI3		0.790		
IFI4		0.785		
IFI5		0.825		
IFC1			0.784	
IFC2			0.795	
IFC3			0.806	
IFC4			0.796	
IFC5			0.725	
AIC1				0.704
AIC2				0.738
AIC3				0.804
AIC4				0.796
AIC5				0.700

5.5.2 Exploratory factor analysis: Innovation capabilities (IC)

KMO value for IC construct is 0.917, which indicates a satisfactory level of sample adequacy. According to the results from varimax rotation, four factors are extracted from the sample data. Three items, IG1, PD4 and PD6, have been eliminated from the scale. IG1 is dropped as it does not load on the targeted construct. PD4 and PD6 are deleted as a result of cross-loading problems. As for PD4 and PD6, their loadings on non-targeted construct are higher than that on the construct they intend to measure. The other 18 items measure the dimensions as intended, with the factor loadings ranging from 0.604 to 0.900. Hence, they are retained in the scale. Besides, the eigenvalues for the four factors exceed the minimum criteria of 1.0. The variance of items extracted in commonality are greater than 0.50. Besides, the four factors achieve the target value of Cronbach's alpha, ranging from 0.823 to 0.919.

Table 5.4. EFA results of IC

	Component			
	Factor 1 Eigenvalue=8.560 Percentage of variance=50.354 Cronbach's alpha=0.919	Factor 2 Eigenvalue=1.535 Percentage of variance=9.032 Cronbach's alpha=0.912	Factor 3 Eigenvalue=1.414 Percentage of variance=8.318 Cronbach's alpha=0.909	Factor 4 Eigenvalue=1.333 Percentage of variance=7.840 Cronbach's alpha=0.823
PcD1	.822			
PcD2	.778			
PcD3	.774			
PcD4	.770			
PcD5	.769			
PD1		.817		
PD2		.831		
PD3		.774		

PD5		.771		
IG2			.725	
IG3			.685	
IG4			.895	
IG5			.901	
OL1				.810
OL2				.818
OL3				.718
OL4				.604

5.6 CONFIRMATORY FACTOR ANALYSIS

CFA is usually used for assessing the validity of a scale based on EFA that have identified the correct pattern of item-factor relationship (Hoyle, 2012; Worthington and Whittaker, 2006). It provides a basis for the structural model that specifies the relationships between various constructs.

Firstly, it is not satisfactory to analyse a single model. In order to confirm the factor model of ESPCN and IC, the researcher examines competing models to appraise the degree to which a priori measurement model fits the data better than alternative models. Comparison of model fit is undertaken to identify whether a significant loss in fit indices occurs when going from the hypothesized factor model to competing models. Two of the four-correlated factor models are compared with Harman’s one-factor models and four-uncorrelated factor models (Harman, 1960).

Secondly, the researcher evaluates construct validity, which can be defined as the degree to which the items in a scale measures the theoretical construct they intend to measure (Peter 1980, p.134). It reflects the notion of convergence, which indicates the degree to which items chosen measure the factors they are hypothesised to measure as well as discrimination between those items and items of a different factor. In order words, construct validity could be achieved when multiple indicators of the same construct are highly correlated and not relate highly with indicators of other constructs. Construct validity is measured in terms of convergent validity and discriminant validity.

With regard to convergent validity, it reflects the extent to which an observed item correlates highly with other items used to measure the same factor (Churchill, 1979). The items designed to measure the same construct should be highly intercorrelated among themselves (Voorhees et al., 2016). According to Fornell and Larcker (1981), the average variance extracted (AVE) value of constructs should be greater than 0.50. Bagozzi and Yi (1998) recommend threshold values of 0.70 for composite reliability.

Compared to convergent validity, discriminant validity is relatively difficult to achieve. Discriminant validity shows the extent to which measures of a particular construct differ from others in the same model (Zeng et al., 2010). All theoretical constructs in a research model should have relatively low inter-correlations (ϕ) (Voorhees et al., 2016). The inter-correlation value (ϕ) that is below 0.70 indicates discriminant validity of constructs in the model. In addition, this study utilizes a stronger test of discriminant validity among the first-order constructs. The AVE values of each latent variables are compared with the square of correlation of the specific construct with any other constructs (ϕ^2) (Zait and Bertea, 2011; Fornell and Larcker, 1981). AVE reflects the explained variance of the construct. This test aims to examine whether the items of the factor explain more variance than do the items of the other factors. Hence, if the AVE values are larger than square of correlation among constructs (ϕ^2) , there is not a problem with discriminant validity.

Thirdly, the researcher performs second-order factor analysis to examine whether the covariances among the first-order constructs are accounted for by second-order constructs. Marsh and Hocevar (1985) propose a index to test if second-order factors are able to explain the factor covariances effectively, which is called target coefficient (T). It is the ratio of the chi-square of the first-order factor model to the chi-square of the second-order factor model. A target coefficient of 1 suggests that the relationships among the first-order variables could be totally explained by a higher-order variable. T coefficient of 0.80-1.00 indicates that the second-order factor effectively accounts for first-order factors.

5.6.1 Confirmatory factor analysis: ESPCN

5.6.1.1 Comparison with competing models

Table 5.5 shows model fit indices of one-factor model (Model 1), four-uncorrelated factor model (Model 2), and four-correlated factor model (Model 3). In the one-factor model, all items of ESPCN are all loaded onto a single factor. Model fitness of one-factor model is evaluated to examine whether observed variables can be explained by a single factor. With regard to Model 2, the covariances among the four first-order constructs are all assumed to be zero. In the hypothesised model, four latent constructs of ESPCN are correlated with each other.

As shown in Table 5.5, the null model with four uncorrelated factors fits the data better than the model with single factor. The one-factor model represents observed data poorly, suggesting that it is an unacceptable model. The results also demonstrate that the fitness performance of four-correlated factor model is better than both one-factor model and null model. This indicates that a priori model fits the data better than the other two models. The fit indices of a priori model indicate a satisfactory level of model fit. Besides, χ^2 difference test is used to compute the difference of χ^2 value between the hypothesized model and the null model. In summary, the results of comparison with alternative models suggests that the hypothesized model of ESPCN is the most satisfactory model.

Table 5.5. Fit statistics of competing models of ESPCN

Model	χ^2	Df	Normed χ^2	CFI	NNFI	RMSEA	SRMR
Model 1	1786.661	189	9.453	0.638	0.598	0.165	0.117
Model 2	714.763	187	3.822	0.881	0.866	0.095	0.310
Model 3	324.354	181	1.792	0.968	0.962	0.050	0.043

5.6.1.2 Validation of first-order constructs

In terms of convergent validity, all the items load strongly on the intended factors as factor loadings are above 0.60. According to Table 5.6, the composite reliabilities of ESPCN's four factors are all higher than 0.70. Table 4 shows that the AVE values of four first-order factors exceed 0.50. The results indicate that all dimensions of the measurement model of ESPCN exhibit good convergent validity. The scale items sufficiently represent their target construct.

With regard to discriminant validity, Table 5.7 demonstrates that the ϕ value is lower than 0.70. It suggests that the scale items do not measure the factors that are not supposed to be theoretically correlated with. Table 5.7 reveals that the AVE values of each latent variable is greater than square of any correlation among any pair of latent variables (ϕ^2) . This result provides evidence of discriminant validity among first-order constructs of IC.

Table 5.6. Convergent validity of first-order model of ESPCN

Construct	CR	AVE
AIC	0.854	0.540
IFC	0.908	0.664
ITI	0.922	0.665
IFI	0.912	0.674

Table 5.7. Discriminant validity of first-order model of ESPCN

Construct	AVE	Inter-correlation	ϕ	ϕ^2	AVE > ϕ^2?
AIC	0.540	AIC and IFC	0.57	0.325	Yes
IFC	0.664	AIC and ITI	0.49	0.240	Yes
ITI	0.665	AIC and IFI	0.43	0.185	Yes
IFI	0.674	IFC and ITI	0.60	0.360	Yes
		IFC and IFI	0.53	0.281	Yes
		IWTI and IFI	0.69	0.476	Yes

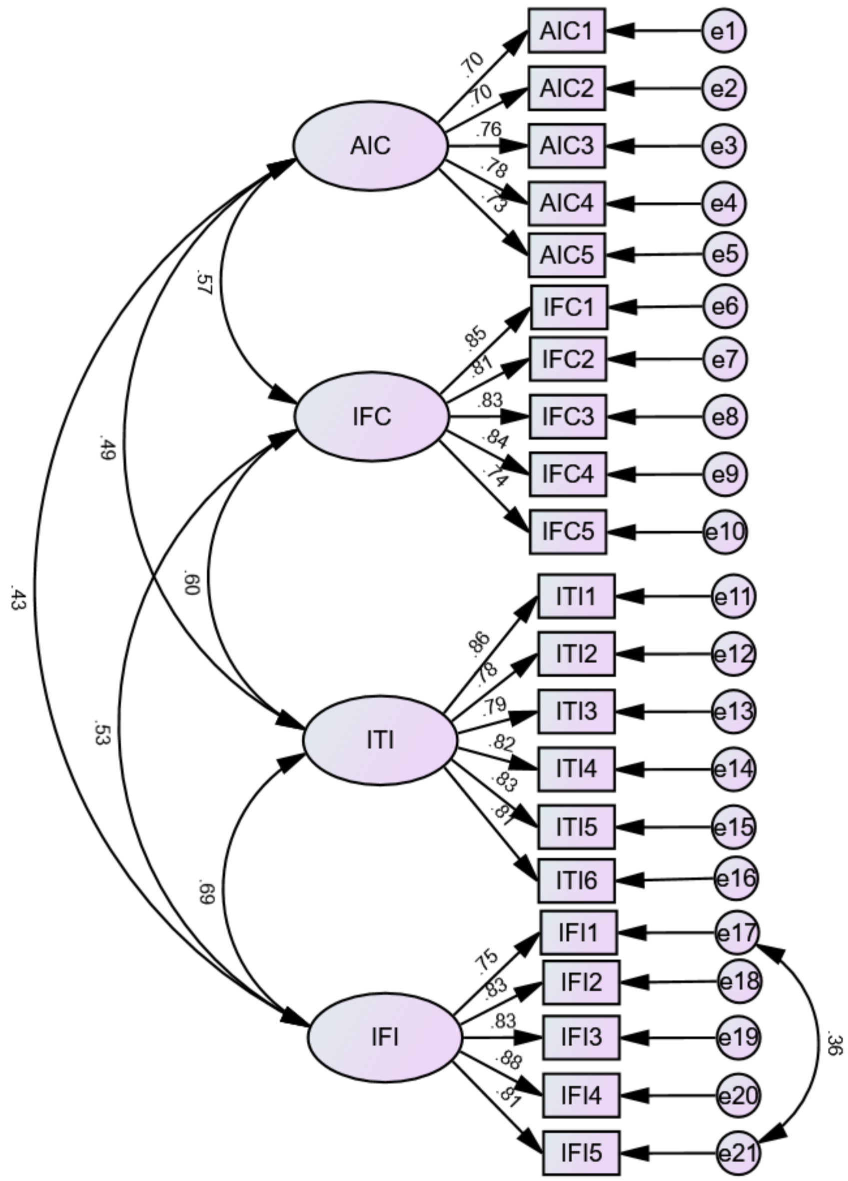


Figure 5.1. First-order model of ESPCN

5.6.1.3Validation of second-order model

The results provide evidence that a satisfactory level of fitness is associated with the second-order factor model (as shown in Table 5.8). In addition, T coefficient is tested to evaluate the extent to which first-order constructs can be subsummed under a higher-order construct. By comparing chi-square value of the second-order model and the model with four intercorrelated factors, it is T coefficients for ESPCN is 0.955, this result indicates the existence of the second-order construct model. Four sub-constructs load significantly onto the second-order construct. The second-order model could sufficiently explain the relations among the corresponding first-order factors.

Table 5.8. Comparison of fitness of second-order model of ESPCN to four-correlated model

Model	χ^2	Df	Normed χ^2	CFI	NNFI	RMSEA	SRMR
Model 3	324.354	181	1.792	0.968	0.962	0.050	0.043
Model 4	339.714	183	1.856	0.965	0.959	0.052	0.051

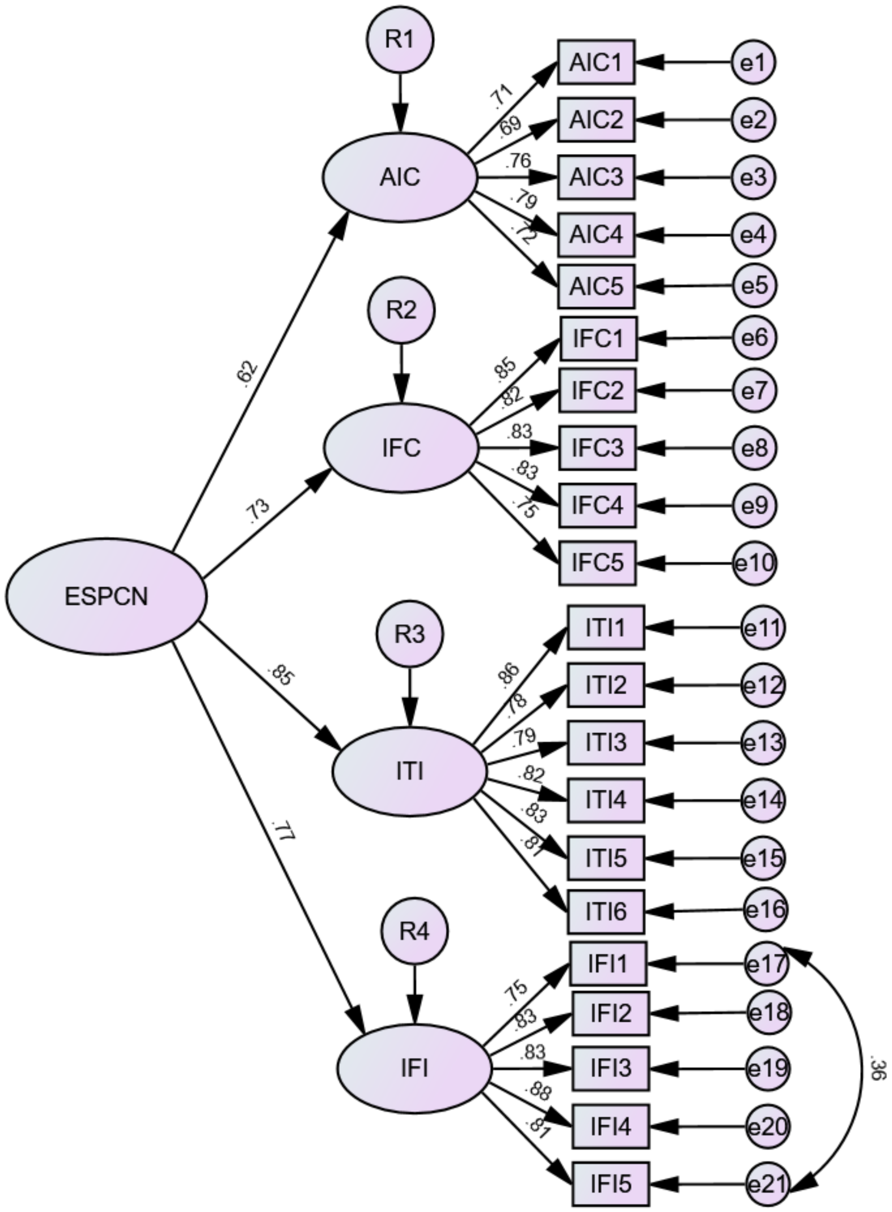


Figure 5.2. Second-order model of ESPCN

5.6.2 Confirmatory factor analysis: IC

5.6.2.1 Comparison with competing models

Table 5.9 shows fit statistics of one-factor model (Model 1), four-uncorrelated factor model (Model 2), and four-correlated factor model (Model 3). It obviously suggests that Model 3 have better performance in fitness than Model 1 and Model 2. The one-factor model and four-uncorrelated factor model. The hypothesized model of IC with four correlated factors fit the sample data better than the other two models. Additionally, the χ^2 difference is significant at 0.01 level. Therefore, the hypothesized first-order model of IC is the best choice for this research.

Table 5.9. Fit statistics of competing models of IC

Model	χ^2	Df	Normed χ^2	CFI	NNFI	RMSEA	SRMR
Model 1	1604.154	119	13.480	0.634	0.582	0.200	0.102
Model 2	735.115	119	6.117	0.848	0.827	0.129	0.354
Model 3	237.050	111	2.136	0.969	0.962	0.060	0.074

5.6.2.2 Validation of first-order constructs

As for convergent validity, Figure 5.3 shows that all the items of IC load strongly on the intended factors as all factor loadings are larger than 0.70. The composite reliabilities of IC's four dimensions are all higher than 0.70. Table 5.10 shows that the AVE values of four first-order factors exceed 0.50. The results indicate that all sub-scales of the measurement model of IC show convergent validity.

Values of inter-correlation (ϕ) between sub-constructs of IC are lower than 0.70, which indicates discriminant validity. Table 5.11 reveals that the AVE values of each latent variable is greater than square of any correlation among first-order variables (ϕ^2) . This result provides evidence of discriminant validity.

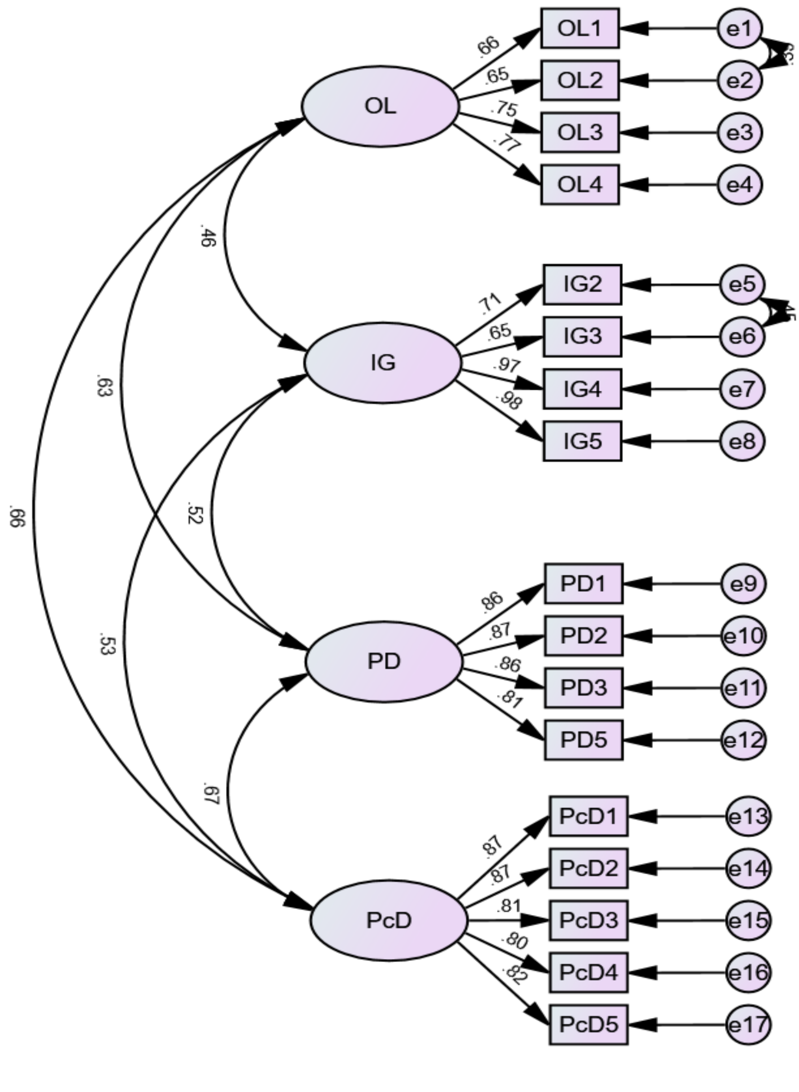


Figure 5.3. First-order model of IC

Table 5.10. Convergent validity of first-order model of IC

Construct	CR	AVE
OL	0.801	0.503
IG	0.903	0.707
PD	0.913	0.723
PcD	0.920	0.697

Table 5.11. Discriminant validity of first-order model of IC

Construct	AVE	Inter-correlation	ϕ	ϕ^2	AVE > ϕ^2
OL	0.503	OL and IG	0.46	0.212	Yes
IG	0.707	OL and PD	0.63	0.397	Yes
PD	0.723	OL and PcD	0.66	0.436	Yes
PcD	0.697	IG and PD	0.52	0.270	Yes
		IG and PcD	0.53	0.281	Yes
		PD and PcD	0.67	0.449	Yes

5.6.2.3 Validation of second-order constructs

For one thing, the result regarding fitness performance of the second-order factor model reveals that the second-order factor model has a good fit to the empirical data. For another, T coefficient for the second-order model of IC is 0.995, which provides strong evidence that the model is acceptable. Four sub-constructs load significantly onto the second-order construct. Thus, the second-order construct is able to represent the relationships between underlying sub-constructs.

Table 5.12. Fitness comparison of second-order model of IC to four-correlated model

Model	χ^2	Df	Normed χ^2	CFI	NNFI	RMSEA	SRMR
Model 3	237.050	111	2.136	0.969	0.962	0.060	0.074
Model 4	238.275	113	2.109	0.969	0.963	0.060	0.074

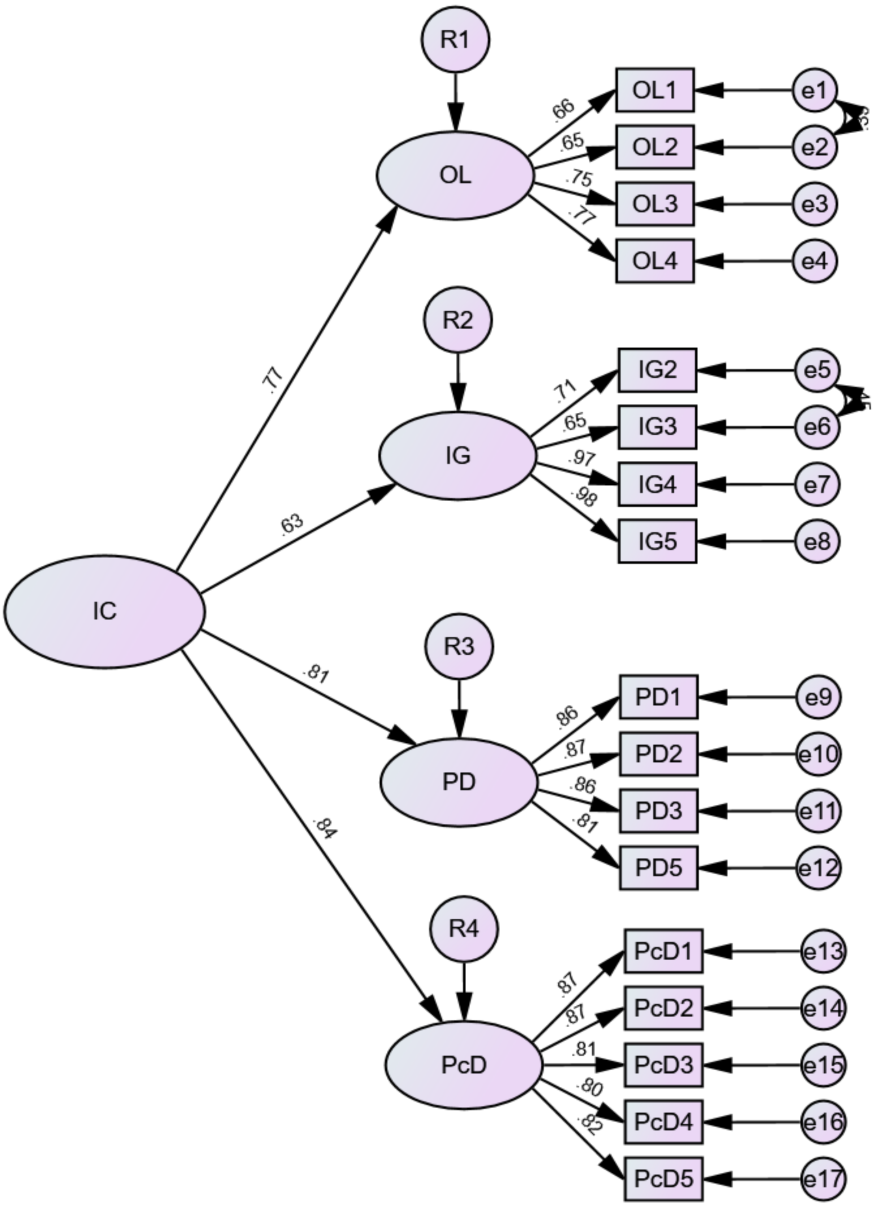


Figure 5.4. Second-order model of IC

5.6.3 Test of CFA model

CFA has been undertaken to examine the measurement model in terms of ESPCN, IC, and financial performance. 9 first-order constructs have been tested together. The model fit performance which is shown in Table 5.13, the measurement model is acceptable. Table 5. indicates that factor loadings are satisfactory. According to Table 5.14 and Table 5.15, the values of AVE and composite reliability suggest convergent validity of the nine constructs. The square of inter-correlation between any two constructs (ϕ^2) in the model is lower than AVE values. Thus, there is no problem with discriminant validity.

Table 5.13. Fitness performance of the CFA model

Model	χ^2	Df	Normed χ^2	CFI	NNFI	RMSEA	SRMR
CFA model	1248.529	781	1.599	0.952	0.947	0.044	0.0539

Table 5.14. Results of CFA model

N=312	Standardised factor loading λ (Error)	t-value	Composite reliability
Academic-industry collaboration (AIC)			
AIC1	0.71 (0.50)	N/A	0.853
AIC2	0.70 (0.51)	11.344	
AIC3	0.75 (0.44)	12.159	
AIC4	0.78 (0.39)	12.488	
AIC5	0.72 (0.48)	11.686	

Inter-firm collaboration (IFC)			
IFC1	0.85 (0.28)	N/A	0.909
IFC2	0.82 (0.33)	17.417	
IFC3	0.83 (0.31)	18.041	
IFC4	0.84 (0.29)	18.141	
IFC5	0.74 (0.45)	15.161	
Interaction with technology intermediaries (ITI)			
ITI1	0.86 (0.26)	N/A	0.923
ITI2	0.77 (0.41)	16.474	
ITI3	0.79 (0.38)	17.155	
ITI4	0.83 (0.31)	18.277	
ITI5	0.83 (0.31)	18.374	
ITI6	0.82 (0.33)	17.901	
Interaction with financial institutions (IFI)			
IFI1	0.75 (0.44)	N/A	0.912
IFI2	0.83 (0.31)	14.957	
IFI3	0.83 (0.31)	18.879	
IFI4	0.88 (0.23)	15.826	
IFI5	0.81 (0.34)	18.131	
Organisational learning (OL)			
OL1	0.75 (0.44)	N/A	0.827
OL2	0.75 (0.44)	12.237	
OL3	0.73 (0.47)	11.925	

OL4	0.72 (0.48)	11.803	
Idea generation (IG)			
IG2	0.71 (0.50)	N/A	0.905
IG3	0.65 (0.58)	15.244	
IG4	0.98 (0.04)	16.873	
IG5	0.98 (0.04)	16.875	
Product development (PD)			
PD1	0.85 (0.28)	N/A	0.911
PD2	0.87 (0.24)	19.881	
PD3	0.87 (0.24)	19.565	
PD5	0.80 (0.36)	17.293	
Process development (PcD)			
PcD1	0.87 (0.24)	N/A	0..920
PcD2	0.87 (0.24)	20.606	
PcD3	0.81 (0.34)	18.362	
PcD4	0.80 (0.36)	17.775	
PcD5	0.82 (0.33)	18.427	
Financial performance (FP)			
FP1	0.81 (0.34)	N/A	0.899
FP2	0.78 (0.39)	15.448	
FP3	0.86 (0.26)	17.385	
FP4	0.87 (0.24)	17.809	

Table 5.15 Discriminant validity test of CFA model

Construct	AVE	Inter-correlation	ϕ	ϕ^2	AVE > ϕ^2?
Academic-industry collaboration (AIC)	0.537	AIC and IFC	0.57	0.325	Yes
Inter-firm collaboration (IFC)	0.667	AIC and ITI	0.49	0.240	Yes
Interaction with technology intermediaries (ITI)	0.668	AIC and IFI	0.43	0.185	Yes
Interaction with technology intermediaries (IFI)	0.674	AIC and OL	0.62	0.384	Yes
Organisational learning (OL)	0.544	AIC and IG	0.43	0.185	Yes
Idea generation (IG)	0.712	AIC and PD	0.55	0.303	Yes
Product development (PD)	0.719	AIC and PcD	0.52	0.270	Yes
Process development (PcD)	0.697	AIC and FP	0.61	0.372	Yes
Financial performance (FP)	0.690	IFC and ITI	0.60	0.360	Yes
		IFC and IFI	0.53	0.281	Yes
		IFC and OL	0.49	0.240	Yes
		IFC and IG	0.47	0.221	Yes
		IFC and PD	0.47	0.221	Yes
		IFC and PcD	0.53	0.281	Yes

		IFC and FP	0.42	0.176	Yes
		ITI and IFI	0.69	0.476	Yes
		ITI and OL	0.55	0.303	Yes
		ITI and IG	0.42	0.176	Yes
		ITI and PD	0.55	0.303	Yes
		ITI and PcD	0.60	0.360	Yes
		ITI and FP	0.52	0.270	Yes
		IFI and OL	0.47	0.221	Yes
		IFI and IG	0.40	0.160	Yes
		IFI and PD	0.52	0.270	Yes
		IFI and PcD	0.54	0.292	Yes
		IFI and FP	0.55	0.303	Yes
		OL and IG	0.43	0.185	Yes
		OL and PD	0.59	0.348	Yes
		OL and PcD	0.63	0.397	Yes
		OL and FP	0.54	0.292	Yes
		IG and PD	0.52	0.270	Yes
		IG and PcD	0.53	0.281	Yes
		IG and FP	0.41	0.168	Yes
		PD and PcD	0.67	0.449	Yes
		PD and FP	0.58	0.336	Yes
		PcD and FP	0.60	0.360	Yes

5.6.3 Common method bias

According to Podsakoff et al. (2003, p.979), common method bias "is attributable to the measurement method rather than to the constructs the measures represent." The use of a common rater is a source of common method bias. In this survey, the researcher designs a questionnaire using 7-point Likert scale, which poses a potential problem to the results of data analysis. Common method bias also occurs when the answers are obtained from a single respondent, which is a potentially serious concern for the researcher. To remediate this problem, Harmon's single-factor model test is conducted to assess the likelihood of existence of common method bias. Confirmatory factor analysis is applied to Harman's single-factor model (Brewer et al., 1979; Flynn et al., 2010). The model fit of a one-factor model is compared to that of a CFA model including 9 proposed constructs. Table 5.16 reflects that single-factor model has a poor fit compared with CFA model, which indicates common method bias is small.

Table 5.16. Common method bias test

Model	χ^2	Df	Normed χ^2	CFI	NNFI	RMSEA	SRMR
CFA model	1248.529	781	1.599	0.952	0.947	0.044	0.0539
Single-factor model	5184.910	819	6.331	0.555	0.532	0.131	0.0967

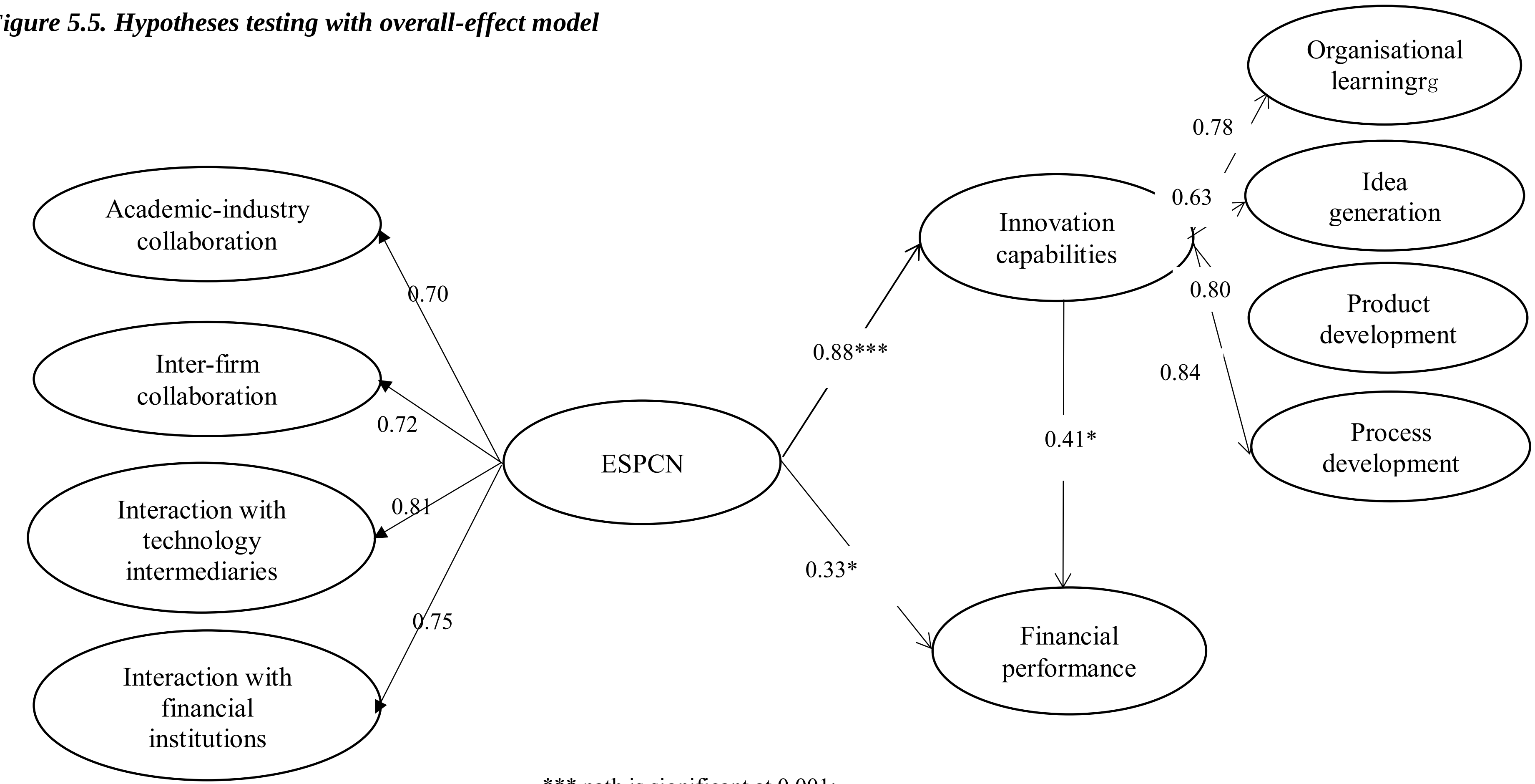
5.7 STRUCTURAL MODEL

The final stage is to check the structural model when the measurement model is confirmed. The next stage is to test the structural model when the measurement model is confirmed. Firstly, the overall model fit of the hypothesized model is measured by both absolute fit indices (RMSEA and SRMR) and incremental fit indices (NNFI and CFI). The fit statistics of the structural model are summarized in Table 5.16. After assessment of model fit, hypotheses proposed in the framework are tested.

Table 5.17. Fit indices of structural model

Model	χ^2	Df	Normed χ^2	CFI	NNFI	RMSEA	SRMR
Overall-effect structural model (Model A)	1280.184	804	1.592	0.951	0.948	0.044	0.061
Individual-effect structural model (Model B)	1216.997	975	1.531	0.957	0.953	0.041	0.055

Figure 5.5. Hypotheses testing with overall-effect model



*** path is significant at 0.001;
**path is significant at 0.01;
*path is significant at 0.05.

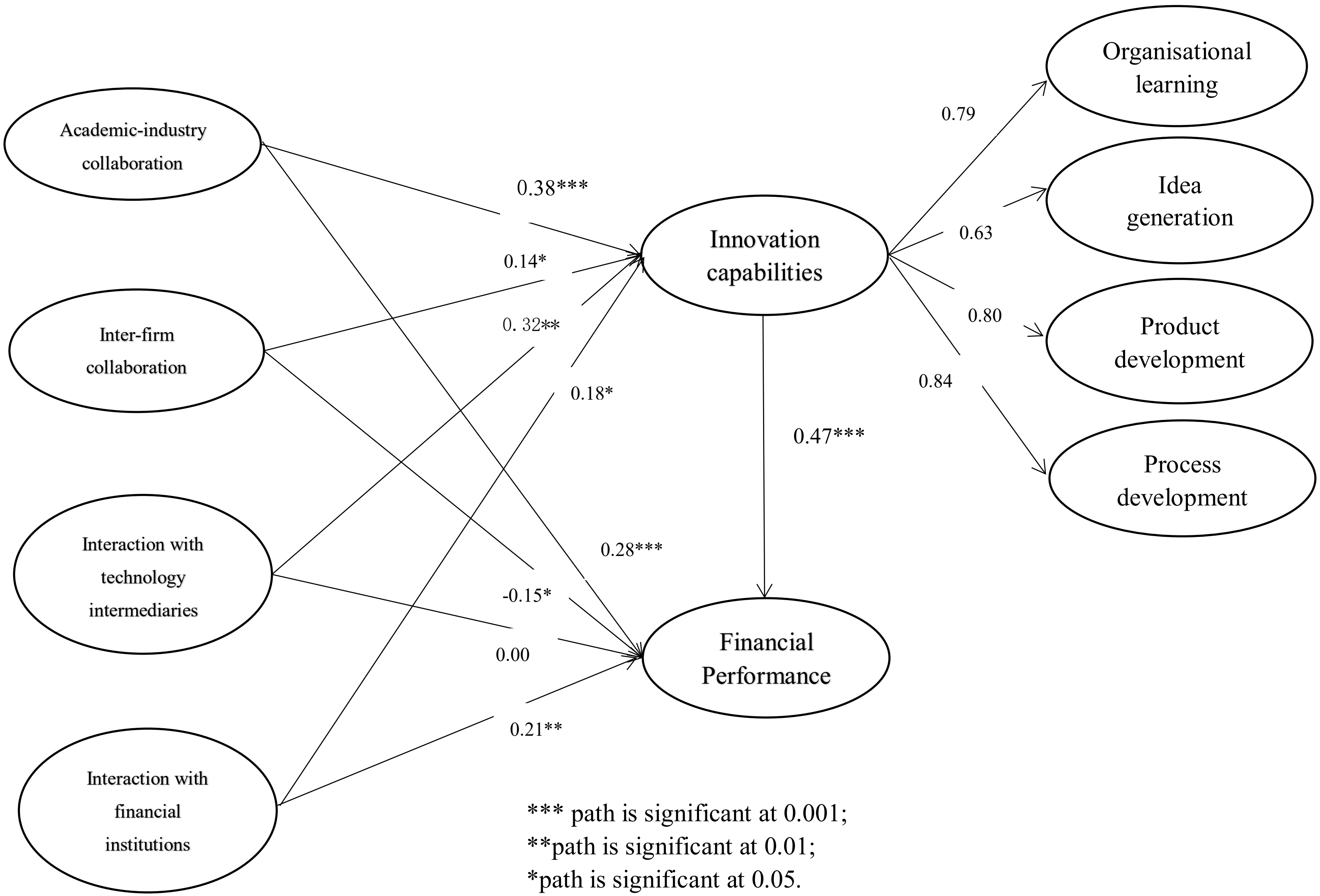


Figure 5.6. Hypotheses testing with individual-effect model

5.7.1Data analysis of overall-effect model

The fit statistics of the structural model are summarized in Table 5.16. The overall goodness of fit indices suggest satisfactory fit of the hypothesized model. The value of normed chi-square (χ^2/df) is 1.592, which is less than 2.0, indicating a good model fit. RMSEA is 0.044, which is below 0.08, reflecting a good fit to the data. The values of NNFI and CFI are above 0.90. The results reveal that the model does a good job in representing the structure underlying the data.

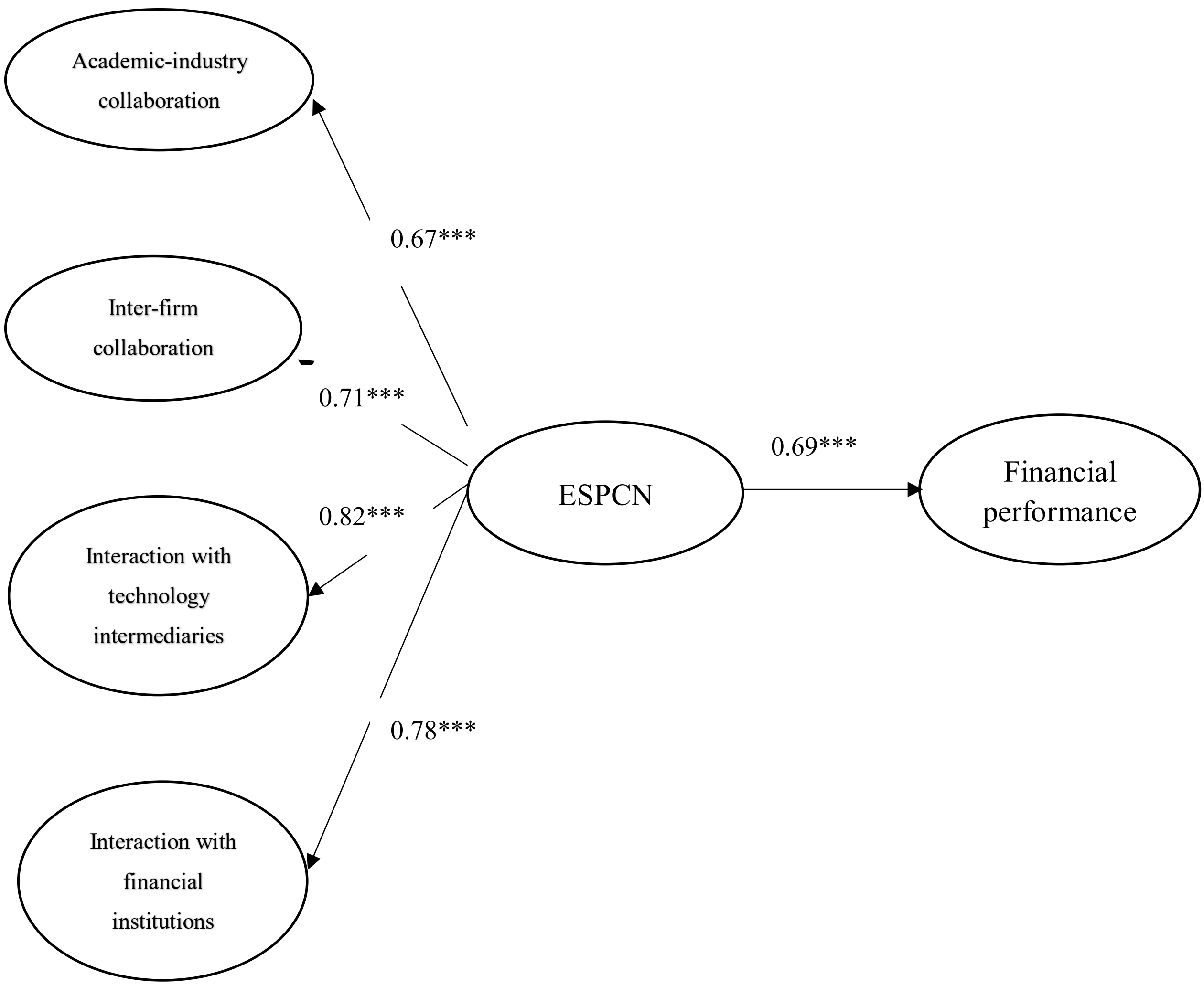
The next step is to test the three hypotheses proposed in this study with an examination of structural coefficients within the structural model. The Figure 1 shows the path diagram for the structural model. H1 predicts the path from ESPCN to IC. As shown in Figure 1, the path coefficient from ESPCN to IC is 0.88, which is statistically significant at the level of 0.001. This indicates that Hypothesis 1 is supported. Engagement in science park network has positive, significant and direct impacts on innovation capabilities of tenant firms. Hypothesis 2 that predicts IC has a positive and significant effect on FP is also supported with path coefficient of 0.41, which is significant at the level of 0.05. By yielding a positive and significant path coefficient for the relationship between ESPCN and FP, Hypothesis 3 is supported. This suggests that engagement in science park network has positive, significant and direct impacts on financial performance of on-park firms. Besides, EPSCN also has an positive and indirect effect on FP along the path of IC In a word, the results support the claim that engagement in science park network drives tenants to achieve superior innovation capabilities and financial performance.

5.7.1.1 Mediation effect test

This study follows the approach developed by Sarkis et al. (2010) to test mediation effect of innovation capabilities. The existence of mediation effect manifest in satisfying four conditions proposed by Sarkis et al. (2010). The first condition is that independent variables have significant impacts on dependent variables without the mediator. The second condition is that independent variables have significant impacts on mediator. Thirdly, mediator needs to exert significant effects on dependent variables. Finally, adding the mediator diminishes the impacts of independent variables on dependent variables. Three results can be obtained from the test of mediation model. If the results do not satisfy any of the conditions, no mediation effect exists. If all the conditions are satisfied and the impact of the independent variable on the dependent variable is significant, the independent variable is partially mediated by the mediator. If all the conditions are satisfied and the independent variable is insignificantly related to the dependent variable, the independent variable is completely mediated.

The first step of testing mediation effect of IC is to examine the relationship between independent variable (ESPCN) and the dependent variable (FP). Figure 7 demonstrates significant relationship between ESPCN and FP ($p < 0.001$). The second step of mediation evaluation is to test the relationship between ESPCN and IC. The figure shows that the impact of ESPCN on IC is significant at the level of $p < 0.001$. The third step is to show the relationship between IC and FP. It can be found that IC has significant impacts on FP at the $p < 0.05$ level. Finally, the author compares the effects of ESPCN on FP with and without the mediator IC. The effect of ESPCN on FP is weaker with the mediator than that without the mediator. Thus, the mediation effect exists. The existence of complete mediation effect is only available when ESPCN has insignificant effects on FP with the mediator. However, there is statistically significant relationship between ESPCN and FP with the mediator IC. Hence, ESPCN is partially mediated by IC.

Figure 5.7. Mediation testing model



5.7.2 Data analysis of individual-effect model

The overall goodness of fit indices suggests satisfactory fit of the hypothesized model. According to Table 11, the value of normed chi-square is less than 2.0; RMSEA is lower than 0.08; SRMR is below 0.08; and the values of CFI, IFI and NNFI exceed 0.95. The results reveal that the model does a good job in representing the structure underlying the data.

The hypotheses are tested after confirming that the structural model fits the data. Figure shows the path diagram for the structural model. The path coefficient from AIC to IC and from AIC to FP are 0.38 and 0.28 respectively ($p<0.001$), indicating that H3a and H4b are supported. Academic-industry collaboration has positive and significant impacts on innovation capabilities and financial performance. H5a that predicts inter-firm collaboration has positive and significant impacts on innovation capabilities is supported with path coefficient of 0.40, which is significant at the level of 0.05. However, H5b is not supported as path coefficient is negative and significant at the 0.05 level. Inter-firm collaboration has negative and significant impacts on financial performance.

By yielding a positive and significant path coefficient for the relationship between ITI and IC, H6a is supported. This suggests that interaction with technology intermediaries has positive and significant impacts on innovation capabilities. However, H6b is not supported as path coefficient is not statistically significant. There is no significant association between interaction with technology intermediaries and financial performance of firms. Both H7a and H7b are supported since path coefficients are positive and significant at the level of 0.05 and 0.01 respectively. Interaction with financial institutions is positively and significantly related to firms' innovation capabilities and financial performance.

Table 5.18. Hypotheses testing results

Structural links	Supported or not supported	Standardised path coefficient	t-value
H1: ESPCN -> innovation capabilities	Supported	0.88	7.436
H2: ESPCN -> financial performance	Supported	0.33	1.993
H3: Innovation capabilities -> financial performance	Supported	0.41	2.432
H4a: Academic-industry collaboration -> innovation capabilities	Supported	0.38	5.236
H4b: Academic-industry collaboration -> financial performance	Supported	0.28	3.528
H5a: Inter-firm collaboration -> Innovation capabilities	Supported	0.14	2.065
H5b: Inter-firm collaboration -> Financial performance	Not supported	-0.15	-2.135
H6a: Interaction with technology intermediaries -> Innovation capabilities	Supported	0.32	3.982
H6b: Interaction with technology intermediaries -> Financial performance	Not supported	0.00	0.20
H7a: Interaction with financial institutions ->	Supported	0.18	2.539

Innovation capabilities			
H7b: Interaction with financial institutions -> Financial performance	Supported	0.21	2.833

5.9 CONCLUSION

First of all, the measurement scale of ESPCN and innovation capabilities have been validated by a rigorous process in this chapter. First-order constructs that compose ESPCN have been assessed through EFA and CFA. ESPCN construct can represent the covariances between four sub-dimensions, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial institutions. The higher-order construct of innovation capabilities that is composed of three first-order constructs, has also been validated. Two structural models developed in Chapter 4 are validated when the measurement model has been confirmed. Overall-effect model reflects the impacts of ESPCN on innovation capabilities and financial performance of tenant firms. Individual-effect model reflects how individual dimensions of ESPCN scale influences innovation capabilities and financial performance of tenants differently. 9 of 11 hypotheses proposed in hypothesised model are supported by a sample data of 312 managers of Chinese science park firms.

CHAPTER 6 DISCUSSION

6.1 INTRODUCTION

This chapter aims to discuss research findings based on the results of data analysis. Each section of Chapter 6 links back to three research questions proposed in introduction chapter. The research questions are listed as below:

RQ1) What would the measurement scale of ESPCN entail?

RQ2) What is the impact of ESPCN on innovation capabilities and financial performance of tenant firms?

RQ3) What are the impacts of four types of relationships exist in science park ecosystem on innovation capabilities and financial performance of tenant firms?

The first research question has been answered by proposing a multi-dimensional construct of ESPCN. The construct has been developed based on Chapter of Literature of Review and then it has been proposed in Chapter 3 as a part of conceptual framework. Its validity and reliability have been checked by Results Chapter. Hence, the measurement scale of ESPCN has been identified and the first question has been solved. In addition, two models proposed in Chapter 3 provide a basis for answering the second and the third research questions. Chapter 5 examines two structural models after the validity tests of measurement scales of ESPCN and innovation capabilities. Chapter 5 tests and validates two structural models, including Model A which examines the overall impacts of ESPCN on innovation capabilities and financial performance of tenant firms in Chinese context, as well as Model B that assesses the impacts of ESPCN's individual dimensions on tenants. The results indicate that 9 of 11 hypothesised relationships proposed in Chapter 3 have been supported by the results of structural model analysis, which answer the second and the third research questions.

Chapter 6 is structured as follows. Section 6.2 discusses the measurement scale of ESPCN. Section 6.3 presents a discussion of the individual impacts of four dimensions of ESPCN on innovation and financial performance of science park firms. In Section 6.4 overall effects of ESPCN on tenant firms have been discussed. The discussion of individual-effect structural model (Model B) has been presented prior to that of overall-effect model (Model A) so that Model A can be discussed based on comparison to Model B.

6.2 DISCUSSION OF MEASUREMENT SCALE OF ESPCN

Chapter 5 has applied SEM approach to validating the measurement scale of ESPCN. The results indicate that four first-order constructs constitute higher-order construct of ESPCN, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial institutions. It is suggested that ESPCN can be represented by four dimensions, which are positively and significantly correlated with each other. The multi-dimensional construct provides a basis for exploring the impacts of science park ecosystem on resident firms. It provides a checklist for tenants regarding how to exploit the benefits brought by a science park location to create value. Firms can utilise network relationships with different organisations within science parks to cope with rapidly changing markets and increasing complexity of technology.

The second-order model of ESPCN reveals that interaction with technology intermediaries demonstrates the highest factor loading of 0.85. It indicates that interaction with technology intermediaries displays the greatest explanatory power of ESPCN. Technology intermediaries function as knowledge brokers which encourage and promote knowledge sharing and networking between resident firms and various organisations in science park ecosystem (Howells, 2006). Within the innovation system of science parks, they play a critical role in supporting and stimulating the growth of tenant firms. Technology intermediaries are committed to performing enabling functions for tenants' innovation process (Miller, 2014). Technology intermediaries sit at the intersection of various actors on science park ecosystem. They integrate knowledge bases of different science park actors, which can help firms identify suitable knowledge or technology (Lin et al., 2016). They play a key role in linking firms and institutions within innovation system of science park (Inkinen and Suora, 2010). With the assistance of technology intermediaries, firms can get quick access to suitable academic or business partners, and financial investors. In addition, there is high level of correlation value between interaction with technology intermediaries and interaction with financial institutions according to first-order model of ESPCN, which is 0.69. Technology intermediaries and financial institutions are both important supportive institutions that give assistance to innovative activities of firms resident on science parks. Technology intermediaries can facilitate tenants' access to finance for R&D and innovative activities and financial services that help tenants to overcome barriers to innovation (Lin et al., 2016).

6.3 DISCUSSION OF INDIVIDUAL-EFFECT MODEL (MODEL B)

This study tests the individual effects of four types of relationships exist in science park ecosystem on the hosted firms. The impacts of academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial institutions on science park firms will be discussed. The results of testing the individual-effect model show that two out of eight hypotheses proposed in Chapter 3 are not supported. Firstly, academic-industry collaboration has the greatest impacts on both innovation capabilities and financial performance of firms. Inter-firm collaboration has positive impacts on innovation capabilities while has negative impacts on financial performance. Interaction with technology intermediaries exert positive impacts on innovation capabilities while is insignificantly related to financial performance of tenants. Interaction with financial institutions is positively related to both innovation capabilities and financial performance. In a summary, relationships with academics and financial institutions are positively associated with both innovative and financial outcomes; relationships with other tenant firms and technology intermediaries have positive impacts on innovation, however, do not show positive impacts on financial value.

6.3.1 The impacts of academic-industry collaboration

Science parks provide an environment that promote linkages and collaborations between industrial businesses and knowledge creation institutions (Miller, 2014). According to Hansson (2007), the rationale for creating science parks lies in locating industrial sites proximate to higher education institutions or research centres, motivating the commercialisation of scientific research. The commercialisation of advancement in emerging areas of knowledge is a key factor for innovation success (Etzkowitz and Klofsten, 2005). Collaboration with universities or research institutions appears to have the strongest effects on innovation capabilities and commercial performance. The findings of this study reveal that universities and research institutions are the most important source of superior innovativeness and commercial performance for science park firms. Science park establishments mainly contributes to promoting knowledge flow between academia and business sector. Cross-fertilization between academic community and business community is the dominate idea of science parks. Spatial proximity is favourable for firms developing close linkages with universities, which allows for greater knowledge exchange and resource sharing (Massey et al., 1992).

Academic institutions are a major source of knowledge and talents that firms need. They are vehicles for knowledge creation and centres for knowledge diffusion (Tsai, 2009). Most of firms located on science parks are knowledge-based and innovate-oriented firms. Innovation plays a key role in achieving competitive advantage. Universities and R&D institutions are producers of new scientific and technological knowledge (Petruzelli, 2011). They provide a knowledge basis for technological development of firms that lead to commercial success. For one thing, they can generate new ideas and knowledge for product or process innovation of science park firms (Massey et al., 1992). For another, universities can also directly support the spin-off process of transforming results of scientific research into commercial businesses. They serve as knowledge repositories that help firms to make technological breakthroughs.

Long duration of basic and fundamental research carried out by universities and public research institutions (PRIs) reduces the livelihood of earning immediate economic returns. However, firms can obtain insights into scientific research and new ideas and knowledge acquired from universities and PRIs to open up new opportunities for innovation (Knudsen, 2007). Maintaining close ties with academic institutions leads to accumulation of knowledge stock, which contributes to innovation in a long term. They are ideal partners for to maintain sustained competitive advantage in the marketplace (Petruzelli, 2011).

University scientific research drives industrial innovation (Perkmann and Walsh, 2009). Cutting-edge scientific research of academic institutions can provide a basis for industries' technological upgrading (Arza, 2010). Companies can cooperate with academics for the development of specific technologies relevant to products and processes. Academics can be involved in testing of new ideas or concepts with commercial potential emerged within firms. Tenant firms can gain access to knowledge about the frontier of scientific research from local knowledge institutions. Academic institutions can provide assistance in terms of problem solving. Businesses can seek assistance from academics in terms of specific issues in their R&D and production process (Perkmann and Walsh, 2009).

6.3.2 The impacts of inter-firm collaboration

The relationship between inter-firm collaboration and financial performance is negative, which does not support H5b, which expects that inter-firm collaboration is positively related to tenants' financial performance. Science park firms fail to achieve commercial benefits from inter-firm relationships. Besides, it is also unexpected that inter-firm network has the weakest impacts on innovation capabilities. Although the impact of inter-firm network on innovation capabilities is the weakest, the effect is significant (5a is supported). The result appears to be contradictory.

Collaboration with co-located firms is effective in improving firms' ability to innovate while fails to improve financial performance. Firms can enhance their ability to generate creative ideas, develop new products and processes through inter-firm network. Inter-firm collaboration involves the combination of multiple knowledge bases to create new knowledge and develop technological innovation (Lin et al., 2016). Integration of knowledge domains enables rapid solutions to specific problems and fast access to suitable technical knowledge, which is important for innovation success (Tomlinson, 2010). However, the benefits obtained from business network in terms of innovation activities can not compensate for the costs associated with such network. Thus, tenant firms are unable to achieve superior financial performance by developing collaborative relationships with co-located firms.

Opportunism has serious influences on inter-firm relationships. It results in increased transaction costs as one party pursue individual interests at the expense of its counterpart (Luo, 2006). Opportunism incurs incur costly monitoring efforts (Wathne adn Heide, 2000). The firm will suffer from reduced economic value consequently. Firms have to invest heavily in coordination, which include the costs associated with the integration of decision-making and operation processes for the purpose of increasing resource utilization (Clemons and Row, 1992; Kumar and Dissel, 1996). The threat of opportunism enhances the need to develop mechanisms to monitor its counterpart's behaviour, which incur increase in costs (Luo, 2006). Transaction risk arises from transaction-specific capital, information asymmetries, and loss of resource control (Kumar and Dissel, 1996). Transaction-specific capital refers to the investment in the asset that has no value in uses other than the specific partnership. Information asymmetries give rise to issues related to monitoring performance. Loss of resource control occurs when the information or know-ow involved in the partnership cannot be returned or controlled if the partnership terminates.

Firms are faced with bargaining, monitoring and maladaption costs in partnership (Dahlstrom and Nygaard, 1999). Negotiation between business partners can incur bargaining costs. Transacting parties need to modify or improve contractual terms. One party may behave opportunistically to enhance their bargaining position. The other party has to devote more resources to reduce the possibility that they are subject to opportunism behaviours. In order to ensure fulfillment of contracts, monitoring costs are incurred. Opportunism behavior of partners can influence monitoring costs significantly. Maladaption costs are expenditures associated with failures in communication and coordination between business partners.

Negative effects of inter-firm relationships on financial performance indicate that firms have difficulty in achieving financial returns from investment in developing. If costs associated with negative aspects of inter-firm networking outweigh the benefits obtained from such relationships, financial performance would diminish. Co-location of science park firms benefit from collective learning and knowledge spillover. They can achieve superior innovation achievement by collaborating with co-located firms. They also face the risk of knowledge leakage (Grillitsch and Nilsson, 2017). However, if costs associated with negative aspects of inter-firm networking outweigh the benefits obtained from such relationships, financial performance would diminish. Despite some benefits, inter-firm relationships could inevitably lead to fiscal waste and inefficiency (Longoria, 2005). Transaction costs involve costs of information, search, negotiation, coordination, monitoring, as well as costs arising from opportunism of partners. Collaborative relationships may have negative effectiveness when the other actors behave inappropriately (Fang et al., 2011).

Oliveira and Lumineau (2019) pointed out multiple dimensions of conflict that may arise from networking relationships, including operating and structural conflicts, personal and cultural conflicts, and disagreements on strategic decisions. Conflicts and opportunism affect the relationships between partners. High level of conflicts between partners can result in decreased productivity and performance of firms (Abosag et al., 2016). Some studies provide evidence for negative impacts of opportunism on firm performance (Luo, 2007; Morgan and Hunt, 1994; Yang and Wang, 2013). The study of Luo (2007) suggests that opportunism in partnership reduce firms' sales growth and financial returns. Opportunistic or unethical behaviours increase transaction costs.

Firms may lose strategic resources to partners that in turn reduces firm performance. Knowledge leakage is a major problem of engaging in business network. Firms' efforts to receive knowledge also result in knowledge leakage (Frishammar et al., 2015). It is believed that firms can improve their knowledge base through inter-firm relationships. However, they are likely to be faced with the loss of commercially valuable knowledge to other actors, which weakens their competitive position in the market. There is a need to control knowledge flow to avoid knowledge leakage (Frishammar et al., 2015). Protection of important knowledge is critical to competitiveness and firms need to develop appropriability regime or mechanism that protect its core knowledge from imitation by other actors. Decreasing the negative effects of dark sides within networking relationships can exert greater impacts on success of network than purely investment in developing positive relationship (Abosag et al., 2016).

Taking Chinese scenario into consideration, the rules of game over inter-firm relationships is different between China and developed economies (Zhou and Xu, 2012). It is difficult to predict and manage incidents in cooperative agreements in highly uncertain situations (Clemons and Row, 1992). Opportunistic behaviour is promoted by uncertainties. Emerging economies are characterized by high market volatility. In emerging economies, opportunism in contractual agreements easily arise from variable government policies, volatile markets, unverifiable information, and incomplete legal protection system (Luo, 2006). Great environmental change and regulatory instability are associated with rapid growth in China. Government intervention pays a key role in economic transition of emerging markets, which leads to market uncertainty. Government policies tend to be variable, making it difficult for firms to predict industry trends and structural change. Regulatory uncertainty poses an obstacle to strategy formation and implementation of firms. Partners are reluctant to contribute resources to joint activities as they have little control over risk arising from the uncertain context. In order to minimize exposure to uncertainty, firms decrease their resource commitment to partnership or behave opportunistically. Firms tend to seek their own interests in the face of such turbulence.

Firms encounter institutional barriers as legal system in China that support market transactions is not well established (Zhou and Xu, 2012). As a result of untrustworthy legal system in emerging markets, firms are prone to withhold information or decrease their resource investment (Luo, 2006). Lack of legal protection of intellectual properties in China results in increased opportunism in cooperative relationships. Despite the enactment of a series of commercial laws by the government, they are not enforced strictly in China. It is inevitable that firms perform opportunistically in the face of weak legal protection. Deficiency in supervision mechanisms increases hazards of appropriation. Firms react defensively to sustain their market position, making knowledge sharing in inter-partner coordination difficult.

6.3.3 The impacts of interaction with technology intermediaries

The data analysis indicates that there is no significant relationship between interaction with technology intermediaries and financial performance of science park firms. There is a positive and significant relationship between interaction with technology intermediaries and innovation capabilities of tenant firms. However, close relationships with technology intermediaries do not exert direct impacts on financial outcomes of firms. They play an important role in improving the efficiency of innovative activities of science park firms (De Silva et al., 2018). They support and facilitate collaborations for knowledge exchange and technology transfer (Lin et al., 2016). Their extensive network allows firms to get access to a large pool of knowledge and resources. As a result, they enable science park firms to maintain competitive advantage in innovation.

Intermediary services do not significantly influence financial performance of tenants. Although technology intermediaries are effective in improving innovation capabilities of firms on science parks, they fail to help firms achieve economic payoffs. Intermediary institutions in China are still new and it is likely that they are not be able to help firms transform innovations into commercial benefits. The quality of services provided by Chinese technology intermediaries might not be high enough. They might fail to develop solid relationships with resident firms.

They may lack essential technology-specific or industry-specific knowledge to support firms to achieve success in the market (Teece 1998; Lichtenthaler, 2013). On the other hand, active involvement in cooperation with intermediary institutions may induce higher costs, making firms fail to improve their profits. Besides, science park firms should take an active part in four types of relationships simultaneously to reach satisfactory level of monetary performance.

6.3.4 The impacts of interaction with financial institutions

Apart from academic-industry collaboration, interaction with financial institutions is another type of relationship that is positively related to both innovation capabilities and financial performance. Many technology-based firms with innovative technologies are short of financial resources, and expertise in managing financial activities. Chinese science parks play a vital role in overcoming shortage of finance as well as financial expertise of hosted firms. They attract the influx of financial institutions as well as facilitate networking between tenants and financial institutions. The availability of finance enables firms in emerging markets to mitigate technological and economic risks to a large degree (George and Prabhu, 2003). Support from financial institutions have important implications for innovative and commercial achievement. Previous studies focus on the role of finance in influencing innovative or financial performance (King and Levine, 1993b; Demirguc-Kunt and Maksimovic, 1998; Celikyurt et al., 2010; Kerr et al., 2011). However, the functions of financial institutions are not limited to provision of finance, but also offer a wide range of value-added services. This study measures the effects of financial institutions on tenant firms in terms of both provision of funding and other types of financial services.

Support from financial institutions is of critical importance for innovation success as innovation involves high risk and high costs (O'Suillivan, 2005; .Yigitcanlar et al., 2018) One of the major obstacles to innovation is shortage of finance (Yigitcanlar et al., 2018). Insufficient finance is a key barrier to firm innovation and firm growth (Fowowe, 2017; Aghion et al., 2005). High-quality financial services are necessary for facilitating the improvement of innovation process. Financial institutions play an important role in assisting science park firms in expanding their technology resources, and financing and improving the efficiency of their innovation activities (Geroge and Prabhu, 2003; King and Levine, 1993). They contribute to reduction of information costs, survival and business growth in the long run (King and Levine, 1993). The assistance provided by financial institutions is crucial for converting innovative ideas into commercialised innovations, which is key to achieving competitive advantage in the market. The expansion of operations, research and development, recruitment of high-qualified talents, and investment in equipment and facilities are unlikely without sufficient funding (Fowewe, 2017).

Innovation activities are associated with uncertainty to a large degree (O'Suillivna, 2005). It is difficult to predict inputs and outputs of innovation activities. Innovative activities are unforeseeable and idiosyncratic, which entail a high likelihood of failure (Hsu et al., 2014). Many contingencies are hard to predict during innovation process. It is hard for firms to obtain immediate commercial returns from innovation process. Financial institutions play a key role in investment evaluation, risk management, and resource allocation (King and Levine, 1993). Knowledge accumulation of financial agencies can be translated into reliable advice for investment and capital management (George and Prabhu, 2003). Knowledge and services provided by financial institutions motivate firms to engage in innovative projects with high risk and high uncertainty (Hsu et al., 2014). Moreover, innovation process is complex, ranging from concept development to market launch, which goes through multiple phases (O'Suillivan, 2005). Financial support should be sustained until the innovative products are introduced to the market. It is widely agreed that innovation is time-consuming process. With the support of financial institutions on science parks, tenants can overcome finance limitations to undertake innovation activities and achieve commercial success in the market.

6.4 DISCUSSION OF OVERALL-EFFECT STRUCTURAL MODEL (MODEL A)

The effects of ESPCN on tenant firms are measured in terms of innovation capabilities and financial performance. The findings strongly support the hypothesis that science park network improves innovation capabilities and financial performance of tenants. Joint value creation process generates benefits for hosted firms. Agglomeration economy is associated with the concentration of economic activities (Malmberg and Maskell, 2002). It is associated with cost advantage as a result of a dedicated infrastructure, an education system of distinctive relevance, and a pool of high-skilled human resources (Maskell, 201). Science park location also helps firms save costs associated with collecting information and knowledge about business environment (Maskell, 2001). The spatially defined community makes it easier for resident firms to gain access to suitable knowledge, technology or partners. The signalling effect a location inside science parks helps hosted firms attract talents and capital, access wider market, and develop external network (Gwebu et al., 2018). Science parks provide assistance for tenants in terms of finance, marketing and training (European Commission, 2013).

Geographical proximity is driving force for interactive relationships (Vedovello, 1997). It is conducive to frequent and face-to-face interactions, which decrease transaction costs (Rodriguez-Pose and Hardy, 2014). Spatial closeness between various types of organisations facilitates knowledge spillover and fosters collective learning climate (Malmberg and Maskell, 2002). It is easier for employers to find good choices of labour with required skills due to the availability of a local pool of high-skilled workforce. The concentration of institutions and commercial firms in one location are conducive to the formation of coordinative relationships and building of mutual trust (Malmberg and Maskell, 2002). The availability of collective resources diminishes transaction costs. Common situations make it easier to discover opportunities and threats and identify strengths and weaknesses (Malmberg and Maskell, 2002). Sharing of common culture with specific norms and values enables firms to acquire and understand subtle, tacit and complex knowledge (Maskell, 2001). Firms can collaborate with other actors of science parks to solve technical problems through exchange of subtle and complex information.

Dynamic capabilities theory highlights firms' ability to adapt external and internal resources to environmental changes, which delivers a competitive advantage (Teece et al., 1997). Science parks help tenants quickly identify and respond to opportunities or challenges brought by dynamic environment. Science parks provide a knowledge-intensive environment for firms to conduct R&D and innovative activities. They create a dynamic ecosystem for knowledge-based development. They provide resource-rich and opportunity-rich environment, allowing tenants to survive and grow in dynamic business environment (Gwebu et al., 2018). Science parks can be seen as innovation ecosystem that is typically characterised by the relationships among institutions that stimulate and support knowledge creation and the companies that exploit the knowledge (George and Prabhu, 2003). Innovative capacity of science parks is dependent on a combination of policies, investments, and resource commitments that underlie the creation of technological innovation. Functions of knowledge exploitation can be improved when firms and institutions co-exist within science parks.

Science parks play a crucial role in promotion of knowledge exchange and synergies between firms and various types of actors (Gwebu et al., 2018). They are growth poles for the technology-based firms. A hybrid network of public or private organisations with the provision of expertise, information, capital is the seedbed for innovation success of resident firms (Etzkowitz and Klofsten, 2005). Science park ecosystem is a source of sustainable competitive advantage. Science parks bring together diverse groups of innovative actors in the same location. They are real estate development projects aimed at developing a knowledge-based ecosystem. Science parks facilitate knowledge-based development by promoting interaction between local actors and transfer of tacit knowledge (Benneworth, 2014). Universities and research institutions are important sources of new scientific and technological knowledge and high-skilled researchers or graduate students. Co-located commercial businesses enable firms to get access to complementary knowledge or resources, and share risk and costs of innovative activities. Technology intermediaries of science parks facilitate networking and technology transfer activities and provide direct services for innovation process of resident firms. Financial institutions provide finance that support innovative activities of firms. They can also provide assistance for firms through provision of financial services, such as investment suggestions and asset management. Firms can exploit network resources to manage the risks and challenges brought by rapid changes in markets and technology trends (Lin and Lin, 2016).

The findings indicate that inter-firm collaboration and interaction with technology intermediaries do not pose positive effects on financial performance of tenants. ESPCN, which is a multi-dimensional construct, is positively related to tenants' ability to achieve commercial success in the market. Tenant firms that engage in four types of relationships at the same time can maximize benefits obtained from science park location. Innovation requires the combination of a diversity of specialized techniques and skills (Calia et al., 2007). Synthesis of knowledge base of diverse types of partners allows firms to achieve rapid solutions to specific problems and fast access to suitable technology. They can share risk and costs, overcome resource weaknesses, and speed up innovation process through active involvement in science park collaborative network (Xie and Gao, 2018). Science park network brings together organizations or institutions with diverse resources and assets, which helps resident firms overcome resource scarcity. Different types of relationships are complementary to each other. The overall effects of four practices are considerably stronger than that of individual practice.

6.5 THEORETICAL CONTRIBUTION

First of all, this study contributes to literature through scale development. ESPCN is conceptualized as a multi-dimensional construct composed of four dimensions. Diverse actors involved in science park ecosystem are classified into four groups: academic institutions, resident firms, technology intermediaries, and financial institutions. The ESPCN scale unpacks four types of network relationships exist on science park ecosystem, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial institutions. A sample of 312 managers of firms on Chinese science parks is applied to the validation of the measurement scale. The results indicate that ESPCN is a higher-order model which can be represented by those four dimensions, which provides a comprehensive view of science park ecosystem. There are heterogeneous actors involved in science park ecosystem, making it difficult to assess the role of science park ecosystem in supporting the growth of tenant firms. ESPCN scale provides a basis for measuring the effects of engagement in science park ecosystem on resident firms. Interaction with technology intermediaries has the strongest explanatory power among these four dimensions of ESPCN. It suggests that interaction with technology intermediaries play a key role in representing ESPCN. Besides, it can be suggested that innovation capabilities is not a single identifiable construct, but a higher-order concept that is measured by four elements in this study. These components are built from existing literature on innovation capabilities and innovation management.

This research extends literature by developing two structural models that test the overall effect of ESPCN and individual effect of ESPCN dimensions on innovation capabilities and financial performance of firms on science parks. The overall-effect model sheds light on how engagement in science park ecosystem contributes to resident firms' innovation achievement and financial value. The results show that overall effect of ESPCN has positive and significant impacts on innovation achievement of resident firms, and in turn transformed into superior commercial value. That is to say, tenants can improve their ability to innovate through engagement in collaborative network of science parks, and increase their financial benefits by reaping benefits from superior innovation capabilities. This study develops a framework that examines how networking, collaborations, knowledge sharing and technology flows involved in science park ecosystem facilitate business growth. It provides a comprehensive picture of how science park ecosystem contributes to tenants' outcomes.

The model overcomes weakness in past studies on assessing the impacts of science park location on tenant firms by providing insights into collaborative network created among firms and institutions. A large amount of existing studies measure the role of science parks in creating value for tenants by comparing performance of firms located inside and outside science parks (Lindelof and Lofsten, 2003; Lamperati et al., 2015; Liberati et al., 2016). However, mixed results of previous studies suggest that there is no direct relationship between science park location and firm performance. Based on literature review, a comprehensive set of practices that exploit benefits associated with science park ecosystem are identified. The tenants that has better capability to exploit the science park location can achieve superior innovation capabilities and financial performance. The degree to which science parks can improve firm performance not only depends on parks' ability to create a favourable environment, but also tenants' ability to make use of the resources and support provided by science park ecosystem.

This study also examines the theoretical model that reflects the individual impacts of ESPCN dimensions on innovation capabilities and financial performance of science park firms. It highlights how four components of ESPCN influence science park firms differently from one to another. Previous research investigates only one or two factors that affect performance of science park firms (Diez-Vial and Fernandez-Olmos, 2013; Diez-Vial and Montoro-Sanchez, 2016; Ramirez-Alesn and Fernandez-Olmos, 2018). This study provides a systematic approach that looks into the contributors to competitive advantage of tenant firms. Two types of relationships exert positive influences on both innovation capabilities and financial performance. Academic-industry collaboration has the greatest impacts on both innovation and financial performance. Interaction with financial institutions is the other type of relationship that support hypotheses proposed in Chapter 4. The other two types of relationships, including inter-firm collaboration and interaction with technology intermediaries, are just positively related to innovation capabilities.

However, the individual-effect model neglects the complexity of the interplay of elements that comprise the ESPCN construct. Four types of relationships are interdependent with each other. Thus, this study also presents the overall-effect model that illustrates the synergy effects of four dimensions of ESPCN scale. Compared with individual-effect model, this model demonstrates better performance with regard to the effectiveness in facilitating tenants' achievement in innovation and growth performance. It provides insights that four types of relationships should be adopted simultaneously, which can generate much greater effects than just adoption of a single type of relationship. Tenant firms can reap more benefits and rewards from operation of four practices as a bundle than employ one of them individually. According to RBV theory, ESPCN can be seen as a bundle of resources or capabilities, which are valuable and difficult to imitate and enables science parks to achieve a competitive advantage.

Furthermore, the study tests the mediation effect of innovation capabilities between ESPCN and financial performance. After adding the mediator, the effect of ESPCN on financial performance has dropped from 0.69 to 0.33. There is still significant relationship between ESPCN and financial performance. The results indicate that innovation capabilities have a partial mediation effect on financial performance. It suggests that part of financial performance can be influenced by the overall effect of ESPCN, and part of financial performance can be enhanced by innovation capabilities.

6.6 MANAGERIAL IMPLICATIONS

The results of this study have some managerial implications for both at science park level and tenant firms' level. For management team of Chinese science parks, they should be proactive with facilitating interactive relationships and networking between firms and institutions. Creating an integrated ecosystem that support innovation and business growth of tenants should be an important concern for science park management. The measurement scale of ESPCN can work as an aid to management team of science parks in design of strategies or policies that can support and encourage growth of resident firms. Management team can implement policies that provide incentives that encourage firms to collaborate with actors within science park ecosystem. They should be committed to creating an entrepreneurial environment that supports and encourages firms' innovation activities. Science parks should not just function as property-based mechanism that house technology-based companies. It is insufficient to only provide shared space and facilities for tenants. Science parks plays a vital role in facilitating knowledge and technology diffusion among firms and institutions.

Science parks play an important coordinating role in the formation and development of network between academia and industry. According to test result of ESPCN scale, technology intermediaries play the most important role in science park ecosystem. The management team should be committed to improving the quality of services provided by technology intermediaries. Good-quality services provided by technology intermediaries of achieve innovation success, and in turn can be transformed into improvement of commercial value. Besides, linkages with financial institutions is another type of relationship that fosters improvement in both innovation and financial performance. Science parks can facilitate access to services provided by financial institutions. Public support programs can be initiated to provide assistance for firms' innovation activities through financial institutions.

Although inter-firm collaboration exerts negative impacts on financial performance according to the results, it is unreasonable to conclude that inter-firm network is not a good thing for tenant firms. Policy makers can be proactive in developing an enabling entrepreneurial ecosystem. It is critical for policy makers to develop a secure and transparent legal system, creating a favourable regulatory environment for firms inside science parks (Etzkowtiz and Zhou, 2017). It is also important for science park management to create a positive collaboration culture (Chan et al., 2009). Science parks can facilitate building of trust between tenant firms. Relationships of trust and reciprocity reduce risk associated with innovation activities (Lawson and Lorenz, 1999). Such relationships avoid competing through vicious competition. Science park management can encourage hosted firms to share their knowledge and resources with other tenants, which can lead to more fruitful and productive results of interactions (Phillimore, 1999). Tenant firms can be trained with regard to intellectual property protection.

The measurement scale of ESPCN provide insights into how firms can exploit the benefits associated with science park location. It provides a checklist for decision-making of managers of firms located on Chinese science parks. Firm who can obtain more rewards from science park location are those that have made considerable efforts and wise strategies too. Science park collaborative network can be viewed as a bundle of resources which facilitates on-park firms to get access to resources and capabilities that are necessary for their innovation. The overall-effect model indicates that four types of relationships should be adopted simultaneously, which can generate much greater effects than adoption of a single type of relationship. Firms which can fully exploit the benefits of science park location are more likely to achieve innovation success and superior financial performance. On-park firms should take an active part in developing close and long-term relationships with various organisations or institutions on science parks. They need to consider in a more comprehensive way. Tenant firms can develop a comprehensive set of relationships with science park actors.

The individual-effect model also provides some implications for tenant firms. They should be proactive with developing network relationships with academic institutions as they are the most strongest contributor to firms' outcomes. Innovation capabilities and financial performance of tenant firms are most easily enhanced by collaboration with universities and research institutions. Firm managers should be aware that they can invest more resources and capital in developing and maintaining close ties with knowledge institutions, which is an important source of technological breakthroughs. Considering the negative impacts of collaboration between tenant firms, they can seek assistance of technology intermediaries on science parks. Rich knowledge base of technology intermediaries can provide tenants with quick access to suitable knowledge, technology, skills, capital, talents and partners. They play a key role in filling in resource gap of science park firms. Besides, tenants should refrain from behaving opportunistically. They need to take a more open attitude towards contribution of their knowledge and resources to collaborative R&D or innovative activities in order to achieve benefit maximization. It is also important develop long-standing and close relationships with business partners, which lead to building of mutual trust. Moreover, firms can seek assistance provided by financial institutions through technology intermediaries. Technology intermediaries can help tenants get easier access to finance and services offered by financial institutions. The governments should be proactive in introducing funding mechanisms as part of their strategies that stimulate innovative activities of science park firms (Yigitcanlar et al., 2018). Some authors posit that technological innovation development must be supported and facilitated by government incentives (Yigitcanlar, 2009; Scotchmer, 2004). In the era of global knowledge economy, innovation plays a fundamental role in the growth of regional and national economy (Yigitcanlar et al., 2018).

6.7 CONCLUSION

This chapter discusses how the research findings answer three research questions proposed in introduction chapter. The validation of ESPCN scale suggests that it is a multi-dimensional construct. ESPCN can be represented by four dimensions, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial institutions. Technology intermediaries has the greatest explanatory power towards ESPCN as they play an in important role in linking firms and institutions on science park ecosystem. The results of overall-effect model indicate that it is favourable for tenants to adopt four types of relationship simultaneously. Tenant firms can reap more benefits from adoption of a comprehensive sets of relationships than just focus on one type of relationship. Science park management team should be committed to creating an integrated ecosystem that promotes technology diffusion and knowledge flows between firms and institutions. The individual-effect model demonstrates different effects of different types of relationships. On-park firms can invest more in developing close ties with knowledge institutions which exert greatest performance effects on tenants. For another, they can overcome risks or challenges with inter-firm network by seeking assistance by technology intermediaries。

CHAPTER 7 CONCLUSION

7.1 INTRODUCTION

Most of prior studies that explore the impacts of science parks on firms are conducted in contexts of developed countries. Thus, this study contributes to science park literature by exploring the impacts of Chinese science parks on affiliated firms, which is the largest developing economy. On the other hand, comparison between the performance of on-park and off-park companies is the most widely approach used by previous studies to assess the effects of science parks on tenants. How interactive innovation and knowledge sharing process within science parks contributes to firms' growth has been ignored to some degree. This research fills in the gap by employing questionnaire survey method for data collection and structural equation modeling (SEM) approach for data analysis. The study contributes to literature by addressing three research questions proposed in previous chapter. Firstly, it develops and validates a multi-dimensional concept for science park collaborative network. Secondly, it extends the literature by examining the effectiveness of science park collaborative network in contributing to innovation capabilities and financial performance of tenant firms. Moreover, this study looks into how individual dimensions of science park ecosystem influences tenants' achievement in innovation and growth in commercial value. The research findings provide implications for managers of both science parks and science park firms. Management team of science parks will have a better understanding of how to promote the growth of hosted firms through networking facilitation. For another, firm managers can better know how to exploit the benefits of science park location for improving their innovation process.

First of all, this chapter summarises research findings that answer three research questions proposed in Chapter 1. Next, theoretical contribution of this research to literature has been clarified. And then, implications for management team of science parks and managers of science park firms have been presented. Finally, this chapter points out the limitations associated with the research and provide some suggestions for future research.

7.2 ADRESSING RESEARCH QUESTIONS

7.2.1 What would the measurement scale for science park collaborative network (ESPCN) entail?

This study comes up with a multi-dimensional concept for answering the first research question. Difficulties associated with measurement of science park effectiveness due to complex nature of science parks. The measurement scale of ESPCN is developed and validated in Chapter 5 by 312 valid questionnaire response. ESPCN is defined as a multi-dimensional construct which is composed of four dimensions, including academic-industry collaboration, inter-firm collaboration, interaction with technology intermediaries, and interaction with financial institutions. The research results indicate that ESPCN can be represented by four dimensions as those four factors are positively and significantly correlated with each other. It provides a comprehensive view of science park ecosystem. Academic institutions act as knowledge providers for firms as they are an important source of high-qualified talents. Technology intermediaries can be regarded as knowledge reservoir that supports both innovation process and networking activities of tenants. Financial institutions provide finance for innovation process of firms as well as offer financial services that helps investment decision-making.

7.2.2 What is the aggregate impact of ESPCN on innovation capabilities and financial performance of tenant firms?

The second research question is associated with the examination of science park collaborative network's overall effects on their affiliated firms. The impacts of science park ecosystem are measured by its innovation effects and commercial effects. The research findings obtained support the hypotheses proposed for the overall-effect model in Chapter 3. Science park network has direct, positive, and significant impacts on innovation capabilities of tenant firms, and in turn contributes to the enhancement of financial performance. Tenant firms improve innovation capabilities through engagement in science park ecosystem, and enhance financial performance by appropriating benefits from innovation improvement. Science parks in China successfully create value for their affiliated firms. The results presented in Chapter 5 suggests that the impacts of science park ecosystem on innovation capabilities is much stronger than impacts on financial performance. Science parks, which can be seen as innovative milieu, has stronger influences on innovation achievement of hosted firms than commercial value. They play a vital role in contributing to stimulating and facilitating innovation. Compared with individual-effect model, overall-effect model shows better performance in terms of impacts on innovation and financial performance of tenant firms. The approach employed by previous studies to assess the effects of science parks is limited to the comparison of performance between on- and off-park companies. This research fills in gap by exploring how knowledge sharing and collaborative innovation involved in science park network contributes to the development of tenant firms.

7.2.3 What are individual impacts of ESPCN's four sub-dimensions on innovation capabilities and financial performance of tenant firms?

As for the last research question, it aims to examine the effects of individual dimensions of ESPCN. Based on SEM analysis, this study has found that four types of network relationships have positive and significant impacts on innovation capabilities of tenant firms. However, it shows mixed results with regard to individual effects of each type of relationship on financial performance of hosted firms. The findings suggest that inter-firm collaboration is negatively related to tenants' financial performance. The impacts of interaction with technology intermediaries on financial performance is insignificant. Collaboration with academics has the greatest positive impacts on both innovative and commercial achievement of science park firms. Interaction with financial institutions is the other type which has positive impacts on both innovative and financial It appears that inter-firm collaboration shows disappointed results in terms of their effectiveness in creating value for tenants. It is also unexpected that its impacts on innovation is the weakest among four types of relationships.

7.3 THEORETICAL CONTRIBUTION

Firstly, the study develops a multi-dimensional construct of ESPCN, which has been validated by factor analysis and structural equation modeling approach in Chapter 5. ESPCN is a four-dimensional concept. This study unpacks different types of collaborations that exist in science park ecosystem. It is difficult to generalise the results with regard to the effectiveness of science parks as heterogeneous actors of science park ecosystem have different objectives. Science parks are regarded as collaborative network with the aim to overcome resource limitations of tenant firms. A diversity of actors involved in science park ecosystem are categorized into four groups, including academic institutions, companies, technology intermediaries and financial institutions. Relationships with four groups of science park actors are four dimensions of ESPCN construct.

This study contributes to literature by shedding light on how collaborative network of science parks can explain or facilitate tenants' achievement in innovation and commercial value. It justifies how science parks deliver value to hosted firms. Most of studies compare performance of on-park firms with that of off-park firms in order to measure the role of science parks in creating value for firms (Lamperti et al., 2015; Liberati et al., 2016; Lindelof and Lofsten, 2003; Ferguson and Olofsson, 2004). Rather than measure the effectiveness of science parks by comparing on-park and off-park firms, this study explores the processes of knowledge sharing and technology transfer that occur in network between different actors in the science park ecosystem. It develops a conceptual foundation for exploring the effectiveness of science park ecosystem in creating value for tenants. The combination of four types of collaboration improves the possibility of science park firms to achieve success in innovation and commercial benefits. The synthesis of different types of network relationships show stronger effects on tenants than individual dimensions of ESPCN. It provides insights that science park firms should be proactive with developing four types of network relationships simultaneously, which can create greater value for them than just adoption of a single type of network. This study provides a comprehensive view of science park ecosystem that supports the growth of affiliated firms. Moreover, mediation effect of innovation capabilities between ESPCN and financial performance has been examined. The test indicates that innovation capabilities have a partial mediation effect on financial performance, suggesting that part of financial performance can be affected by ESPCN and part of it can be influenced by innovation capabilities.

This study also looks into the effects of individual dimension of ESPCN. Whether direct and positive impacts of ESPCN components have been exerted on tenant firms' ability to innovate and create commercial returns has been examined. The most and the least influential types of relationship have been identified. Some previous studies focus on one or two factors that influence the performance of firms residing in parks (Diez-Vial and Fernandez-Olmos, 2014; Ramirez-Aleson and Fernandez-Olmos, 2018). Science park network coordinates the resources and efforts of diverse actors. This study develops a systematic approach that examines the contributors to competitive advantage of science park firms. This research extends the literature by exploring which type of organization involved in science park ecosystem has the stronger or weaker impacts on tenant firms. According to the results, collaborating with universities and research institutions is the most effective way for science park firms to facilitate innovation achievement as well as increase financial benefits. Inter-firm collaboration performs the worst in terms of creating value for on-park firms.

7.4 MANAGERIAL IMPLICATIONS

This study has implications for management team of Chinese science parks. Science parks not only offer shared spaced and facilities for firms but also fosters interactions and networking that makes knowledge diffusion among firms and other organizations easier. Managers of science parks should be committed to creation of an integrated ecosystem that facilitate innovation success and financial growth of tenant firms. it is insufficient to only offer shared space and facilities for firms. Science parks' management team should take an active part in fostering and stimulating knowledge diffusion and technology flows among firms and various science park actors. For one thing, the results suggest that universities or research institutions have the strongest impacts on science park firms. Park managers should place great emphasis on creating effective institutional arrangements or strategies to promote academic-industry collaboration. Universities or research institutes play a vital role not only as the creators of new knowledge and technology but also as the suppliers of the capable personnel. Park firms' interactions with technology intermediaries and financial institutions should also be encouraged by the science park side. Technology intermediaries play a critical role in facilitating knowledge sharing and technology flows between firms and other organisations. Technology intermediaries should play a greater role in supporting inter-firm collaboration in particular. They can help firms overcome the challenges involved in inter-firm relationships through providing services related to partner selection, negotiation support, intellectual property protection etc. The quality of services provided by technology intermediaries should be improved, which helps firms achieve superior commercial benefits from business network. On the other hand, policy makers

For managers of science park firms, it is suggested that they can actively develop linkages with different actors of science park ecosystem. The measurement scale of ESPCN proposed in this study provides a checklist for tenant firms on Chinese science parks regarding how to exploit the benefits of park location. The overall-effect model indicates that four types of relationships should be adopted simultaneously, which can generate more benefits than adoption of a single type of relationship. The success of science park firms depends on the combination of various types of network relationships to a greater degree. The individual-effect model suggests that firms should invest more resources in developing close relationships with public research sector and financial institutions because they contribute significantly to improving both innovation capabilities and financial performance. They can collaborate with academics to pursue technology development and make breakthroughs in their sector. Close ties with financial institutions can help them overcome challenges and mitigate risk associated with innovative activities. Networking with other tenants exerts negative influences on commercial gains of tenant firms. There is risk or challenges associated with inter-firm network within Chinese science parks. Apart from formal cooperation and collaboration, informal communication and close and long-term ties between tenants are required for building mutual trust. Firms can seek assistance from technology intermediaries, which can help them cope with the risks involved in inter-firm relationships. Close ties with them enable firms to mitigate challenges brought by volatile legal and business environment.

7.5 LIMITATIONS AND FUTURE RESEARCH

There are some limitations associated with this study. For one thing, high costs are associated with approaching all the science parks in China. For another, the difficulties in collecting data from more than 100 science parks in China could not be ignored. Moreover, it is unlikely to approach all Chinese science parks. The respondents of survey is limited to firms located on science parks in Beijing and Shanghai, which are the most developed cities in China. Both of them have an advantage over other regions in China with regard to preferential government policies, powerful financial support, and high concentration of both universities with good reputation and world-known enterprises' Chinese headquarters. It can be assumed that the effectiveness of science parks located in other regions of China in creating value for their hosted firms might be different from that of parks in Beijing and Shanghai. Furthermore, the questionnaire survey was undertaken in two waves.

Statistical approach is adopted in this study to examine the role of science parks in shaping tenants' innovation capabilities and financial performance. More qualitative research can be undertaken to explore the impacts of science park collaborative network on innovation process of science park firms. For example, future research can dig into how science park network influences firms' idea generation and product or process innovation by means of interviews. The reasons why some types of collaborative relationships do not produce satisfactory results can be investigated. Different from quantitative studies, qualitative studies are more effective in answering "how" and "why" questions.

Future research can focus on how park characteristics, founder characteristics and firm characteristics affect the location-performance relationship. Heterogeneity of tenants on science parks may leads to different firm performance. The degree to which start-ups and established firms benefit from the park location might be different. The opportunities or challenges facing smaller and younger firms are likely different from that facing larger and older firms. Future studies could consider comparisons between diverse groups of tenant firms. Besides, parks with different characteristics may exert different impacts on their affiliated firms. The impacts of science park network on tenants may also depend on size, age, and location of science parks.

Secondly, future research can also examine how collaborative network within science park ecosystem influences performance of tenant firms in other regions of China or even other countries. Furthermore, this study focuses on collaborative relationships between firms and different actors within science park ecosystem, which tends to be formal. Future research can explore how informal linkages contribute to firms' achievement in innovation and commercial value. Informal linkages is a good way to share and exchange tacit knowledge, which is context-speicifc, based on experience, and difficult to communicate (Duffield and Whitty, 2015).

REFERENCES

AABOEN, L. (2009). Explaining incubators using firm analogy. *Technovation*, 29 (10), pp. 657-670.

ABETTI, P.A. (2004). Government-supported incubators in the Helsinki Region, Finland: infrastructure, results, and best practices. *The Journal of Technology Transfe*r, 29 (1), pp. 19-40.

ADLER, P.S. and SBENBAR, A. (1990). Adapting your technological base: the organizational challenge. *Sloan Management Review*, 32 (1), pp. 25-37.

AHUJA, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly*, 45 (3), pp. 425-455.

ALEGRE, J. and CHIVA, R. (2008). Assessing the impact of organizational learning capability on product innovation performance: an empirical test. *Technovation*, 28 (6), pp. 315-326.

AL-TABBAA, O. and ANKRAH, S. (2016) Social capital to facilitate "engineered" university-industry collaboration for technology transfer: a dynamic perspective. *Technological Forecasting and Social Change* 104, pp.1-15.

ANDERSON, J.C. and GERBING, D.W. (1988). Structural equation modeling in practice: a review and recommended two-step approach. *Psychological Bulletin*, 103 (3), pp. 411-423.

ARANDA, D.A. and MOLINA-FERNANDEZ, L.M. (2002). Determinants of innovation through knowledge-based theory lens. *Industrial Management & Data Systems*, 102 (5), pp. 289-296.

ARAUZO-CAROD, J., SEGARRA-BLASCO, A. and TERUEL, M. (2018). The role of science and technology parks as firm growth boosters: an empirical analysis in Catalonia. *Regional Studies*, 52, pp. 645-658.

ARZA, V. (2010). Channels, benefits and risks of public-private interactions for knowledge transfer: conceptual framework inspired by Latin America. *Science and Public Policy***,** 37 (7), pp. 473-484.

ASPARA, J., HIETANEN, J. and TIKKANEN, H. (2010). Business Model Innovation vs Replication: Financial Performance Implications of Strategic Emphases. *Journal of Strategic Marketing*, 18 (1), pp. 39-56.

AYYAGARI, M., DEMIRGUC-KUNT, A. and MAKSIMOVIC, V. (2011). Firm innovation in emerging markets: the role of finance, governance, and competition. *Journal of Financial and Quantitative Analysis*, 46 (6), pp. 1545-1580.

BAGOZZI, R.P. and YI, Y. (2012). Specification, evaluation, and interpretation of structural equation models. *Journal of the Academy of Marketing Science*, 40 (1), pp. 8-34.

BAI, X., YAN, W. and CHIU, Y. (2015). Performance evaluation of China's Hi-tech zones in the post financial crisis era – analysis based on the dynamic network SBM model. *China Economic Review*, 34, pp. 122-134.

BAKOUROS, Y. MARDAS, D. and VARSAKELIS, N. (2002). Science park, a high tech fantasy?: An analysis of science parks of Greece. *Technovation*, 22, pp. 123-128.

BANBURY, C.M. and MITCHELL, W. (1995). The effect of introducing important incremental innovations on market share and business survival. *Strategic Management Journal*, 16 (S1), pp. 161-182.

BARNEY, J. (2001). Firm resources and sustained competitive advantage. *Journal of Management*, 17, pp. 99-120.

BARNIR, A. and SMITH, K.A. (2002). Interfirm alliances in the small business: the role of social networks. *Journal of Small Business Management*, 40 (3), pp. 219-232.

BAUM, J., CALABRESE, T. and SILVERMAN, B.S. (2000). Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology. *Strategic Management Journal*, 21, pp. 267-294.

BECK, T. and DEMIRGUC-KUNT, A. (2006). Small and medium-sized enterprises: access to finance as a growth constraint. *Journal of Banking & Finance*, 30 (11), pp. 2931-2943.

BECK et al. (2006). The determinants of financing obstacles. *Journal of International Money and Finance*, 25 (6), pp. 932-952.

BEERS, C. and ZAND, F. (2013). R&D cooperation, partner diversity, and innovation performance: an empirical analysis. *Journal of Product Innovation Management*, 31 (2), pp. 292-312.

BEKKERS, R. and BODAS FREITAS, I.M. (2008). Analysing knowledge transfer channels between universities and industry: to what degree do sectors also matter? *Research Policy*, 37, pp. 1837-1853.

BELDERBOS, R., CARREE, M. and LOKSHIN, B. (2004). Cooperative R&D and firm performance. *Research Policy*, 33 (10), pp. 1477-1492.

BELL, G.G. (2005). Clusters, networks, and firm innovativeness. *Strategic Management Journal*, 26, pp. 287-295.

BENNEWORTH, P. and RATINHO, T. (2014). Reframing the role of knowledge parks and science cities in knowledge-based urban development. *Environment and Planning C:*

Government and Policy, 32, pp. 784-808.

BERTONI, F. and TYKVOVA, T. (2015). Does governmental venture capital spur innovation and innovation? Evidence from young European biotech companies. *Research Policy*, 44 (4), pp. 925-935.

BIGLIARDI, B. et al. (2006). Assessing science parks' performances: directions from selected Italian case studies. *Technovation*, 26, pp. 489-50.

BLOCH, P.H. (1995). Seeking the ideal form: product design and consumer response. *Journal of Marketing*, 59, pp. 16-29.

BISHOP, K., D'ESTE, P. and NEELY, An. (2011) Gaining from interaction with universities: multiple methods for nurturing absorptive capacity. *Research Policy* 40, pp. 30-40.

BODAS FREITAS, I., GEUNA, A. and ROSSI, F. (2013). Finding the right partners: Institutional and personal modes of governance of university-industry interactions. *Research Policy*, 42, pp. 50-62.

BOER, H. and DURIGN, W.E. (2001). Innovation, what innovation? A comparison between product, process and organizational innovation. *International Journal of Technology Management*, 22 (1/2/3).

BORJESSON, S. and ELMQUIST, M. (2011) Developing innovation capabilities: A longitudinal study of a project at Volvo Cars. *Creativity and Innovation Management*, 20 (3).

BOYCE, C. and NEALE, P. (2006). Conducting in-depth interviews: a guide for designing and conducting in-depth interviews for evaluation input.

BRISLIN, R.W. (1983). Cross-cultural research in psychology. *Annual review of Psychology*, 34, pp. 363-400.

BRYMAN, A. and BELL, E. (2015). *Business Research Methods.* 4th ed. Oxford: Oxford University Press.

CALANTONE, R.J., CAVUSGIL, S.T. and ZHAO, Y. (2002). Learning orientation, firm innovation capability, and firm performance. *Industrial Marketing Management*, 31, pp. 515-524.

CALIA, R.C., GUERRINI, F.M. and MOURA, G.L. (2007). Innovation networks: From technological development to business model reconfiguration. *Technovation*, 27, pp. 426-432.

CALOGHIROU, U., KASTELLI, I. and TSAKANIKAS, A. (2004). Internal capabilities and external knowledge sources: complements or substitutes for innovative performance? *Technovation*, 24 (1), pp. 29-39.

CANTNER, U., MEDER, A. and WAL, A. (2010). Innovator networks and regional knowledge base. *Technovation*, 30, pp. 496-507.

CAO, C. (2004). Zhongguancun and China's high-tech parks in transition. Asian Survey, 44 (5), pp. 647-668.

CASANUEVA, C., CASTRO, I. and GALAN, J.L. (2013). Informational networks and innovation in mature industrial clusters. *Journal of Business Research,* 66, pp. 603-613.

CASTELLS, M. and HALL, P. (1994). *The making of 21st Century Industrial Complexes: Technopoles of the world.* London: Routledge.

CELIKYURT, U., SEVILIR, M. and SHIVDASANI, A. (2010). How an IPO helps in M&A. *Journal of Applied Corporate Finance*, 22 (2), pp. 94-99.

CHARLES, D. (2006). Universities as key knowledge infrastructures in regional innovation systems. *Innovation,* 19 (1), pp. 117-130.

CHEMMANUR, T.J. and FULGHIERI, P. (2013). Entrepreneurial finance and innovation: an introduction and agenda for future research. *The Review of Financial Studies,* 27, pp. 1-19.

CHEN, C. et al. (2006). Evaluating the development of high-tech industries: Taiwan's science park. *Technological Forecasting and Social Change*, 73 (4), pp. 452-465.

CHEN, S. and KARWAN, K. (2008). Innovative cities in China: Lessons from Pudong New District, Zhangjiang High-tech Park and SMIC Village. *Innovation: management, policy & practice,* 10 (2-3), pp. 247-256.

Chiesa, V., COUGHLAN, P. and VOSS, C.A. (1996). Development of a technical innovation audit. *Journal of Product Innovation Management,* 13 (2), pp. 105-136.

CHOY, L.T. (2014). The strengths and weaknesses of research methodology: comparison and complimentary between qualitative and quantitative approaches. *IOSR Journal of Humanities and Social Science (IOSR-JHSS),* 19 (4), pp. 99-104.

CHRISTENSEN, J.F. (1995). Asset profiles for technological innovation. *Research Policy,* 24, pp. 727-745.

CHURCHILL, R.A. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research,* 16, pp. 64-73.

CLEMONS, E.K. and ROW, M.C. (1992). Information Technology and Industrial Cooperation: The Changing Economics of Coordination and Ownership. *Journal of Management Information systems,* 9 (2), pp. 9-28.

COHEN, W.M. and LEVINTHAL, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly,* 35 (1), pp. 128-152.

COHEN, W., NELSON, R.R. and WALSH, J. (2002). Links and impacts: the influence of public research on industrial R&D. *Management Science,* 48, pp. 1-23.

O'CONNOR, G.C. (2008). Major innovation as a dynamic capability: a systems approach. *Journal of Product Innovation Management,* 25 (4), pp. 313-330.

COLOMBO, G., DELL'ERA, C. and FRATTINI, F. (2014). Exploring the contribution of innovation intermediaries to the new product development (NPD) process: a typology and an empirical study. *R&D Management,* 45 (2), pp. 126-146.

COOKE, P. and WILLS, D. (1999). Small firms, social capital and the enhancement of business performance through innovation programmes. *Small Business Economics,* 13, pp. 219-234.

COOPER, R. (1998). Benchmarking new product performance: Results of the best practices study. *European Management Journal,* 16 (1), pp. 1-17.

COOPER, R. (2019). The drivers of success in new-product development. *Industrial Marketing Management*, 76, pp. 36-47.

CORBETT, L.M. and CLARIDGE, G.S. (2002). Key manufacturing capability elements and business performance. *International Journal of Production Research*, 40 (1), pp. 109-131.

CRONBACH, L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika,* 16 (3), pp. 297-334.

CROWTHER, D. and LANCASTER, G. (2008). *Research methods: a concise introduction to research in management and business consultancy.* 2nd ed. Oxford: Linacre House.

DABROWSKA, J. (2011). *Measuring the success of science parks: performance monitoring and evaluation.* Manchester Science Park.

DAGNINO, G.B. et al (2015). Interorganizational network and innovation: a bibiliometric study and proposed research agenda. *Journal of Business & Industrial Marketing,* 30 (3/4), pp. 354-377.

DAMANPOUR, F., WALKER, R.M. and AVELLANEDA, C.N. (2009). Combinative effects of innovation types and organizational performance: a longitudinal study of service organizations. Journal of Management Studies, 46 (4), pp. 650-675.

DA SILVA, A. and FORTE, S. (2016). Technology parks strategic capacity evaluation structure: a framework proposal for implementation in Latin America. *RAI Revista de Administracao e Inovacao,* 13(1), pp. 67-75.

DE FUENTES, C. and DUTRENIT, G. (2012), Best channels of academia-industry interaction for long-term benefit. *Research Policy*, 41, pp. 1666-1682.

DEMIRGUC-KUNT, A. and MAKSIMOVIC, V. (2002). Law, finance, and firm growth. *The Journal of Finance*, 53 (6), pp. 2107-2137.

DE PROPIS, L. (2002). Types of innovation and inter-firm cooperation. *Entrepreneurship and Regional Development*, 14, pp. 337-353.

DE SILVA, M., HOWELLS, J. and MEYER, M. (2018). Innovation intermediaries and collaboration: Knowledge-based practices and internal value creation. *Research Policy,* 47, pp. 70-87.

D'ESTE, P. and PATEL, P. (2007). University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy* 36, pp. 1295-1313.

D'ESTE, P. and PERKMANN, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer,* 36, pp.316-339.

DIEZ-VIAL, I. and FERNANDEZ-OLMOS, M. (2015) The effects of Science and Technology Parks on a firm's performance: a dynamic approach over time. *Journal of Technology Transfer,* 40, pp. 70-84.

DIEZ-VIAL, I. and MONTORO-SANCHEZ, A. (2016). How knowledge links with universities may foster innovation: the case of a science park. *Technovation* 50-51, pp. 41-52.

DOLOREUX, D. (2004). Regional networks of small and medium sized enterprises: evidence from the Metropolitan Area of Ottawa in Canada. *European Planning Studies,* 12(2), pp. 173-189.

DUKE, D. et al. (2006). The psychometric properties of the brief fear of negative evaluation scale. *Journal of Anxiety Disorders,* 20 (6), pp. 807-817.

DYER, J.H. and HATCH, N.W. (2006). Relation-specific capabilities and barriers to knowledge transfer: creating advantage through network relationships. *Strategic Management Journal,* 27, pp. 701-719.

DYER, J.H. and NOBEOKA, K. (2000). Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal,* 21, pp. 345-367,

EASTERBY-SMITH, M. and LYLES, M.A. and TSANGl, W.K. (2008). Inter-organizational knowledge transfer: current themes and future prospects. *Journal of Management Studies,* 45 (4), pp. 677-690.

EISENHARDT, K.M. and MARTIN, J.A. (2000) Dynamic capabilities: What are they?

Strategic Management Journal, 21, pp. 1105-1121.

EMORY, C.W. and COOPER, D.R. (1991). *Business research methods,* 5th ed. McGraw Hill companies. Inc.

EOM, B. and LEE, K. (2010). Determinants of industry-academy linkages and, their impact on firm performance: The case of Korea as a latecomer in knowledge industrialization. *Research Policy,* 39, pp. 625-639.

ETZKOWITZ, H. and KLOFSTEN, M. (2005). The innovating region: toward a theory of knowledge-based regional development. *R&D Management,* 35 (3), pp. 243-255.

ETZKOWITZ, H. and LEYDESDORFF, L. (2000). The dynamics of innovation: from national systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy*, 29 (2), pp. 109-123.

ETZKOWITZ, H. and ZHOU, C. (2018). *The triple helix: University-industry-government innovation and entrepreneurship*, 2nd ed. New York: Routledge.

EUROPEAN COMMISSION (2014). S*etting up, managing and evaluating EU science and technology parks.* 10.2776/73401.

EUROPEAN UNION (1990). *Official Journal of the European Union*, OJ C186-51/52, 27 July.

FAEMS, D., LOOY, B.V. and DEBACKERE, K. (2005). Interorganizational collaboration and innovation: Toward a portfolio approach. *Journal of Product Innovation Management,* 22, pp. 238-250.

FAIRBANK, J.F. and WILLIAMS, S.D. (2001). Motivating creativity and enhancing innovation through employee suggestion system technology. *Creativity and Innovation Management*, 10(2), pp. 68-74.

FAN, P. (2018) Catching up in economic transition: Innovation in the People's Republic of China and India. Asian Development Bank Institute, Tokyo, Japan.

FARIA, A.P. and BARBOSA, N. (2014). Does Venture Capital Really Foster Innovation? *Economics Letters*, 122 (2) pp. 129-131.

FERGUSON, R. and OLOFSSON, C.(2004) Science Parks and the development of NTBFs - Location, Survival and Growth. *Journal of Technology Transfer* 29, p. 5-17.

FERRARA, M., LAMPERTI, F. and MAVILIA (2016) Looking for best performers: a pilot study towards the evaluation of science parks. *Scientometrics* 106, p. 717-750.

FLYNN, M. et al. (2003) Idea management for organisational innovation. *International Journal of Innovation Management*, 7(4), pp. 417-442.

FOWOWE, B. (2017). Access to finance and firm performance: Evidence from African countries. *Review of Development Finance,* 7 (1), pp. 6-17.

FRANCIS, D. and BESSANT, J. (2005). Targeting innovation and implications for capability development. *Technovation*, 25 (3), pp. 171-183.

FREEL, M.S. (2012). Barriers to product innovation in small manufacturing firms. *International Small Business Journal*, 18(2).

Freeman, L.C. (1979) Centrality in social networks conceptual clarification. *Social network*, 1, pp. 215–239.

FRISHAMMAR, J. et al. (2012). Antecedents and consequences of firms' process innovation capability: a literature review and a conceptual framework. *IEEE Transactions on Engineering Management*, 59 (4).

FU, X. et al. (2010) *Open innovation in China: Policies and practices.* University of Oxford: Department of International Development.

FUKUGAWA, N. (2006) Science parks in Japan and their value-added contributions to new technology-based firm. *International Journal of Industrial Organisation* 24, p. 381-400.

GANDINI, A. (2015). The rise of coworking spaces: A literature review. *Ephemera: Theory & Politics in Organization*, 15(1), pp. 673-696.

GARCIA, R. and CALANTONE, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, 19, pp. 110-132.

GARCIA-MUINA, F.E. and NAVAS-LOPEZ, J.E. (2007). Explaining and measuring success in new business: The effect of technological capabilities on firm results. *Technovation,* 27, pp. 30-46.

GARNSEY, E. and HEFFERNAN, P. (2005). High-technology clustering through spin-out and attraction: the Cambridge case. *Regional studies*, 29(8), pp.1127-1144.

GEORGE, G. and PRABHU, G.N. (2003). Developmental Financial Institutions as Technology Policy Instruments: Implications for Innovation and Entrepreneurship in Emerging Economies. *Research Policy,* 32 (1), pp. 89-108.

GEORGE, G., ZAHRA, S.A. and WOODE, D,R, (2002). The Effects of Business-University Alliances on Innovative Output and Financial Performance: A Study of Publicly Traded Biotechnology Companies. *Journal of Business Venturing,* 17 (6), pp. 577-609.

GIRMA, S., GONG, Y. and GORG, H. (2008). Foreign Direct Investment, Access to Finance, and Innovative Activity in Chinese Enterprises. *The World Bank Economic Review,* 22 (2), pp.

367-382.

GOES, J.B. and PARK, S.H. (1997). Interorganizational links and innovation: The case of hospital services. *The Academy of Management Journal,* 40(3), pp. 673-696.

GRANDORI, A. and SODA, G. (1994). Inter-firm networks: Antecedents, mechanisms and forms. *Organization Studies,* 16(2), pp. 183-214.

GRANT, R.M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal,* 17 (S2), pp. 109-122.

GRIFFIS, S.E., GOLDSBY, T.J. and COOPER, M. (2011). Web-based and mail surveys: a comparison of response, data, and cost. *Journal of Business Logistics,* 24 (2), pp. 237-258.

GRONUM, S., VERREYNNE, M. and KASTELLE, T. (2012). The role of networks in small and medium-sized enterprise innovation and firm performance. *Journal of Small Business Management,* 50(2), pp. 257-282.

GUAN, J.C., YAM, C.M. and LAU, K.W. (2009). Innovation strategy and performance during economic transition: Evidences in Beijing, China. *Research Policy,* 38, pp. 802-812.

GULATI, R. (19990 Network location and learning: the influence of network resources and firm capabilities on alliance formation. *Strategic Management Journal* 20, p. 397-420.

GWEBU, K.L. et al. (2018). Differential performance of science park firms: an integrative model. *Small Business Economics,* 52 (1), pp. 193-211.

HAIR, J.F. et al. (2014). Partial least squares structural equation modeling (PLS-SEM). *European Business Review,* 26 (2), pp. 106-121.

HANSSPN, F. (2007). Science parks as knowledge organizations – the “ba” in action? *European Journal of Innovation Management,* 10 (3), pp. 348-366.

HARGADON, A. and SUTTON, R.I. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly,* 42, pp. 716-749.

HEELER, R.M. and RAY, M.L. (1972). Measure validation in marketing. *Journal of Marketing Research,* 9, pp. 361-370.

HENRIQUES, I.C., SOBREIRO, V.A. and KIMURA, H. (2018). Science and technology park: future challenges. *Technology in Society,* 53, pp. 144-160.

HINE, D.C., PARKER, R. and IRELAND, D. (2010). The Knowledge Exchange Intermediary as Service Provider: A Discussion and An Australian Case. *The Service Industries Journal,* 30 (5), pp. 713-729.

HOLAHAN, P.J., SUILLIVAN, Z. and MARKHAM, S.K. (2013). Product development as core competence: how formal product development practices differ for radical, more innovative, and incremental product innovations. *Journal of Product Innovation Management*, 31 (2), pp. 329-345.

HONG, J. And LU, J. (2016) Assessing the effectiveness of Business Incubators in fostering SMEs. *International Journal of Entrepreneurship and Innovation Management***,** 20(1/2).

HOOPER, D., COUGHLN, J. and MULLEN, M. (2008). *Structural equation modelling: guidelines for determining model fit.* Dublin Institute of Technology.

HOWELLS, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy,* 35, pp. 715-728.

HOX, J.J. and BECHGER, T.M. (1998). An introduction to structural equation modeling. *Family Science Review*, 11, pp. 354-373.

HOYLE, R.H. (2012). *Handbook of Structural equation modeling*. London: Gilford Press.

HSU, P., TIAN, X. and XU, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of Financial Economics*, 112*,* pp. 116-135.

HU, A.G. (2007). Technology parks and regional economic growth in China. *Research Policy,* 26 (1), pp. 76-87.

HU, L. and BENTLER, P.M. (1998). Fit indices in covariance structure modeling: sensitivity to underparameterised model misspecification.

HUANG, K., YU, C. and SEETOO, D. (2012) Firm innovation in policy-driven parks and spontaneous clusters: the smaller firm the better? *Journal of Technology Transfer,* 37, pp. 715-731.

HUGGINS, R. JOHNSTON, A. and THOMPSON, P. (2012). Network capital, social capital and knowledge flow: How the nature of inter-organisational networks impacts on innovation. *Industry and Innovation,* 19(3), pp. 203-232.

INKINEN, T. and SUORSA, K. (2010). Intermediaries in regional innovation systems: high-technology enterprises survey from Northern Finland. *European Planning Studies,* 18(2), pp. 169-187.

JAFFE, A.B., TRAJTENBERG, M. and HENDERSON, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *The Quarterly Journal of Economics,* 108(3), pp. 577-598.

JANGER, J. (2017) The EU 2020 innovation indicator: A step forward in measuring innovation outputs and outcomes? *Research Policy* 46(1), p. 30-42.

JANSEN, W, STEENBAKKERS, W. and JAGERS, H. (2017). *New Business Models for the Knowledge Economy.* New York: Routledge.

JEREZ-GOMEZ, P., CESPEDES-LORENTE, J. and VALLE-CABRERA, R. (2005). Organizational learning capability: a proposal of measurement. *Journal of Business Research,* 58, pp. 715-725.

JOSHI, A. et al. (2015). Likert scale: explored and explained. British Journal of Applied Science & Technology, 7 (4), pp. 393-403.

KAFOUROS, M. et al. (2015). Academic Collaborations and Firm Innovation Performance in China: The Role of Region-Specific Institutions. *Research Policy,* 44 (3), pp. 803-817.

KBAR, G. and ALY, S. (2015) Goal-based key performance indicators of science parks' effectiveness: a case study at Riyadh Techno-Valley. *British Journal of Economics, Management & Trade,* 8(3), p. 237-257.

KEEBLE, E. (1989). High-technology industry and regional development in Britain: the case of the Cambridge phenomenon. *Environment and Planning C: Government and Policy,* 7, pp. 153-172.

KEEBLE, D.E. et al. (1999). Collective learning processes, networking and "institutional thickness" in the Cambridge Region. *Regional Studies,* 33(4), pp. 319-332.

KENNY, D.A. and MCCOACH, D.B. (2009). Effect of the number of variables on measures of fit in structural equation modeling. *Structural Equation Modeling: A multidisciplinary Journal,* 10 (3), pp. 333-351.

KERR, W.R., LERNER, J. and SCHOAR, A. (2011). The consequences of entrepreneurial finance: evidence from angel financings. *The Review of Financial Studies,* 27 (1), pp. 20-55.

KHARABSHEH, R. et al. (2011) Obstacles of success of Technology Parks: the case of Jordan. *International Journal of Economics and Finance* 3(6).

KIHLGREN, A. (2003). Promotion of innovation activity in Russia through the creation of science parks: the case of St. Petersburg (1992-1998). *Technovation,* 23 (1), pp. 65-76.

KING, R.G. and LEVINE, R. (1993). Finance, entrepreneurship, and growth: Theory and evidence. *Journal of Monetary Economies,* 32, pp. 513-542.

KNOCKAERT, M. and SPITHOVEN, A. (2014). Under which conditions do technology intermediaries enhance firms' innovation speed? The case of Belgium's collective research centres. *Regional Studies,* 48(8), pp. 1391-1403.

KNOCKAERT, M., SPITHOVEN, A. and CLARYSSE, B. (2014). The impact of technology intermediaries on firm cognitive capacity additionality. *Technological Forecasting & Social*

Change, 81, pp. 376-387.

KRAAIJENBRINK, J., SPENDER, J.C. and GROEN, A.J. (2009). The Resource-based view: a review and assessment of its critiques. *Journal of Management,* 36 (1), pp. 349-372.

KNUDSEN, M.P. (2007). The relative importance of interfirm relationships and knowledge transfer for new product development success. *Journal of Product Innovation Management,* 24, pp. 117-138.

KOGUT, B. and ZANDER, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science,* 3(3), pp. 383-398.

KOH, C.C., KOH, T.H. and TSCHANG, T. (2005) An analytical framework for science parks and technology districts with an application to Singapore. *Journal of Business Venturing,* 20, p. 217-239.

KONSTI-LAAKSO, S., PIHKALA, T. and KRAUS, S. (2012). Facilitating SME innovation capability through business networking. *Creativity and Innovation Management*, 21 (1), pp. 93-105.

KOSTOPOULOS, K. et al. (2011). Absorptive Capacity, Innovation, and Financial Performance. *Journal of Business Research,* 64 (12), pp. 1335-1343.

KOUFTEROS, X., BABBAR, S. and KAIGHOBADI, M. (2009). A paradigm for examining second-order factor models employing structural equation modeling. *International Journal of Production Economics*, 120 (2), pp. 633-652.

KRISHNAN, V. and ULRICH, K.T. (2001) Product development decisions: a review of the literature. *Management Science* 47(1), p. 1-21.

KUMAR, K. and VAN DISSEL, H.G. (1996). Sustainable Collaboration: Managing Conflict and Cooperation in Interorganizational Systems. *MIS Quarterly*, 20 (3), pp. 279-300.

LAI, H. and SHYU, (2005) A comparison of innovation capacity at science parks across the Taiwan Strait: the case of Zhangjiang High-Tech Park and Hsinchu Science-based Industrial Park. *Technovation* 25, p. 805-813.

LALL, S. (1992). Technological capabilities and industrialization. *World Development,* 20(2), pp. 165-186.

LAMINE, W. et al. (2018). Technology business incubation mechanisms and sustainable regional development. *The Journal of Technology Transfer,* 43 (5), pp. 1121-1141.

LAMPERTI, F., MAVILIA, R. and CASTELLINI, S. (2015) The role of Science Parks: a puzzle of growth, innovation and R&D investments. *Journal of Technology Transfer,* 42 (1), pp. 158-183.

LANDONI, P., SCELLATO, G. and CATALANO, G. (2010) Science parks contribution to scientific and technological local development: the case of AREA Science Park Trieste. *International Journal of Technology, Policy and Management* 10(1/2).

LANGERAK, F. and HULTINK, E.J. (2006). The impact of product innovativeness on the link between development speed and new product profitability. *Journal of Product Innovation Management,* 23 (3), pp. 203-214.

LAU, A., TANG, E. and YAM, R. (2010). Effects of supplier and customer integration on product innovation and performance: empirical evidence in Hong Kong manufacturers. *Journal of Product Innovation Management,* 27, pp. 761-777.

LAURSEN, K., REICHSTEIN, T. and SALTER, A. (2011). Exploring the effect of geographical proximity and university quality on university-industry collaboration in the United Kingdom. *Regional Studies*, 45(4), pp. 507-523.

LAWSON, C. ad LORENZ, E. (1999). Collective learning, tacit knowledge and regional innovative capacity. *Regional Studies*, 33(4), pp. 305-317.

LAWSON, B. and SAMSON, D. (2001). Developing innovation capability in organizations: a dynamic capabilities approach. *International Journal of Innovation Management,* 5 (3), pp. 377-400.

LECHNER, C. and DOWLING, M. (2003). Firm networks: external relationships as sources for the growth and competitiveness of entrepreneurial firms. *Entrepreneurship & Regional Development*, 15(1), pp. 1-26.

LEE, Y.S. (2000) The sustainability of university-industry research collaboration: An empirical assessment. *Journal of Technology Transfer* 25, p. 111-133.

LEE, N. and LINGS, I. (2008). *Doing business research: a guide to theory and practice.* London: SAGE Publication Ltd.

LEE, H. and KELLU, D. (2008). Building dynamic capabilities for innovation: an exploratory study of key management practices. *R&D Management*, 38 (2).

LHUILLERY, S. and PFISTER, E. (2009). R&D Cooperation and Failures in Innovation Projects: Empirical Evidence from French CIS Data. *Research Policy,* 38 (1), pp. 45-57.

LI, X. (2009). China’s Regional Innovation Capacity in Transition: An Empirical Approach. *Research Policy*, 38 (2), pp. 338-357.

LI, C., LAN, T. and LIU, S. (2015). Patent attorney as technology intermediary: A patent attorney-facilitated model of technology transfer in developing countries. *World Patent Information,* 43, pp. 62-73.

LIBERATI, D., MARINUCCI, M. and TANZI, G.M. (2016) Science and Technology Parks in Italy: main features and analysis of their effects on the firms hosted. *Journal of Technology Transfer,* 41, p. 694-729.

LICHTENTHALER, U. (2013). The collaboration of innovation intermediaries and manufacturing firms in the markets for technology. *Journal of Product Innovation Management,* 30(S1), pp. 142-158.

LICHTENTHALER, U. and ERNST, H. (2008). Intermediary services in the markets for technology: Organisational antecedents and performance consequences. *Organization Studies,* 29(7), pp. 1003-1035.

LIN, F. and LIN, Y. (2016). The effects of network relationship on the performance of SMEs. *Journal of Business Research,* 69, pp. 1780-1784.

LIN, C. and TZENG, G. (2009). A value-created system of science park by using DEMATEL. *Expert Systems with Applications*, 36, p. 9683-9697.

LIN, M. WEI, J. (2018). The impact of innovation intermediary on knowledge transfer. *Physica A*, 502, pp. 21-28.

LIN, H. et al. (2016). How do intermediaries drive corporate innovation? A moderated mediating examination. *Journal of Business Research*, 69, pp. 4821-4836.

LINK, A.N. and SCOTT, J.T. (2005). Opening the ivory tower's door: an analysis of the determinants of the formation of US university spin-off companies. *Research Policy,* 34 (7), pp. 1106-1112.

LINK, A.N. and SIEGEL, D.S. (2007). *Innovation, entrepreneurship, and technological change.* New York: Oxford University Press.

LINK, A.N. and SCOTT, J.T (2007). The economics of university research parks. *Oxford Review of Economic Policy*, 23 (4), pp. 661-674.

LIU, J. (2012). Dynamics of technological innovation network and its impact on organisational learning and innovation performance. *Innovation and development,* 2 (1), pp. 159-174.

LOFSTEN, H. and LINDELOF, P. (2002). Science Parks and the growth of new technology-based firms – academic-industry links, innovation and markets. *Research Policy,* 31, pp. 859-876.

LOFSTEN, H. and LINDELOF, P. (2002). Science parks and the growth of new technology-based firms academic-industry links, innovation and market. *Research Policy,* 31, pp. 859-876.

LOFSTEN, H. and LINDELOF, P. (2003). Determinants for an entrepreneurial milieu: science parks and business policy in growing firms. *Technovation,* 23, pp. 51-64.

LOFSTEN, N. and LINDELOF, P. (2005) R&D networks and product innovation patterns - academic and non-academic new technology-based firms on science parks. *Technovation* 25, p. 1025-1037.

LONGHI, C. (1999). Networks, collective learning and technology development in innovative high technology regions: The case of Sophia-Antipolis. *Regional Studies,* 33 (4), pp. 333-342.

LORENZONI, G. and LIPPARINI, A. (1999). The leveraging of interfirm relationships as a distinctive organizational capability: a longitudinal study. *Strategic Management Journal,* 20 (4), pp. 317-338.

LOVE, J.H. and ROPER, S. (2001). Location and network effects on innovation success: evidence for UK, German and Irish manufacturing plants. *Research Policy,* 30, pp. 643-661.

LUI, S.S., WONG, U. and LIU, W. (2008). Asset Specificity Roles in Interfirm Cooperation: Reducing Opportunistic Behavior or Increasing Cooperative Behavior? *Journal of Business Research,* 62 (11), pp. 1214-1219.

LUO, Y. (2006). Opportunism in Inter-Firm Exchanges in Emerging Markets. *Management and Organization Review,* 2 (1), pp. 121-147.

LYU, L. et al. (2017). An evolving regional innovation network: collaboration among industry, university, and research institution in China's first technology hub. Journal of *Technology Transfer,* 44 (3), pp. 659-680.

MAIETTA, O.M. (2015). Determinants of University-Firm R&D Collaboration and its Impacts on Innovation: A Perspective from a Low-Tech Industry. *Research Policy,* 44 (7), pp. 1341-1359.

MALECKI, E.J. (1991). *Technology and economic development: the dynamics of local, regional and national change*. London: Longman.

MALMBERG, A. and MASKELL, P. (2002). The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering. *Environment and Planning A: Economy and Space.*

MARSH, H.W., BELLA, J. and MCDONALD, R. (1988). Goodness-of-fit indexes in confirmatory factor analysis: the effect of sample size. *Psychological Bulletin,* 1030 (3), pp. 391-410.

MARSH, H.W. and HOCEVAR, D. (1985). Application of confirmatory factor analysis to the study of self-concept: first and higher order factor moels and their invariance across groups. *Psychological Bulletin,* 97 (3), pp. 562-582.

MARSHALL, A. (1980). *Principles of Economics.* London: Macmillan.

MARTINEZ-CANAS, R. and RUIZ-PALOMINO, P. (2010). Social capital generation inside science parks: An analysis of business-university relationships. *International Journal of Management & Information Systems*, 14 (4).

MASSEY et al., QUINTAS, P. and WIELD, D. (1992). *High tech fantasies: science parks in society, science and space.* London: Routledge.

MASSEY, D. and WIELD. (1992). Science parks: a concept in science, society, and "space" (A realist tale). *Environment and Planning D: Society and Space.*

MAYLOR, H. and BLACKMON, K. and HUEMANN, M. (2017). *Researching Business and Management.* 2nd ed. London: Palgrave.

MAZZOLA, E., PERRONE, G. and KAMURIWO, D.S. (2016). The interaction between inter-firm and interlocking directorate networks on firms' new product development outcomes. *Journal of Business Research*, 69, pp.672-682.

MCADAM, M. and MCADAM, R. (2008). High tech start-ups in University Science Park incubators: The relationship between the start-up's lifecycle progression and use of the incubator's resources. *Technovation,* 28, pp. 277-290.

MCADAM, R. and MCCLELLAND, J. (2002). Sources of new product ideas and creativity practices in the UK textile industry. *Technovation,* 22 (2), pp. 113-121.

MCEVILY, B. and MARCUS, A. (2005) Embedded ties and the acquisition of competitive capabilities. *Strategic Management Journal* 26, p.1033-1055.

MEDDA, G., PIGA, C. and SIEGEL, D.S. (2006). Assessing the returns to collaborative research: Firm-level evidence from Italy. *Economics of Innovation and New Technology,* 15 (1), pp. 37-50.

MIAN, S.A. (1996). Assessing value-added contributions of University Technology Business Incubators to tenant firms. *Research Policy,* 25, pp. 325-335.

MILLER, K. et al. (2014). The changing university business model: a stakeholder perspective. *R&D Management,* 44 (3), pp. 265-287.

MONCK, C. and PETERS, K. (2009). Science parks as an instrument of regional competitiveness: measuring success and impact.

MU, J. et al. (2017). Strategic orientation and new product development performance: The role of networking capability and networking ability. *Industrial Marketing Management,* 64, pp. 187-201.

MULAIK, S.A. and MILLSAP, R.E. (2000). Doing the four-step right. *Structural Equation Modeling,* 7 (1), pp. 36-73.

NAHAVANDI, N. et al. (2012). Design of an intelligent system for evaluation of science parks. *International Journal of Industrial Engineering & Production Research,* 23 (2), pp. 73-83.

NAHM, A.Y. et al. (2002). The Q-sort method: assessing reliability and construct validity of questionnaire items at a pre-testing stage. *Journal of Modern Applied Statistical Methods,* 1 (1), pp. 114-125.

NAJAFI-TAVANI, S. et al. (2018). How collaborative innovation networks affect new product performance: Product innovation capability, process innovation capability, and absorptive capacity. *Industrial Marketing Management,* 73, pp. 193-205.

NIETO, M.J. and SANTAMARIA, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, 27, pp. 367-377.

NOAR, S.M. (2009). The role of structural equation modeling in the scale development. *Structural Equation Modeling: a Multidisciplinary Journal,* 10 (4), pp. 622-647.

NONAKA, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science,* 5 (!), pp. 1-118.

O'SUILLIVAN, M. (2005). Finance and innovation, in FAGERBERG, J., MOWERY, D. and NELSON, R.R. (eds), *The Oxford Handbook of Innovation.* Oxford: Oxford University Press.

OZMAN, M. (2009). Inter-firm networks and innovation: a survey of literature. *Economic of Innovation and New Technology,* 18 (1), pp. 39-67.

PANDA, H. and RAMANATHAN, K. (1996). Technological capability assessment of a firm in the electricity sector. *Technovation,* 16 (10), pp. 561-588.

PARKER, R. (2010). Evoluation and change in industrial clusters: An analysis of Hsinchu and Sophia Antipolis. *European Urban and Regional Studies*, 17 (3), pp. 245-260.

PAULUS, P.B. and YANG, H. (2000). Idea generation in groups: a basis for creativity in organizations. *Organizational Behavior and Human Decision Processes,* 82 (1), pp.76-87.

PARIDA, V. et al. (2016). Network partner diversity, network capability, and sales growth in small firms. *Journal of Business Research,* 69, pp. 2113-2117.

PARKER, R. and HINE, D. (2014). The role of knowledge intermediaries in developing firm learning capabilities. *European Planning Studies,* 22 (5), pp. 1048-1061.

PENROSE, E. (1959). *The theory of the growth of the firm.* New York: John Wiley & Sons.

PERKMANN, M. and WALSH, K. (2007) University-industry relationships and open innovation: towards a research agenda. *International Journal of Management Reviews,* 9 (4), p.259-280.

PERKMANN, M. and WALSH, K. (2009). The two faces of collaboration: impacts of university –industry relations on public research. *Industrial and Corporate Change,* 18 (6), pp. 1033-1065.

PETER, E. and MAAS, A. (2016). *Disruptive innovation, passionate entpreneurship and high-tech startups.* Amsterdam: University Press.

PETERAF, M.A. (1993). The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal*, 14 (3), pp. 179-191.

PETRUZELLI, A.M. (2011). The impact of tecnological relatedness, prior ties, and geographical distance on university-industry collaborations: a joint-patent analysis. *Technovation*, 31, pp. 309-319.

PHILLIMORE, J. (1999). Beyond the linear view of innovation in science park evaluation: an analysis of Western Australian Technology Park. *Technovation*, 19 (11), pp. 673-680.

PORTER, M.E. (1998). *Clusters and new economics of competition*. Harvard Business Reivew.

PORTER, M.E. (2000). Location, competition, and economic development: local clusters in global economy. *Economic Development Quarterly.*

POWELL, W.W., KOGUT, K.W. and SMITH-DOERR, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly,* 41(1), pp. 116-145.

QUAL, D. (2001). ICT clusters in development: theory and evidence. European Investment Bank.

RAMIREZ, M. and DICKENSON, P. (2010). Gatekeepers, knowledge brokers and inter-firm knowledge transfer in Beijing's Zhngguancun Science Park. *International Journal of Innovation Management,* 14 (1), pp. 93-122.

RAMIREZ-ALESON, M. and FERNANDEZ-OLMOS, M. (2018). Unravelling the effects of science parks on the innovation performance of NTBFs. *The Journal of Technology Transfer,* 43 (2), pp.482-505.

REICHSTEIN, T. and SALTER, A. (2006). Investigating the sources of process innovation among UK manufacturing firms. *Industrial and Corporate Change,* 15 (4), pp. 653-682.

RIBEIRO, J. et al (2016). A framework for the strategic management of science & technology parks. *Journal of Technology Management & Innovation,* 11 (4).

RITTER, T. and GEMUNDEN, H.G. (2003). Network competence: Its impact on innovation success and its antecedents. *Journal of Business Research,* 56, pp. 745-755.

RODRIGUEZ-POSE, A. and HARDY, D. (2014). *Technology and Industrial Parks in emerging countries: Panacea or Pipedream?* London: Springer.

ROGERs, M. (2004). Networks, firm size and innovation. *Small Business Economics,* 22, pp. 141-153.

ROMJIN, H. and ALBALADEJO, M. (2002). Determinants of innovation capability in small electronics and software firms in southeast England. *Research Policy*, 31, pp. 1053-1067.

ROSENFELD, S.A. (1996). Does cooperation enhance competitiveness? Assessing the impacts of inter-firm collaboration. *Research Policy,* 25, pp. 247-263.

ROTHAERMEL, F.T. (2001). Incumbent's advantage through exploiting complementary assets via interfirm cooperation. *Strategic Management Journal*, 22, pp .687-699.

ROTHAERMEL, F.T. and HESS, A.M. (2007). Building dynamic capabilities: Innovation driven by individual-, firm-, and network-level effects. *Organization Science,* 18 (6), pp. 898-921.

RUBIO, D.M., BERG-WEGER, M. and TEBB, S.S. (2009). Using structural equation modeling to test for multidimensionality. *Structural Equation Modeling: A Multidisciplinary Journal*, 8 (4), pp. 613-626.

RUSH, H., BESSANT, J. and HOBDAY, M. (2007). Assessing the technological capabilities of firms: developing a policy pool. *R&D Management*, 37 (3).

SADEGHI, M.E. and SADABADI, A.A. (2015). Evaluating science parks capacity to create competitive advantages: comparison of Pardis Technology Park and Sheikh Bahaei Sccience Park in Iran. *International Journal of Innovation and Technology Management,* 12 (6)

SAMPSON, R.C. (2007). R&D alliances and firm performance: The impact of technological diversity and alliance organization on innovation. *Academy of Management Journal*, 50(2), pp.364-386.

SAUNDERS, M. LEWIS, P. and THORNHILL, A, (2013). *Research methods for business students.* 6th ed. Essex: Pearson Education Limited.

SCHARTINGER, D. et al. (2002). Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants. *Research Policy* 31, pp. 303-328.

SCHILLING, M.A. and PHELPS, C.C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management Science,* 53 (7), pp. 1113-1126.

SCHMITT, T.A. (2011). Current methodological considerations in exploratory and confirmatory factor analysis. *Journal of Psychoeducational Assessment,* 29 (4), pp. 304-321.

SCHREIBER, J.B., et al. (2010). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research,* 99 (6), pp. 323-338.

SCHUMACKER, R.E. and LOMAX, R.G. (2004). *A beginner's guide to structural equation modeling*. 2nd ed. Mahwah: Lawrence Erlbaum Associates.

SEGARRA-BLASCO, A. and ARAUZO-CAROD, J. (2008). Sources of innovation and industry-university interaction: evidence from Spanish firms. *Research Policy,* 37 (8), pp. 1293-1295.

SHEARMUR, R. and DOLOREUX, D. (2000). Science parks: actors or reactors? Canadian Science Parks in their urban context. *Environment and Planning A: Economy and Space.*

SEGARS, A.H. (1997). Assessing the unidimensionality of measurement: a paradigm and illustration within the context of information systems research. *Omega*, 25 (1), pp. 107-121.

SIEGEL, D.S., WALDMAN, D. and LINK, A. (2003). Assessing the impact of organisational practices on the relative productivity of university technology transfer offices: an exploratory study. *Research Policy,* 32, pp.2 7-48.

SIGGELKOW, N. (2007). Persuasion with case studies. *Academy of Management Journal,* 50 (1), pp. 20-24.

SLACK, N., BRANDON-JONES, A. and JOHNSTON, R. (2013) *Operations Management.* 7th ed. Harlow, England: Pearson.

SLACK, N. and LEWIS, M. (2008) Operations Strategy. 2nd ed. Harlow, England: Pearson.

SMITH, D. (2010). *Exploring innovation*. 2nd ed. Maidenhead: McGraw-Hill Education.

SOH, P. and SUBRAMANIAN, A.M. (2014). When do firms benefit from university-industry R&D collaborations? The implications of firm R&D focus on scientific research and technological recombination. *Journal of Business Venturing,* 29, pp. 807-821.

SONG, M (2011). Does strategic planning enhance or impede innovation firm performance? *Product Development & Management Association, 2*8, pp. 503-520.

SONG, W., Cao, J. and Zheng, M. (2016). Towards an integrative framework of innovation network for new product development project. *Production Planning & Control*, 27 (12), pp. 967-978.

SONG, S.H., KIM, J. and KANG, J. (2016). The effects of ambidextrous alliances on product innovation. *Journal of Global Scholars of Marketing Science,* 26 (1), pp. 4-18.

SPENDER, J.D. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal,* 17 (S2), pp. 45-62.

SQUICIARINI, M. (2008). Science parks' tenants versus out-of-park firms: who innovates more? A duration model. *The Journal of Technology Transfer*, 31 (1), pp. 45-71.

STUART, T.E. (2000). Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strategic Management Journal,* 21, pp. 791-811.

SUTHERLAND, D. (2005). China's Science Parks: Production bases or a tool for institutional reform? *Asia Pacific Business Review,* 11 (1), pp. 83-104.

SYMONDS, P.M. (1924). On the loss of reliability in ratings due to coarseness of the scale. *Journal of Experimental Psychology,* 7 (6), pp. 456-461.

TEECE, D.J., PISANO, G. and SHUEN, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18 (7), pp. 509-553.

TER WAL, L.J. (2013). Cluster emergence and network evolution: A longitudinal analysis of the inventor network in Sophia-Antipolis. *Regional Studies*, 47 (5), pp. 651-688.

THORGREN, S., WINCENT, J. and ORTQVIST, D. (2009). Designing interorganizational networks for innovation: An empirical examination of network configuration, formation and governance. *Journal of Engineering and Technology Management,* 26, pp. 148-166.

TOMLINSON, P.R. (2010) Cooperative ties and innovation: Some new evidence for UK manufacturing. *Research Policy,* 39 (6), pp. 762-775.

TORRE, A. and GILLY, J. (2000). Debates and surveys: on the analytical dimension of proximity dynamics. *Regional Studies,* 34 (2), pp. 169-180.

TRAN, U., HSUAN, J. and MAHNKE, V. (2011). How do innovation intermediaries add value? Insight from new product development in fashion markets. *R&D Management,* 41 (1).

TRIPPL, M., SINOZIC, T. and SMITH, H.L. (2015). The role of universities in regional development: conceptual models and policy institutions in the UK, Sweden and Austria. *European Planning Studies,* 23(9), pp. 1722-1740.

TSAI, K. (2009). Collaborative networks and product innovation performance: Toward a contingency perspective. *Research Policy,* 38, pp. 765-778.

TSENG, C. et al. (2016) The relationship between innovation network and innovation capability: a social network perspective. *Technology Analysis & Strategic Management*, 28 (9), pp. 1029-1040.

UBEDA, F., ORTIZ-DE-URBINA-CRIADO, M. and MORA-VALENTIN, E. (2019). Do firms located in science and technology parks enhance innovation performance? The effect of absorptive capacity. *The Journal of Technology Transfer,* 44 (1), pp. 21-48.

ULLMAN, J.B. and BENTLER, P.M. (2003). Structural equation modeling. In: *Handbook of Psychology*.

UN, D.A. and ASAKAWA, K. (2015). Types of R&D collaborations and process innovation: The benefit of collaborating upstream in the knowledge chain. *Journal of Product Innovation Management,* 32 (1), pp. 138-153.

VACCARO, A., PARENTE, R. and VELOSO, F.M. (2010). Knowledge Management Tools, Inter-Organizational Relationships, Innovation and Firm Performance. *Technological Forecasting & Social Change*, 77 (7), pp. 1076-1089.

VAN DE VEN, A.H. (1986). Central problems in the management of innovation. *Management Science,* 32 (5), pp. 513 – 644.

VASQUEZ-URRIAGO, A.R., BARGE-GIL, A. and RICO, A.M. (2016). Science and technology parks and cooperation for innovation: empirical evidence from Spain. *Research Policy*, 45 (1), pp. 137-147.

VEDOVELLO, C. (1997). Science parks and university-industry interaction: geographical proximity between the agents as a driving force. *Technovation,* 17 (9), pp. 491-502.

WALCOTT, S.M. (2002). Chinese Industrial and Science Parks: Bridging the gap. *The Professional Geographer*, 54 (3), pp. 349-364.

WALTER, S.G., WALTER, A. and MULLER, D. (2014). Formalization, Communication Quality, and Opportunistic Behavior in R&D Alliances between Competitors. *Journal of Production Innovation Management,* 32 (6), pp. 954-970.

WANG, C.L. and AHMED, P.K. (2007). Dynamic capabilities: a review and research agenda. *International Journal of Management Reviews,* 9 (1), pp. 31-51.

WATKINS, D. and HORLEY, G. (1986). Transferring technology from large to small firms: the role of intermediaries. *Small Business Research,* 35 (5), pp. 715-728.

WATSON, J. (2007). Modeling the relationship between networking and firm performance. *Journal of Business Venturing,* 22, pp. 852-874.

WERNERFELT, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, 5 (2), pp. 171-180.

WESTHEAD, P. (!997). “R&D inputs” and “outputs” of technology-based firms located on and off science parks. *R&D Management,* 27 (1), pp. 45-61.

WESTON, R. and GORE, P.A. (2006). A brief guide to structural equation modeling. *The counseling Psychologist*, 34 (5), pp. 719-751.

WIKLUND, J. and SHEPHERD, D. (2003). Knowledge-based resources, entrepreneurial orientation, and the performance of small and medium-sized businesses. *Strategic Management Journal,* 24 (13), pp. 1307-1314.

WILKINSON, B. et al. (2005). Human Resources Barriers to Partnership Sourcing in China. *International Journal of Human Resource Management,* 16 (10), pp. 1886-1900.

WONG, A., TJPSVOLD, D. and YU, Z. (2005). Organizational Partnerships in China: Self-Interest, Goal Interdependence, and Opportunism. *Journal of Applied Psychology,* 90 (4), pp. 782-791.

WORTHINGTON, R.L. and WHITTAKER, T.A. (2006). Scale development research: a content analysis and recommendations for best practices.

WRIGHT, M. et al. (2008). Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries. *Research Policy,* 37, pp. 1205-1223.

WU, S. (2007). Cultivating research universities and industrial linkages in China: The case of Shanghai. *World Development,* 35 (6), pp. 1075-1093.

WUYTS, S., DUTTA, S. and STREMERSCH, S. (2004). Portfolios of interfirm agreements in technology-intensive markets: consequences for innovation and profitability. *Journal of Marketing,* 68, pp. 88-100.

XIE, X. and GAO, Y. (2018). Strategic networks and new product performance: the mediating role of ambidextrous innovation. *Technology Analysis & Strategic Management,* 30 (7), pp. 811-824.

YAM, C.M. et al. (2004). An audit of technological innovation capabilities in Chinese firms: some empirical findings in Beijing, China. *Research Policy***,** 33, pp. 1123-1140.

YAM, C.M., et al. (2011). Analysis of sources of innovation, technological innovation capabilities, and performance: An empirical study of Hong Kong manufacturing industries. *Research Policy,* 40, pp. 391-402.

YANG, C., MOTOHASHI, K. and CHEN, J. (2009). Are new technology-based firms located on science parks really more innovative?: Evidence from Taiwan. *Research Policy,* 38 (1), pp. 77-85.

YANG-WALLENTIN, F., JORESKOG, K.G. and LUO, H. (2010). Confirmatory factor analysis of ordinal variables with misspecfied models. *Structural Equation Modeling: A Multidisciplinary Journal,* 17 (3), pp. 392-423.

YAUCH, C.A. and STEUDEL, H.J. (2003). Complementary use of qualitative and quantitative cultural assessment methods. *Organizational Research Methods.*

YIGITCANLAR, T. et al. (2018). Impact of Funding Sources on Innovation: Evidence from Brazilian Software Companies. *R&D Management,* 48 (4), pp. 460-484.

YILMAZ, K. (2013). Comparison of quantitative and qualitative research traditions: epistemological, theoretical, and methodological differences. *European Journal of Education,* 48 (2), pp. 311-325.

YUN, S. and LEE, J. (2013). An innovation network analysis of science clusters in South Korea and Taiwan. *Asian Journal of Technology Innovation* 21 (2), pp. 277-289.

ZAHEER, A. and BELL, G.G. (2005). Benefiting from network position: firm capabilities, structural holes, and performance. *Strategic Management Journal,* 26, pp. 809-825.

ZAHRA, S.A. and GEORGE, G. (2002). Absorptive capacity: a review, reconceptualization, and extension. *Academy of Management Review,* 27 (2), pp. 185-203.

ZAHRA, S.A., SAPIENZA, H.J. and DAVIDSSON, P. (2006). Entrepreneurship and dynamic capabilities: A review, model and research agenda. Journal of Management Studies, 43 (4).

ZENG, S., XIE, X. and TAM, C. (2010). Evaluating innovation capabilities for science parks: a system model. *Technological and Economic Development of Economy* 16 (3), pp. 397-413.

ZHANG, Y. and Li, H. (2010). Innovation search of new ventures in a technology cluster: The role of ties with service intermediaries. *Strategic Management Journal*, 31, pp. 88-109.

ZHANG, H. and SONOBE, T. (2011). Development of science and technology parks in China, 1988-2008. Economics: The Open-Access, Open-Assessment Journal 5.

ZHANG, F. and WU, F. (2012). “Fostering indigenous innovation capacities”. The development of biotechnology in Shanghai’s Zhangjiang High-Tech Park. *Urban Geography,* 33 (5), pp. 728-755.

ZHAO, W., WATANABE, C. and GRIFFY-BROWN, C. (2009). Competitive advantage in an industry cluster: the case of Dalian Software Park in China. *Technology in Society.* 31, pp. 139-149.

ZHONG, X. and YANG, X. (2007). Science and technology policy reform and its impact on China’s national innovation system. *Technology in Society,* 29 (3), pp. 317-325.

ZHOU, Y. (2005). The making of an innovative region from a centrally planned economy: institutional evolution in Zhongguancun Science park in Beijing. *Environment and Planning,* 37, pp.1113-1134.

ZHU, D. and TANN, J. (2007). A regional innovation system in a small-sized region: A clustering model in Zhongguancun Science Park. *Technology Analysis & Strategic Management,* 17 (3), pp. 375-390.

Appendix 1 Questionnaire

Dear sir/madam,

Hello! Thanks for participating in this survey. This study aims to explore the how the engagement in science park collaborative network influences firms' innovation capabilities and financial performance. In this study, science parks are regarded as collaborative network that mitigate resource deficiencies of tenants. Your relationships with different actors on science park ecosystem, innovation capabilities and financial performance will be measured in terms of following question items. Your answers will help the researcher examines how science park ecosystem creates value for tenant firms. For management team of science parks, they can have an understanding of how to create a favourable environment for the growth of hosted firms. For firm managers within science parks, the study may provide insights into how to exploit the benefits of science park location to improve their innovative and financial outcomes.

All questionnaire will be completed anonymously. Your answers to this questionnaire will be CONFIDENTIAL. We promise that access to information held on this questionnaire will not be given to anyone else without your written permission. You can rest assured that fill in the questionnaire according to actual conditions of yourself and your company. This study is undertaken by a PhD student of the York Management School at the University of York. The information is just used for academic research, not for business purpose.

Contact details:

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Part A: Basic information

1. You are in:

○Beijing

○Shanghai

2. Your age: [单选题] *

○Below 20

○20-30

○31-40

○41-50

○51-60

○61-70

○More than 70

2. Your gender: [单选题] *

○Male

○Female

3. Your role in the company: [单选题] *

○CEO

○R&D Manager

○Manufacturing Manager

○Operations Management Manager

○Marketing Manager

○Other

4. The sector of the company: [单选题] *

○Electronics and Information Technology

○Biopharmaceuticals

○New materials

○New energy

○Advanced Manufacturing

○Earth/Space/Marine Engineering

○Environmental Protection

○Aviation and Aerospace

○Automobile

○Other

5. Ownership of the company [单选题] *

○State-owned enterprises

○Private enterprises

○International joint ventures/Foreign direct investment

○Other

6. Age of the firm [单选题] *

○Less than 2 years

○2-5 years

○6-10 years

○11-20 years

○More than 20 years

7. Number of the firm's employees [单选题] *

○Less than 10

○10-50

○51-200

○200-500

○More than 500

Part B: Please indicate your level of agreement to following statements.

9. Academic-Industry Collaboration[矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree

AIC1 Scientists or students are often involved in our R&D projects. 经常有学者或学生参与公司的研发项目.	1	2	3	4	5	6	7
AIC2 We maintain close ties with local universities or research institutions to obtain the latest results of scientific research. 我们和本地的大学或研究机构保持密切的联系来获取最新科研成果。	1	2	3	4	5	6	7
AIC3 We have close cooperation with local universities or research institutions to develop new product technologies. 我们和本地的大学或研究机构有开发新产品技术的密切合作.	1	2	3	4	5	6	7
AIC4 We have close cooperation with local universities or research institutions to solve technical problems. 我们和本地的大学或研究机构有共同解决技术性问题的密切合作.	1	2	3	4	5	6	7
AIC5 We have close cooperation with local universities or research institutions to speed up product development process. 我们经常为了提高产品开发进度和本地的大学或研究机构进行密切合作.							

10. Inter-firm Collaboration[矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree

IFC1 We maintain close ties with other tenants on science parks. 我们和园区其他企业保持着密切的联系。	1	2	3	4	5	6	7
IFC2 We regularly share and exchange information about the latest technological trends with other tenants. 我们经常和科技园其他企业分享科技发展趋势的最新资讯.							
IFC3 We regularly cooperate with other tenants to develop new product technology. 我们经常与科技园其他企业合作开发新产品技术.	1	2	3	4	5	6	7
IFC4 We regularly cooperate with other tenants to solve technical problems. 我们经常和科技园其他企业合作解决技术性问题.	1	2	3	4	5	6	7
IFC5 We regularly cooperate with other tenants to speed up product development process. 公司经常为了加快产品开发进度和科技园其他企业合作.	1	2	3	4	5	6	7

11. Interaction with technology intermediaries[矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree

ITI1 We maintain close ties with technology intermediaries of the science park. 我们与园区的科技中介保持着密切的关系.	1	2	3	4	5	6	7
ITI2 We regularly participate in conferences or meetings organised by technology intermediaries. 我们经常参加园区科技中介组织的会议或社交活动.	1	2	3	4	5	6	7
ITI3 We usually find collaborative partners through technology intermediaries. 我们通常通过园区科技中介寻找合作伙伴.	1	2	3	4	5	6	7
ITI4 We regularly search talents through technology intermediaries. 我们经常通过园区科技中介寻搜罗人才.	1	2	3	4	5	6	7
ITI5 We regularly use technology assessment services provided by technology intermediaries. 我们经常利用园区科技中介提供的科技评估服务.	1	2	3	4	5	6	7
ITI6 We regularly use training services provided by technology intermediaries. 我们经常利用园区科技中介提供的员工培训服务.	1	2	3	4	5	6	7

12. Interaction with financial institutions[矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree

IFI1 We have close ties with financial service organisations of the science park. 我们与园区的金融服务机构有着密切的联系.	1	2	3	4	5	6	7
IFI2 We regularly use funding services provided by financial institutions on science parks. 我们经常利用科技园提供的融资服务.	1	2	3	4	5	6	7
IFI3 We regularly use investment decision services provided by financial institutions on science parks. 我们经常利用科技园提供投资决策服务.							
IFI4 We regularly use capital management services provided by financial institutions on science parks. 我们经常利用科技园提供的资本管理服务.	1	2	3	4	5	6	7
IFI5 We regularly use financial information consulting services provided by financial institutions on science parks. 我们经常利用科技园提供的金融信息咨询服务.	1	2	3	4	5	6	7

13. Organisational learning[矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree
OL1 We are skilled at identifying opportunities for improvement.	1	2	3	4	5	6	7

我们擅长发现改进的机会。							
OL2 Our employees can quickly detect problems or mistakes in the process of innovation. 我们的员工能够迅速发现创新过程中的问题和错误。	1	2	3	4	5	6	7
OL3 We are skilled at capturing lessons learned from previous innovative activities. 我们善于从过去的创新活动中吸取教训。	1	2	3	4	5	6	7
OL4 We are skilled at applying lessons from past experience to future innovative activities. 我们善于将过去吸取的经验运用到未来的创新活动中.	1	2	3	4	5	6	7

14. Idea generation [矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree
IG1 Both quantity and quality of ideas generated are high. 我们的创意在数量和质量上都很高.	1	2	3	4	5	6	7
IG2 Ideas come from different departments and areas in organisations. 创意来源于企业的不同部门或领域.	1	2	3	4	5	6	7
IG3 Many of the ideas generated were new to the company. 很多创意对于公司来说是全新的.	1	2	3	4	5	6	7

IG4 Many of the ideas generated were new to our existing customers. 很多创意对于我们现有的客户来说是全新的.	1	2	3	4	5	6	7
IG5 Many of the ideas generated were new to the market. 很多创意对于市场来说是全新的.	1	2	3	4	5	6	7

15. Product development[矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree
PD1 Our company continuously introduces new products and develops new market. 我们公司持续不断地推出新产品和开发新市场.	1	2	3	4	5	6	7
PD2 Our company brings new and innovative products more often to market than our rivals. 我们比其他公司更频繁地向市场推出新产品.	1	2	3	4	5	6	7
PD3 The percentage of new and innovative products in the product portfolio is higher than our rivals. 新产品在公司产品组合中的比重比竞争对手高.	1	2	3	4	5	6	7
PD4 Our new product development cycle has been shorter than our rivals. 我们的新产品开发周期低于竞争对手.	1	2	3	4	5	6	7
PD5 Our products have more unique features than our rivals.	1	2	3	4	5	6	7

我们的产品比竞争对手有更多与众不同的特性.							
PD6 Our product development use technologies never used in our industry before. 我们的产品开发使用在本行业中从未使用过的技术.	1	2	3	4	5	6	7

16. Process development[矩阵量表题] *

	Strongly disagree			Neutral			Strongly agree
PcD1 We have more efficient production or operation process than our rivals. 我们的运营流程比竞争对手效率更高.	1	2	3	4	5	6	7
PcD2 We are creative in methods or skills for managing operation process. 我们管理运营流程的方法或技术具有创造性。	1	2	3	4	5	6	7
PcD3 We continuously generate new methods or skills for improving the efficiency of production or operation process. 我们持续地创造出提高生产或运营效率的新方法或新技术.	1	2	3	4	5	6	7
PcD4 We continuously generate new methods or skills for cost saving. 我们持续地创造出节约成本的新方法或新技术.	1	2	3	4	5	6	7

PcD5 We are flexible to adapt to our operational process to address market changes. 我们可以灵活地调整我们的运营流程来应对市场的变化.	1	2	3	4	5	6	7

17. Financial performance[矩阵量表题]

	Significantly decrease			No change			Significantly increase
FP1 Our firm's profitability over last two years 近两年来我们公司的利润	1	2	3	4	5	6	7
FP2 Our firm's sales over last two years 近两年来我们公司的销售额	1	2	3	4	5	6	7
FP3 Our firm's return on asset over last two years 近两年来我们公司的资产回报率	1	2	3	4	5	6	7
FP4 Our firm's return on investment over last two years 近两年来我们公司的投资回报率	1	2	3	4	5	6	7

Two samples of questionnaire response are presented as below.
Beijing

答题信息

Q1、您所在的城市：【单选题】
北京

Q2、您的年龄：【单选题】
51-60岁

Q3、您的性别：【单选题】
男

Q4、您的职位:【单选题】
研发部经理

Q5、您的公司所在的行业:【单选题】
电子与信息技术

Q6、企业性质:【单选题】
国有企业

Q7、企业成立时间:【单选题】
11-20年

Q8、企业的员工数量:【单选题】

答题详情

200-500个

Q9、与学术机构的协作【矩阵单选题】
Q9.1、经常有学者或学生参与公司的研发项目
非常同意
Q9.2、我们和本地的大学或研究机构保持密切的交流来获取最新的科技发展咨询
非常同意
Q9.3、我们和本地的大学或研究机构有开发新产品技术的密切合作
同意
Q9.4、我们和本地的大学或研究机构有共同解决技术性问题的密切合作
非常同意
Q9.5、我们经常为了提高产品开发进度和本地的大学或研究机构进行密切合作
同意

Q10、与园区企业的协作【矩阵单选题】
Q10.1、公司经常和科技园其他企业分享科技发展趋势的最新咨讯
非常同意
Q10.2、公司经常与科技园其他企业合作开发新产品技术
非常同意
Q10.3、公司经常和科技园其他企业合作解决技术性问题
非常同意

Shanghai

答题详情

Q1、您所在的城市：【单选题】
上海

Q2、您的年龄：【单选题】
31-40岁

Q3、您的性别：【单选题】
女

Q4、您的职位:【单选题】
运营管理部经理

Q5、您的公司所在的行业:【单选题】
电子与信息技术

Q6、企业性质:【单选题】
私营企业

Q7、企业成立时间:【单选题】
2-5年

Q8、企业的员工数量:【单选题】
51-200个

答题详情

Q7、企业成立时间:【单选题】
2-5年

Q8、企业的员工数量:【单选题】
51-200个

Q9、与学术机构的协作【矩阵单选题】
Q9.1、经常有学者或学生参与公司的研发项目
有点同意
Q9.2、我们和本地的大学或研究机构保持密切的交流来获取最新的科技发展咨询
非常同意
Q9.3、我们和本地的大学或研究机构有开发新产品技术的密切合作
同意
Q9.4、我们和本地的大学或研究机构有共同解决技术性问题的密切合作
有点同意
Q9.5、我们经常为了提高产品开发进度和本地的大学或研究机构进行密切合作
同意

Q10、与园区企业的协作【矩阵单选题】
Q10.1、公司经常和科技园其他企业分享科技发展趋势的最新咨讯
非常同意

Appendix 2 Correlation analysis

The correlation between question items is tested before conducting exploratory factor analysis.

Table A. Pearson correlation coefficient between items of AIC

	AIC1	AIC2	AIC3	AIC4
AIC2	0.530			
AIC3	0.522	0.549		
AIC4	0.526	0.522	0.620	
AIC5	0.485	0.473	0.530	0.600

Table B. Pearson correlation coefficient between items of IFC

	IFC1	IFC2	IFC3	IFC4
IFC2	0.696			
IFC3	0.699	0.705		
IFC4	0.711	0.660	0.707	
IFC5	0.632	0.602	0.588	0.642

Table C. Pearson correlation coefficient between items of ITI

	ITI1	ITI2	ITI3	ITI4	ITI5
ITI2	0.721				
ITI3	0.679	0.588			
ITI4	0.694	0.595	0.714		
ITI5	0.713	0.623	0.629	0.675	
ITI6	0.675	0.639	0.617	0.674	0.717

Table D. Pearson correlation coefficient between items of IFI

	IFI1	IFI2	IFI3	IFI4
IFI2	0.661			
IFI3	0.662	0.689		
IFI4	0.625	0.719	0.741	
IFI5	0.744	0.657	0.657	0.730

Table E. Pearson correlation coefficient between items of OL

	OL1	OL2	OL3
OL2	0.650		
OL3	0.489	0.577	
OL4	0.517	0.444	0.566

Table F. Pearson correlation coefficient between items of IG

	IG1	IG2	IG3	IG4
IG2	0.466			
IG3	0.441	0.702		
IG4	0.287	0.677	0.636	
IG5	0.273	0.693	0.629	0.953

Table G. Pearson correlation coefficient between items of PD

	PD1	PD2	PD3	PD4	PD5
PD2	0.758				
PD3	0.724	0.763			
PD4	0.535	0.603	0.623		
PD5	0.707	0.689	0.691	0.563	
PD6	0.474	0.560	0.550	0.641	0.537

Table H. Pearson correlation coefficient between items of PcD

	PcD1	PcD2	PcD3	PcD4
PcD2	0.763			
PcD3	0.695	0.721		
PcD4	0.697	0.664	0.676	
PcD5	0.725	0.704	0.635	0.664

Appendix 3 Science Parks in Western countries

The origin of science parks - Silicon Valley, USA

Silicon Valley has been the world's premier innovation community. It is a high-tech hotspot filled with entrepreneurs who are ambitious, creative, open-minded, and willing to take risk (Klepper, 2010). Silicon Valley creates a region of that other countries are eager to learn from. Next to New York, it hosts the second largest number of Global Fortune 500 companies. Hi-tech firms in Silicon Valley have achieved enormous success, such as Apple, Google, HP, Facebook, Twitter, etc. They are brand names with global impacts and global reputation. It is a vivid dream. A range of factors contribute to the success story of Silicon Valley, including government support, links with high-education institutions, venture capital, entrepreneurial culture etc.

The influences of government intervention on Silicon Valley cannot be underestimated. R&D investment of government has substantial impacts on innovation and start-ups (Bell et al., 2008). The government plays a facilitating role in the growth of Silicon Valley. They provide the necessary infrastructure and remove the institutional barriers e.g. liberal visa policy. Immigrant entrepreneurs, especially from China and India, have set up half of first-generation start-ups in Silicon Valley (Engel et al., 2011). Some immigrant entrepreneurs such as Elon Musk of Tesla and Sergey Brin of Google have become role models. The US government plays a proactive role not only in funding R&D activities, but also stimulating commercialization and technology transfer (Hyde, 2017). The Bayh-Dole Act of 1980 designed a uniform IPR policy that encourages the commercialization.

Universities are indispensable part of science park innovation system. Higher education institutions is a cornerstone of the success of Silicon Valley (Engel et al., 2011). The Bay area is the home to world-leading universities, federal and state research institutions and R&D laboratories. Silicon Valley has access to a huge pool of highly skilled talents, which are indispensable resources for firms (Guzman, 2012). Thousands of PhD students, doing state-of-the-art research, constituting Silicon Valley highly qualified workforce. The highly skilled talent pool is an important source of Silicon Valley's continuous development of technological innovation (Woodward et al., 2006). Knowledge institutions active in Bay area have reputation for leading-edge innovation. They are innovation magnet for the best and the most potential researchers and exceptional students around the world.

Tapan Munroe, Silicon Valley analyst, said "Ideas are the soul of innovation, money is the life blood." Half of the US venture capital is invested in firms on Silicon Valley (Engel et al., 2011). One of preconditions for the success of Silicon Valley is access to plentiful venture capital. The ample availability of funding is the pillar of innovative development of Silicon Valley. The two innovative giants in Silicon Valley, Apple and Google, invest 12.5 billion US dollars on R&D activities together (Hyde, 2017). Venture capital firms are concentrated on the Wall Street of Silicon Valley (Bell et al., 2008). They play an indispensable role in the achievement of Silicon Valley. They are central ingredients in Silicon Valley ecosystem.

Cambridge Phenomenon, UK

Science parks are a focal component of European economic context (Miller, 2014). Cambridge phenomenon is known as "Silicon Fen", which is one of the top hi-tech clusters in Europe (Library house, 2008). Cambridge firms are specialised in information technology (IT), biotechnology, advanced electronics etc (Garnsey and Heffernan, 2010). Cambridge is an innovation milieu, which is featured by synergies between businesses, universities, research institutions, financial organizations, and intermediary institutions. Cambridge is characterised by the tradition of spin-off from the Cambridge University. Cambridge is geographically proximate to London for capital markets, international trade, and customers (Keeble, 1999). It can benefit from a large pool of resources and advanced service structures. In the 1960s, Cambridge region has witnessed rapid growth in a cluster of knowledge-based SMEs (Breznitz, 2011). The boom of innovative companies in Cambridge has attracted public attention. The initiator of Cambridge Science Park is John Brownfield, who is the Bursar of Trinity College. Cambridge Science Park and St John's College were built in 1970 and 1987 respectively.

Trinity College is a rich college, not expecting returns on its investment. The companies within Cambridge Science Park put an emphasis on scientific research and development. Different from Trinity, St John's College showed more interest in commercial returns.

University and R&D consultancies are significant in fostering the regional culture of trust (Keeble et al., 1999). They encourage the formation of spin-offs and facilitate collaborative research, which are conducive to technological innovation capabilities of Cambridge region. The University of Cambridge has a reputation of world-leading scientific research. It contains diverse high-technology sectors, which serves as a strong scientific and technological base for local economic development. It is also known for its liberal attitude towards commercialization of scientific results (Myint et al., 2005). The university plays a focal role in Cambridge hi-tech region. Its liberal collaborative research. The local common codes of conduct allows for the development of trust-based relationships, which is the key to the success of innovative collaborations. The local cultural context feeds cross-fertilizing R&D between on-park companies. Cambridge cluster of small-sized, technology-based companies has attracted international attention (Lawson and Lorenz, 1999). Cambridge high-tech region has a concentration of consultancies. Technology-based companies concentrate around centres of science. According to Garnsey and Heffernan (2005), "resources in the local science base are converted into and attract business activity, giving rise to a richer, more diverse economic habitat."

Sophia-Antipolis, France

Pierre Laffitte, who is the Director of the Ecole Nationale Superieure des Mines de Paris (Parker, 2010). His idea was transition from an agricultural region to a region of science and technology. The model focuses on stimulating local-led innovation and entrepreneurship (Wal, 2013). The original idea was to develop a high-technology region through influx of the investment by multinational companies (MNCs). Sophia-Antipolis relies on the attraction of national and international MNCs, which is regarded as the basis for local growth. The provision of well-developed infrastructure is a key factor for MNCs' decision to locate in Sophia-Antipolis. The system places an emphasis on local entrepreneurial activities and networking process. Sophia-Antipolis has supported entrepreneurship by development relationships with venture capitals and business angels.

The growth rate of number of companies has slowed down since the end of the 1980s (Wal, 2013). The competitiveness in terms of the attraction of foreign investment has decreased. Ireland and Scotland can provide cheap workforce than Sophia-Antipolis; Metropolises like Paris and London provides proximity to markets and business and financial services. Sophia-Antipolis has lost its competitive advantage relative to other regions. The shift of locational preferences drives firms to locate to other regions. Sophia-Antipolis is just a "satellite platform" according to Markusen (1996). The absence of local interactive linkages is a major shortcoming of Sophia-Antipolis. The absence of collective learning processes was a clear signal for the crisis of Sophia-Antipolis (Longhi, 1999). The concept of collective learning is associated with "innovative milieu" which are created through "the creation and further development of a base of shared knowledge among the individuals within a productive system" (Lawson, 1997). The process of collective learning is critical to the sustainable development of regional economy and viability of regional innovation system. Keeble et al. (1998) and Longhi (1999) have identified prerequisites for the process of collective learning.

The strategy has transformed from attracting international and national investments from large enterprises to creation of local innovation and entrepreneurship through interactions between institutions within the ecosystem (Longhi, 1999). Sophia-Antipolis has evolved from over-dependence on investment by MNCs to the generation of local sources of innovation and entrepreneurship. The region has shifted from a region for global activities of MNCs to a region of local-led learning and innovation processes. Besides, a series of institutions are associated with the transition. Eurocom provides Masters and PhD programs for engineers, which is a source of highly qualified human resources. INRIA stimulates the growth of start-ups and promotes technology transfer (Lawson, 1997). Greater emphasis was put on local sources of competencies. Sophia-Antipolis has witnessed increasing growth rate of high-technology SMEs.

Appendix 4 Summary of studies about innovation capabilities

Capabilities	Authors
Product creation Product innovation Product development	Berkhout et al. (2010); Christensen (1995); Francis and Bessant (2005); Lim et al. (2013); Nassimbeni (2001); Wang and Chang (2011); Wonbglimpiyarat (2010); Adler and Sbenbar (1990); Chiesa et al. (1997); Holahan et al. (2014)
Process innovation Innovation process improvement	Chiesa et al. (1997); Christensen (1995); Francis and Bessant (2005); Holahan et al. (2014); Nassimbeni (2001); Wang and Chang (2011); Wonbglimpiyarat (2010); Boly et al (2014);
Innovation culture Culture and climate Innovation climate Organisational culture Culture and climate Innovation-oriented culture	Acur et al. (2010); Brettel and Cleven (2011); Frishammar et al. (2012); Leskovar-Spacapan and Bastic (2007); Lawson and Samson (2001); Cormican and I'Sulivan (2004); Frishammar et al. (2012); Neely et al. (1990); Holahan et al. (2014); Salter et al. (2014); Lawson and Samson (2001) Leskovar-Spacapan and Bastic (2007)
Marketing capability	Cheng and Lin (2012); Guan and Chen (2010); Guan and Ma (2003); Guan et al. (2006); Hull and Covin (2010); Lancker et al. (2016); Panda and Ramanathan (1997);

	Schweisfurth and Herstaff (2014); Wang et al. (2008); Yam et al. (2004); Yam et al. (2011);
Manufacturing capability	Guan and Chen (2010); Guan and Ma (2003); Sher and Yang (2005); Wang et al. (2008); Yam et al. (2004); Yam et al. (2011); Guan et al. (2006); Panda and Ramanathan (1997);
Strategic management capacity Strategy capability Strategic planning capability Strategic alignment Business planning Vision and Strategy Technology strategy New product development strategy	Burgelman et al. (1988) Guan and Ma (2003) Cheng and Lin (2012); Yam et al. (2004); Yam et al. (2011); Guan et al. (2006) Frishammar et al. (2012) Guan and Chen (2010); Lawson and Samson (2001) Koc and Ceyland (2007); Rush et al. (2007); Hull and Covin (2011)
Idea research/ creativity Idea generation Idea development Creativity and idea management Ideation capability	Boly et al. (2014); Koc and Ceylan (2007); Lancker et al. (2016); Lawson and Samson (2001) Schweisfurth and Herstaff (2014);

Project management Project portfolio management Project organization	Boly et al. (2014); Frishammar et al. (2012) Acur et al. (2010); Boly et al. (2014); Holahan et al. (2014); Schweisfurth and Herstaff (2014);
Learning capability	Boly et al. (2014); Guan and Chen (2010); Guan and Ma (2003); Martinez-Roman et al. (2011); Rush et al. (2007); Tidd et al. (2005); Yam et al. (2004); Yam et al. (2011); Guan et al. (2006)
R&D capability	Boly et al. (2014); Guan and Ma (2003); Martinez-Roman et al. (2011); Wang et al. (2008); Yam et al. (2004); Yam et al. (2011); Guan et al. (2006)
Organisational capability Organisational infrastructure Organisational structure & systems	Boly et al. (2014); Guan and Ma (2003); Martinez-Roman et al. (2011); Xu and Li (2011); Yam et al. (2004); Yam et al. (2011); Guan et al. (2006) Kramer et al. (2011) Lawson and Samson (2001)
Resource availability and allocation Resource provision Resource exploiting capability Resource allocation capability	Burgelman et al. (1988); Guan and Ma (2003); Chiesa et al. (1997); Guan and Ma (2003) Yam et al. (2004); Yam et al. (2011); Guan et al. (2006)
Knowledge creation Knowledge management	Berkhout et al. (2010) Boly et al.(2014); Persaud (2005)

Knowledge and skills capability Knowledge base	Cheng and Lin (2012) Xu and Xi (2011)
Absorptive capacity	Wu et al. (2013); Xu and Li (2011)
Design capability	Boly et al. (2014); Moultrie et al. (200); Panda and Ramanathan (1997); Sher and Yang (2005)
Leadership	Chiesa et al. (1997); Cormican and I'Sulivan (2004); Salter et al. (2014); Tang (1998)
Radical innovation capability	Salter et al. (2014); Subramaniam and Youndt (2005)
Technological intelligence Organisational intelligence	Boly et al. (2014) Lawson and Samson (2001)
Market orientation	Brettel and Cleven (2011); Leskovar-Spacapan and Bastic (2007)
Capability to understand environment Capacity to understand technological developments Capacity to understand competitor innovative strategies and industry evolution Ability to respond promptly to unexpected technology moves by competitors and to unforeseen opportunities	Neely et al. (1990); Burgelman et al. (1988) Burgelman et al. (1988) Adler and Sbenbar (1990)