The Role of Science Parks in Promoting and Supporting Tenant Firms to be Innovative and Competitive with Particular Reference to the Case of Thailand

by

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Abstract

There is a growing policy need in many countries for improvements in the innovativeness and competitiveness of business enterprises. This is reflected in a recent shift of emphasis from resource-based growth to knowledge-based growth. One result of this policy trend has been growth in the belief that science and technology park projects can provide a vehicle for the emergence of innovative enterprises and for the implementation of the triple helix innovation system – the engagement among government, universities, and industry. In Thailand, this prompted the establishment of science parks, with the first regional science park, the Northern Thailand Science Park (NSP), launched in 2018.

What is unclear – and what has yet to be probed – is how such policy initiatives have helped promote the development of innovative and competitive enterprises, and why some firms choose to be located within these science parks. In this thesis, these questions are explored, based on the combined experiences of 22 tenant firms in the NSP through a questionnaire-based survey and face-to-face interviews using quantitative and quantitative methods.

In this study, the provision of space, utility and facilities is found to be what matters most for the majority of tenant firms who decide to join the NSP by creating an eco-system that encourages tenants to support each other by sharing knowledge and experiences, which can result in new ideas and the emergence of venture companies. Firms agreed the services they received from the NSP were helpful in achieving better results in terms of innovative and competitive performance than would be the case if they had not joined the park. In the longer term, firms believe that the NSP can incubate and continue to support them as they evolve as competitive enterprises. It is also found that the science parks respond to the learning needs of younger start-up firms, supported by firms that have been long in residence in the park. Small and medium enterprises (SMEs) are found to be more likely than larger and/or

older enterprises to develop innovative inputs. This study also finds that the provision of infrastructure and facility (INFA) and prospecting of market opportunities (MAOP) by the park have significant positive influence on the expected innovative performance/ innovative output of tenant firms.

On the basis of findings of this study, bolstered by the experiences across other countries covered in the literature, it can be argued that science parks have an important role to play as intermediary agency integrating tenant firms into the triple helix system of innovation. This is supported by the results of both the quantitative and qualitative analyses of the survey data. The science park ecosystem – and its triple helix underpinning – provide favorable conditions for triggering interactions among tenant firms to learn from specialised knowledge and experiences that can be accessed via the science park platform as long as they are well managed.

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Finally, I declare the responsibility of all errors of omissions and commissions in this thesis to be entirely my own.

Kanit Sawasdee, 5th January 2021

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List of Abbreviations

ABBREVIATION	DEFINITION
AIT	Asian Institute of Technology
BOI	The Board of Investment
DBD	Department of Business Development
DIP	Department of Intellectual Property
DITP	Department of International Trade Promotion
GDP	Gross Domestic Product
HEI	Higher Education Institutions
HPLC	High Performance Liquid Chromatography
HT	High Technology
IASP	International Association of Science Parks
ICT	Information, Computer, and Technology
IPR	Intellectual Property Right
IRCT	Industrial Research and Technology Capacity Development Platform
MOST	Ministry of Science and Technology
NESDC	National Economic and Social Development Council
NESP	Northeastern Science Park
NIA	National Innovation Agency
NRCT	National Research Council of Thailand
NSP	Northern Science Park
NSTDA	National Science and Technology Development Agency
NTBF	New Technology Based-Firm
NXPO	Office of National Higher Education Science Research and Innovation Policy Council
OPS	Office of Permanent Secretary
PITEC	Technology Innovation Panel
RTP	Research Triangle Park
SME	Small and Medium Enterprise
SPA	Science Park Promotion Agency
STDB	Science and Technology Infrastructure Databank
STI	Science, Technology, and Innovation
STSP	Southern Science Park
SWOT	Strength Weakness Opportunity and Threat
TISI	Thai Industrial Standard Institute
TISTR	Thailand Institute of Science and Technological Research
TSP	Thailand Science Park
TSRI	Thailand Science Research and Innovation

UIL	University-Industry Linkages
UK	United Kingdom
UKSPA	United Kingdom Science Park Association
USA	United State of America
VC	Venture Capital
VIF	Variance Inflation Factor

CHAPTER 1
INTRODUCTION

Over the past four decades or so, there has been growing policy concern in many countries for improvements in the competitiveness of economic performance and sustainable economic growth. This concern about competitiveness and rapid growth has brought a shift of policy from emphasis on resource-based growth to emphasis on knowledge-based growth. The trend has been particularly apparent in the emerging economies of the so-called 'newly industrializing countries', like Brazil and South Korea, and more recently, in countries like Thailand. One result of this policy trend has been growth in the belief that investment in science or technology park projects would provide a vehicle for the emergence of innovative enterprises and for the implementation of the triple helix innovation system on the basis of such projects. The science park appeal draws on the experience of the Silicon Valley in the USA in the emergence and growth of innovative enterprises and the implication of this experience for 'technological leapfrogging' in developing countries (Malairaja, 2003).

1.1 Background of study

The first science park was created in 1950 at the campus of Stanford University. This science park was responsible for the transformation of one of the most inaccessible regions in the USA into a global leading regional hub of education, research, technologies, and finances and laid the basis for the development of the so-called Silicon Valley. Soon the business success of the Silicon Valley project and the regional development associated with it culminated in the global phenomenon known as 'Siliconia', which saw the establishment of science parks in a wide range of countries. The general function of science parks is mainly to create favorable environment for research and knowledge exchange aimed at the development of products and services and their commercialization through the provision of physical infrastructure, including facilities and rental space, and technology-based knowledge, which is known to be crucial for the emergence of ‘global born’ firms. Science parks have also enjoyed government support through funding and the creation of market opportunities. To date, there are over five hundred science parks around the world (United Nations Educational Scientific and Culture Organization, 2016).

Science parks are good examples of hybrid institutions that provide the forum for the triple helix system of innovation through the reflexivity of interactions between the agencies of government, academia and industry (Etzkowitz and Leydesdorff, 2000). As such, science parks are knowledge-based initiatives involving collaborative interactions among universities, research centers, government agencies and industrial firms; and operating with the aim to widely commercialise the innovated products and services. Science parks thus provide firms that join them as tenants, the knowledge and infrastructure support that would help them acquire the competitive drive to be able to evolve as ‘global born’ firms or as ‘niche players’ in the global market (Díez-Vial and Montoro-Sánchez, 2016). There is a growing body of knowledge explaining that development of science and technology-based knowledge is crucial for enhancing competitiveness and economic growth (Lindelöf and Löfsten, 2003).

In the case of Thailand, the Ministry of Science and Technology (MOST) is the leading government agency charged with the responsibility of formulating and promoting science, technology, and innovation (STI) policy and strategic plans. It is also responsible for developing research and development programmes and collaborative mechanisms amongst players from various sectors, particularly universities, research centres, and business and industry. This policy commitment is in keeping with Thailand’s ambition to be grouped in the category of developed countries by 2036. At present, the extent of knowledge-based industry that is acknowledged to be essential for economic sustainable economic and social development is low in Thailand. In view of this, one of the areas of policy concern has been to adopt the science park model as an effective instrument for providing emerging enterprises with support systems that would enhance their knowledge networks as well as technological and marketing capabilities. Science parks are thus presumed to be an effective instrument of policy for promoting the growth and development of enterprises in various industrial sectors through the delivery of research infrastructure and support systems for knowledge exchange (Dabrowska, 2011). However, the evidence is not conclusive enough to warrant the proposition that science park firms are invariably more innovative and competitive than off-park firms (Malairaja, 2006). This is particularly true in the case of developing countries where science park management is typically weak, and the relevance of the “supply-push” science park model of innovation and industrial competitiveness is often found wanting seen in the light of prevailing socio-economic circumstances in these countries (Zawdie, 1995).

The general function of science parks is to create favorable environment for research by the provision of physical infrastructure, facilities, accommodation space, and networking for technology-based knowledge exchange amongst academia, industry and government and non-government organisations (Ferguson and Olofsson, 2004; Fukugawa, 2006; Chia-Li Lin and Tzeng, 2009; Squicciarini, 2009b; Rush, Rozmi and Ieee, 2014; Minguillo, Tijssen and Thelwall, 2015; Lamperti, Mavilia and Castellini, 2017). Science parks are important and beneficial particularly to small and new firms. This is because of the high cost of capital investment that would impair such firms to engage in innovative initiatives. Small firms and new entrepreneurs do not of their own have the R&D funding. This severely limits their capability to innovate. It is, therefore, in their interest either to engage in a cost sharing collaborative scheme or else to share the benefits deriving from centrally provided science park projects (Boehm and Hogan, 2013).

This study is about the role of science parks in supporting tenant firms to be innovative and competitive. The study is conducted based on the experience of Northern Thailand Science Park (hereafter the NSP), which was set up as a strategy for the development of knowledge-based industrialization in Thailand. The NSP is one of the regional science parks in the Northern part of Thailand. Construction of the establishment was started in 2014 and fully completed in 2018.

Questions may arise as to whether there is any perceptible evidence to suggest that the NSP can help its tenant firms improve their innovative and business performances. The outcomes of this study are expected to shed some light on the presumption of tenant firms that participation in science parks would improve their innovativeness and competitiveness. To the extent that the firms surveyed in this study have been operating in the Park for as long as the NSP has been in in operation – i.e. since 2018 – the evidence deriving from analysis of data can only be suggestive and not conclusive, even after the tenant firms were surveyed for update of their on-park experiences two years after the first survey. Thus, the experiences firms gain after participation in the Park even for a year or so would help them to decide whether to continue operation on-park or move off-park; and if they decide to continue on-park, to work out how to maximize the benefits they would derive from the knowledge and infrastructural services delivered by the Park. The firms' feedback to the management of the science park can also help the Park to improve its services delivered to its tenant firms.

For all its limitations, this study has contributions to make to the body of knowledge of science parks in general, and Thailand, in particular. The first contribution relates to the locational aspect of science parks seen from the vantage point of regional development based on the specificities of the resource endowments of regions. NSP is the first regional science park in Thailand and was established to serve the northern region of Thailand as a centre for the development of enterprises and innovation that are crucial for the regional economy. The second contribution relates to the relationship between science parks and their tenants, particularly in terms of the significance of the feedback the former obtains from latter for improving the effectiveness of the knowledge and infrastructural services they deliver. The third contribution relates to the significance of science parks as a strategy for the development of knowledge-based economy at regional and national levels, and hence for plans for the establishment of more parks and the implications of this for network development, and for the sustainable provision of funds to foster capacity building programmes.

The NSP has currently 22 tenant firms of various scales drawn from various business sectors. The study draws on the experiences of the NSP because it is the first regional science park in Thailand. Moreover, the NSP is located in Chiangmai province, which is an economically active region, richly endowed mainly with agricultural resources. The operation of the NSP in this region would therefore be expected to have significant economic impact, equipping firms with technological and management knowledge to be able to thrive on the back of regional resources.

The NSP is one of the three regional science parks in Thailand. The other two regional science parks are Northeastern Thailand Science Park and Southern Thailand Science Park, which are still under construction. The NSP has driven policies for rice and herb development and for software and application, Northeastern Science Park is dedicated for poultry and agricultural products; and Southern Science Park is for rubber.

1.2 The research question: research aim, and objectives

The establishment of science parks involves huge investments, which could strain government budgets, particularly if the expected benefits of the investments are not immediately forthcoming. In this respect, it may be asked if the investment in the establishment of science parks in Thailand is worth the while. Focusing on the case of the NSP, the aim of this study is, as mentioned above, to explore the role of science parks in promoting and supporting tenant firms to be innovative and competitive by providing the conditions for embedding innovation and competitiveness in the overriding culture of business and industry in Thailand. The major question arising from this issue is how firms might respond to the science park initiative of the government. Hence the following research objectives.

Research objectives

1. To explore the firms' characteristics and perception of tenant firms about the importance of their participation in NSP for enhancing their aim to evolve as innovative and competitive enterprises.

2. To explore the views of tenant firms on the effectiveness of the delivery of the services of the NSP and of the relevance of these services to the perceived innovative development of firms.

3. To empirically investigate the relationship between the various categories of support services provided by NSP and the perceived innovative performance of firms.

4. To explore the triple helix mechanism underpinning the functions of science parks aimed at supporting and promoting tenant firms to evolve as innovative and competitive enterprises.

5. To explore the lessons to be learned from NSP's experiences and tenants' views and recommendations using SWOT analysis (the strengths, weaknesses, opportunities, and threats) of the science park strategy for the emergence of innovative and competitive enterprises in developing countries, in general, and Thailand, in particular.

Administration of questionnaires and face-to-face interviews

22 firms serviced by NSP

OBJECTIVE 1	OBJECTIVE 2	OBJECTIVE 3	OBJECTIVE 4	OBJECTIVE 5
To explore characteristics and perception of tenant firms about the importance of their participation in NSP	To explore the views of tenant firms on the effectiveness of the delivery of the services of NSP and of the relevance of these services to the perceived innovative performance of firms	To empirically investigate the relationship between the various categories of support services provided by NSP and the perceived innovative performance of firms.	To explore the triple helix mechanisms underpinning the functions of science parks aimed at supporting and promoting tenant firms to be innovative and competitive.	To explore the lessons to be learned from NSP's experiences and tenants' views and recommendations using SWOT analysis

Figure 1.1 Chart of objectives

1.3 Scope and method of the study

The concept and practice of regional science park initiative was first incorporated into the science and technology policy system of Thailand in 2014. This culminated in the establishment of the NSP. The Ministry of Science and Technology is the leading government agency in Thailand charged with the responsibility of promoting science, technology, and innovation policy and strategic plans, and the implementation of such plans and policies through, among other things, the establishment of science parks and collaborative mechanisms, like the engagement among government, university, and private sectors, that provide the basis for the development of knowledge and innovation networks.

The Thailand Science Park (TSP), which predates regional science parks, has been operating as the first national science park since 2002 under the management of the National Science and Technology Development Agency (NSTDA). TSP is located in Pathumtani province, close to Bangkok, on eighty acres of land with a fully integrated hub for R&D in product development and commercialization of products. In 2012, the Thai government made policy commitment to establish three regional science parks: the Northern Thailand Science Park (involving six university members); the Northeastern Thailand Science Park (involving four university members); and the Southern Thailand Science Park (involving two university members). The establishment of these regional science parks has been driven by access to regional universities to provide the requisite knowledge chain through consultancy, incubation, and project workshop programs, while the government provides the infrastructure and the facilities for setting up the parks. Work on the NSP was completed in late 2017, and the park has since been ready to start operation in 2018. The other two are still under construction expecting to be completed by 2019. Although only the NSP has been currently fully operational, the other two regional parks do not yet cater for 'in-wall' tenants. They have been functioning under the management of universities in the regions, providing consultancy support to local firms.

Questions have been asked about how services of science parks can be used as mechanisms for promoting knowledge exchange and innovation among businesses and the emergence of industrial enterprises; and to what extent science parks can learn from the experiences of others - from the NSP, in the case of this study. Would the scope for innovation and technological progress be enhanced and enlarged in Thailand with science parks as an instrument of policy? These are the questions that will be empirically investigated in the study.

The study will be conducted using mixed approach, which involves quantitative and qualitative analysis. Data was collected through a questionnaire-based survey and through face-to-face interviews (see Chapter 4 on methodology for detailed account). The data and information collected was used for investigating the research question in quantitative and qualitative terms. For instance, it is important to characterize the tenant firms to be able to gauge the influence of the various categories of services provided by the science park on the different categories of tenant firms, particularly with respect to the firms' commitment to evolve as innovative and competitive enterprises.

Generally, the services of science parks are meant to provide supports for tenant firms to develop the technological, marketing, and managerial capabilities that would underpin their evolution as innovative and competitive enterprises. However, this can be achieved only if science parks prove to be effective in facilitating and fostering the development of innovative culture among tenant firms through the delivery of the services of 'innovative inputs'. Examples of such service inputs, which are common to most science parks around the world, include human resources, infrastructure and facilities, knowledge linkage, funding, and market opportunities (Colombo and Delmastro, 2002; Westhead, 1997).

Innovative service inputs are usually measured by the outputs they deliver to market, and are, hence, reflected by market side factors, such as sales, number of patents, number of new products, revenue, market share. In this study, however, the innovative service inputs administered by the science park do not necessarily reflect fully the innovativeness of the tenant firms in terms of the range and number of new products and services they deliver to the market. This is because the business scales of tenant firms covered in this study and the business sectors the tenant firms come from vary, so that use of the average number of new products or services as indicator of firms' innovative outcomes would grossly misrepresent the innovativeness – still less the competitiveness – of firms as it presumes comparison of like with like, whereas this is not the case in reality. For example, one large enterprise produces small material parts for manufacturing furniture, vehicles, and a variety of equipment. They normally produce over one thousand new products a year, while technology-based firms produce a few new software items a year. This would make it difficult for the outcomes of the services of innovative inputs of all tenant firms to be aggregated to generate the average number of new products to indicate whether the NSP services help tenants to be innovative. Moreover, most of tenants are new firms who have not yet been in the market, so they do not have sales to record, market shares to compete for, and patents to register and license. Data and information on these factors are not sought, because they are not available. These lead the reason why this study does not cover the comparison of innovative performance between on-park and off-park firms like others.

To get around this problem, firms are asked questions that would reflect their perceived innovative performance as a result of participating in the NSP. This is reasonable as firms' perception of the innovative influence of the services delivered by the NSP is scale- and sector-neutral, given that the firms covered in the study vary in scale and the business sectors they come from.

Accordingly, this study will look at firms' perception of what they are likely to derive from the service support they get from the NSP in terms of the scope for evolving as creative, innovative and competitive enterprises. Based on this, it would be reasonable to explore the association between the category of services firms receive from the NSP during the period of tenancy and their perceived long-term innovative performance. This would be reflective of the level of confidence of tenant firms in the support systems administered by the NSP. The NSP can use this as feedback to improve its services in ways that would release the creative and innovative potential of the tenant firms. On the back of such feedback, SWOT analysis can be conducted to explore the range of lessons that other science parks – be it in Thailand or in other developing countries - can learn from the NSP's experiences.

1.4 Context of the study

Science parks provide a forum for the implementation of the triple helix system of innovation in which institutional actors, including academia, government agencies and business and industry, interact collaboratively in generating knowledge, exchange this knowledge and commercialise it, while at the same time providing the basis for the emergence of 'global born' innovative and competitive enterprises.

What science parks can do to make firms succeeded is an open question in view of the wide range of experiences across countries. There are indeed lessons to be learned; but the belief that the 'Silicon Valley' experience can seamlessly be replicated in different counties cannot be more erroneous, as this study seeks to explore in the light of the experience of Thailand. As government-initiated policy mechanisms for promoting innovation and enterprise development, science parks operate as intermediate agencies liaising between academia, government agencies and business and industry. This liaison involves delivery of a range of services to tenant firms. In this study, five main categories of science park services are identified. These include services relating to access to human resources, infrastructure and facility provision, knowledge network development, access to funding, and exploration of market opportunities.

The first category of service science parks provide to tenant firms is access to human resources such as the expertise and professional experiences of researchers and consultants. This category of resources is generally found in academia, namely universities and research institutes. They play an important role in supporting firms for developing products, reducing cost of products, experimental research, extending shelf life of products, and solving problems that might be encountered in the process of production through engagement in experimental research and access to the benefits deriving from investment in research and development projects at universities and government sponsored agencies. Tenants who participate in science parks are often driven, at least initially, by the belief that they would be better off with the cost of human resources being on-park rather than being off-park, which would require them to hire consultants at much higher costs (Link and Scott, 2003a). Science parks are often located near universities because this arrangement would allow academic researchers to closely liaise with firms and explore innovative ideas and translate these ideas into new marketable products and processes. As much as academic researchers are keen to improve the industrial and market appeal of their research projects, on-park firms would also be keen to access research ideas through the science park channel to leverage their desire to evolve as innovative and competitive enterprises capable of establishing niche markets at national and global levels. This university-industry link represents a space in the triple helix framework where knowledge sharing, and knowledge exchange take place and consensus is subsequently achieved among knowledge producers and knowledge users culminating in the design, development and commercialization of new products and new processes (Ranga and Etzkowitz, 2013).

The second service category provided by science parks, which involves the provision of infrastructure and facility services to tenant firms, represents the crucial role of governments in the triple helix scheme as providers of the funds required for the development of research infrastructure through the establishment of science parks. Not all firms have the ability to invest in the construction of buildings and the installation of facilities and infrastructure, because of the high cost such investments involve. Moreover, some businesses require small working space, as in the case of firms in the application and software business sector, while others, particularly agriculture-based processing firms, require wide space and facilities to accommodate laboratories for testing and experimenting, production floors, and storage area. But it does not mean science parks have the duty to provide tenants with large areas to accommodate all their processing activities. Generally, science parks provide the working space required for creating the culture, environment and opportunity for sharing knowledge and experiences among on-park firms. They also provide facilities to leverage the innovative potential of tenant firms. This is an advantage for newborn firms that do not have the capability to invest in infrastructure to provide for accommodation space and facilities. They would rather choose to be residents in science parks where as well as having access to the benefit of knowledge networks, they would be able to acquire the full service of facilities and the floor space they need for accommodation at low rental cost enjoying the environment of sharing and exchange of new ideas among tenant firms. Where the aim of policy is to build science park cities, science parks are designed to be self-contained with the provision of infrastructure and facilities including the services of small banks, post offices, entertainment centres in the science park area (Löfsten and Lindelöf, 2002).

The third service category offered by science parks to tenant firms is access to knowledge networks. This enables firms to access new ideas through knowledge sharing and knowledge exchange. Science parks largely exist as a triple helix-based forum to promote knowledge exchanging and knowledge sharing through the development of networks that create opportunities for access to new ideas and knowledge, as well as opportunities for funding, commercialization and marketing of products. The development of knowledge networks is enhanced by the proximity of science parks to universities, which makes it attractive for firms to be located in science parks. Knowledge networks evolving within science parks give firms access to knowledge deriving not only from universities, but also from other network participants within and outwith the domain of science parks. Thus, on-park firms would share their business ideas and experiences. This would create opportunities for business matching and partnership of new businesses. Forging business partnerships among on-park firms is crucial as a mechanism for enhancing opportunities for innovation since it would help firms to reduce risk of investment in innovative projects. The networking service science parks offer would thus help their tenants to engage in exercises in open innovation as a strategy for evolving as innovative and competitive enterprises.

The fourth category of service afforded to tenant firms is access to funding, which is actually provided in the form of incentives by the government, such as tax reduction, free rental space, and research and development support. The role of government in the triple helix network underlying the activities of science parks is crucial in this respect. This is particularly important for newborn firms who would find it difficult to mobilise resources of their own, and because growth and realization of the competitive potential of enterprises would be constrained by lack of access to funds and institutionalized support mechanisms. Thus, science parks serve newborn firms not only as platforms for incubation, but also as a mechanism for mitigating funding risk.

The fifth category of service in science parks relates to the provision of support for exploring market opportunities. As much as innovation is important in the design and development of products, it is also important in ensuring the innovated products are marketable. The process is systemic in that product design and development is inseparable from the marketing of products. This is mainly why newborn and small firms usually find the option of being on science parks attractive. Science parks provide them with strategic plans starting from product concept through the processes of product design and development, market testing, and product launch. Whether innovated products are a result of ‘market drive’ or ‘supply push’ is not at issue here; what is important for firms aspiring to be innovative and competitive is that they would need to be aware of market trends to give their products an edge that would allow them to establish niche markets and even emerge as ‘global born’ companies. Firms seeking on-park location would expect to benefit from professional advice and consultation on how to create strategic business plans that would enable them to thrive even in the event of technology and market disruptions.

While the five service categories outlined above provide the raison d’etre for the activities of science parks, in general, it is not clear whether firms would perform better as a result of their decisions to be located on-park rather than stay off-park. This is an empirical challenge to the general understanding that science parks nurture their tenants with networking skills that would enhance their technology and market profiles and make them potentially resilient to changing conditions. This study is an attempt to explore, if in a limited way, whether there is any perceptible evidence in the experiences of on-park firms to suggest that the services offered by science parks could have a potentially progressive effect on future business profiles of tenant firms.

A major problem that would need to be resolved to investigate the proposition of this study relates to how to quantify the innovative output of firms deriving from access to the various category of services in situations where the performance being considered is perceived (ex-ante) and not realized (ex post). The perceived innovative performance of firms was investigated in the following terms: development of innovative products or processes; development of markets; cost reduction and environmental impact; and registration of intellectual property. If perceived output performance of firms can be so categorized, it can be set against the five service categories in a matrix of relationships to show the importance of science park services for the perceived innovative performance of tenant firms. The matrix would specifically show how the various service categories relate to the various categories of output performance; and where the focus of science parks should be to promote the emergence of innovative and competitive enterprises.

1.5 Significance of Study

The focus of this study on the services the NSP provides to its tenant firms is expected to shed light on the strengths, weaknesses, opportunities, and threats associated with the policy objective of promoting the development of innovative and competitive enterprises through allocation of public funds for the establishment of science parks. By exploring the experiences of the NSP, this study would also provide lessons of experience to other science park administrations in Thailand and elsewhere on how effectively business ideas can be incubated; the problems that are likely to be envisaged in the process; and how science parks manage knowledge and market networks to maximize the benefits accruing to tenant firms. In addition, the findings of this study could serve as a guide for policy whether science parks represent the best option as a strategy for promoting the emergence of innovative and competitive enterprises in developing countries, in general, and in Thailand, in particular.

1.6 Expected Results

Basically, science parks offer a platform for collaboration between government, university and business and industry actors with the view to promoting innovativeness and competitiveness of tenant firms (International Association of Science Parks and Areas of Innovation, 2009). The research is expected to produce results that would show the strengths, weaknesses, opportunities, and threats associated with the role of science parks in supporting and promoting tenant firms to be innovative and competitive. The results of the study would also be expected to shed light on factors that influence the effectiveness of science parks as an instrument of science and technology policy in Thailand. Moreover, the long-term experiences of regional science parks like the NSP would provide lessons of experience to existing and new science parks not only in Thailand, but also in other developing countries.

1.7 Structure of Study

This study is organized in eight chapters. The first chapter introduces the issue the study addresses, including the aim, objectives, context, and conceptual basis of the study. In the second chapter, the relevant literature on science parks is explored, covering the history and development of science parks; the conceptual and empirical relationships between innovation and economic growth; and the impact of science parks on the business performance of firms in terms of innovativeness and competitiveness. In the third chapter, the emergence of science parks in Thailand is discussed in the context of the development of business and industry, in general, and small and medium size enterprises (SMEs), in particular. The research methodology is discussed in chapter four. The chapter discusses the procedures of data collection based on a sample survey of tenant firms in the NSP through the administration of questionnaires and semi-structured interviews with tenant firms. The chapter also discusses the methods for analyzing the data collected. The profile of the survey data is discussed in Chapter five; and analysis of the data and discussion of the results are discussed in Chapter six. Chapter seven engages the qualitative analysis from the interviews. The last chapter presents summary, discussion, and conclusions of the study; recommendations based on the results of the study; and areas for further research based on questions arising from the results of the study.

1.8 Conclusion

This chapter has raised the research issue in which the effectiveness of science park services are called to question. It has set the issue in context; defined the scope of the study; outlined the procedures for investigating the research question; and highlighted the conceptual and practical problems envisaged in the course of investigation and analysis. The chapter has also briefly highlighted the significance of the study as a guide for policy in promoting science parks as a strategy for the development of innovative and competitive enterprises in Thailand, and as a lesson of experience from which other science parks can learn. The points raised in this chapter are fully explored in the subsequent chapters.

CHAPTER 2
SCIENCE PARKS AS CRADLES OF INNOVATION, AND THE DEVELOPMENT OF CREATIVE AND COMPETITIVE ENTERPRISES: SURVEY OF THE LITERATURE

The purpose of this chapter is to provide an overview of the salient features of hitherto research on science parks. Evidence deriving from papers published between 1986 and 2019 are reviewed to provide the conceptual and empirical bases for the conduct of this study. Thus, the concept of innovation is explored not only as a theoretical construct, but also in terms of how science parks serve as policy mechanisms to nurture innovation as a strategy for economic growth, in general, and the development of innovative and competitive enterprises, in particular (Bell and Sadlak, 1992). Central to the study is the role of science parks play as intermediaries liaising with academia and government agencies to facilitate knowledge exchange and enable tenant firms to emerge as innovative and competitive enterprises. The remainder of this chapter, which is organized in five parts, addresses the conceptual and empirical aspects of science parks as triple helix platforms for the development of innovative and competitive enterprises.

2.1 The development of science parks in perspective

The first science and technology park was established on the campus of Stanford University in the United States of America, in 1950s. It changed Silicon Valley, the most impoverished region in the USA, into a global centre of high-technology and innovative research (United Nations Educational Scientific and Culture Organization, 2016).

In the period between the 1950s and the 1970s, technology innovation was understood as a linear process flowing from research activities in universities to business enterprises for application in the form of product development, manufacturing, and marketing. It was from the linear model of innovation that the concept of science parks was obtained and developed (Plaeksakul, 2010). Because of the intensive collaboration between universities and business and industry, involving the engagement of researchers and graduates, science parks played a major role in promoting the emergence of technology-based firms that were at the heart of the economic transformation of the region, and the Silicon Valley itself, as a global technology hub. The experience of Silicon Valley shows science parks as intermediaries linking knowledge producers and knowledge users, thus facilitating the transfer of knowledge to all stakeholders in business and industry who would exploit it for commercial ends (Kenney, 1993).

The Research Triangle Park (RTP) in North Carolina was the next science park established in 1959. This park was set up as a response to the declining economy in North Carolina. RTP was founded in an attempt to persuade industries and research companies to collaborate with three local universities – North Carolina State University in Raleigh; the University of North Carolina at Chapel Hill; and Duke University in Durham. These universities house world-class research institutions; and they have longstanding experiences as entrepreneurial universities (Plaeksakul, 2010).

Since 1970, RTP has seen the emergence of over 1,500 new entrepreneurs, and the creation of more than 40,000 jobs. RTP has thus played a major role in the development of the regional economy. It has also at the same time evolved as the most extensive research park in the USA (Link and Scott, 2003b). North Carolina's RTP has 145 resident companies, 80% of which have R&D engagements. About 93% of the employees in the Park work for R&D companies; and at least 80% of the employees work for multinational organizations. Another interesting aspect of RTP is that the average monthly salary of employees in the Park is higher than the national average (Zhan, 2013).

Traditionally, the university-based science park model in the USA has served as a trail-blazer for the development of science parks around the world. In 1970, the first two science parks in the UK were established - the Herriot Watt Science Park and the Cambridge Science Park. These parks were aimed to serve their respective universities as revenue generators by transferring new technologies to business and industry; incubating new businesses; and commercializing their universities' research outputs. Subsequently, more science parks were established in the UK and around the world as a strategy for the development of knowledge-based economy through the incubation of high-tech SMEs (Quintas, Wield and Massey, 1992).

Science parks provide a platform for the development of triple helix knowledge networks along which knowledge producers (academia), knowledge users (business and industry); and regulators and controllers of the market for knowledge (government agencies) interact to generate new ideas and innovation. In this triple helix framework for knowledge development and innovation, universities are challenged to collaborate with industries through the provision of funding from the government. Science parks have thus been adopted as policy instruments for promoting economic development and particularly regional development, through the emergence of innovative enterprises, creating job opportunities and regenerating regional economies (Quintas, Wield and Massey, 1992).

In this respect, one of the most important science parks in the UK is the Cambridge science park. The Cambridge science park, which houses the centre of research and development for high technology companies, particularly information technology, biotechnology, and services, has played a vital role in supporting and developing business matching between on-park and off-park companies and also in stimulating on-park firms in sharing space and facilities for creating knowledge linkage among them.

In the early 1980s, most Asian countries found science parks as an effective strategy to foster knowledge-based economic development (Chien-Yuan Lin, 1997). Science parks have subsequently been adopted by many countries as part and parcel of their respective development strategies. Science parks encouraged collaboration between universities and industries in a triple helix framework with the creation of spin-off companies and the provision of benefits deriving from proximity of companies to sources of knowledge and facilities that constitute crucial inputs for the development of innovative and competitive firms that could evolve as niche players in local and global markets (Allen, 2007).

According to Felsenstein (1994), there are two objectives for the establishment of science parks. Firstly, science parks play an incubator role by supporting, promoting and enhancing prospects for the development and growth of new and small firms. Secondly, science parks act as a catalyst for the development of regional economic growth. Likewise, Link and Scott (2003c) specify the aims of science park in the USA as a mechanism for the commercialisation of academic research; and as a source of knowledge spillover. Massey and Wield (1992) accounted the rationale for the establishment of UK science parks as the creation of employment; the incubation of new firms; the development of knowledge networks between universities and firms; and the emergence of innovative and competitive high-tech firms. However, science parks in Asian countries are established with objectives that are slightly different from those in European countries. These objectives include raising the level of technology through the promotion of R&D; promoting foreign investments, particularly in value-added activities; and accelerating transition from a labour-intensive to knowledge-intensive economy (Boehm and Hogan, 2013).

Science parks are generally expected to serve as a catalyst for economic growth through the nurturing of innovative ideas and the development of high technology firms (Castells and Hall, 1995). As such, science parks have been long considered as policy instruments that attempt to promote research-based industries and innovative activities (Lindelöf and Löfsten, 2004). The knowledge-based activities of science parks are aimed to diffuse the benefits of economic growth to local areas by promoting high-tech firms and creating linkages between universities and business and industry. Thus, science parks have the mechanism for leveraging the diffusion of new and advanced technologies among firms, and consequently, for promoting competitiveness of firms (Quintas, Wield and Massey, 1992). The culture and environment of science parks also promote proximity among researchers and firms, thus increasing the frequency and depth of interactions among 'triple helix players' on the knowledge network (Hansson, Husted and Vestergaard, 2005). The science park platform makes knowledge and expertise available to tenant firms and enables academia to forge links with tenant firms and commercialize innovative research outputs (Quintas, Wield and Massey, 1992).

According to the history of science parks, there are three generations in the evolution of science parks. The first-generation science park was the one established at Silicon Valley, essentially predicated on the 'science out' idea. The 'science out' idea refers to the spin-off of small units from universities and research institutes that would be located either within or without but close to the parent universities (Bell and Sadlak, 1992). Science parks are a property-based institutional mechanism designed to assist the growth of knowledge-based firms by supporting and stimulating them through knowledge sharing and the provision of property-based-facilities and services. As such, science parks represented a "supply push" or "science push" platform for 'arms-length collaboration' between government, academia, and the business community. (Kusharsanto and Pradita, 2016).

The second generation of science park development is based on the 'market pull' idea (Jaeger, 2017). In this model, science parks would operate as part of universities or research institutes. Market foresight plays a major role in driving the performance of science parks as seedbed for the emergence of innovative and competitive enterprises. Science parks cater for the business objective of firms by facilitating the provision of suitable infrastructure for conducting research and development, and for providing value-added services for business incubation. The Cambridge Science Park is a good example of a second-generation science park. Cambridge science park was set up to interface between the university and the private sector and to increase new start-ups and spin-off firms from the university in response to prevailing market trends. Hence the emergence of the ‘Cambridge phenomenon’ in the late 1980s, following the growth in the number of new technology-based-firms (Plaeksakul, 2013).

The third generation of science parks is based on the cluster-oriented, networked and interactive innovation system. The research-intensive clusters, often located near major cities, create local wealth by promoting knowledge networks linking universities, industry and business establishments, and government agencies. The third generation of science parks involve public-private partnerships and make strategic decisions which underpin government policy on private sector initiatives. The Hong Kong Science Park is a good example of this model of science park establishment (Plaeksakul, 2013).

Luger and Goldstein (1991) identify three stages in the processes of science park development: incubation, consolidation, and maturation. Alternatively, Allen (2007) also explains the process of science park development in three phases: initial planning and development, steady state growth, and maturation. The way science parks develop and operate is largely influenced by the needs and characteristics of residents and the resource endowments of the regions where they are established. Knowledge of this helps policymakers to understand how science parks should be established and supported as a strategy for the development of innovative and competitive enterprises.

Science parks are also established to facilitate the transformation of pure research into commercial products by using technological innovation from basic research (Vásquez-Urriago *et al*., 2014). The principal mission of science parks is to strengthen industries’ competitiveness by supporting the culture of innovation and enhancing synergy deriving from interactions between universities and companies through engagement in collaborative initiatives (International Association of Science Parks and Areas of Innovation, 2009).

Figure 2.1 shows aspects of the science park ecosystem, which includes technology commercialization, R&D infrastructure, entrepreneurship, professional networks, public-private partnerships, information on venture capital and investment, workforce, and business environment. The science park ecosystem provides a context for the government to evolve policies aimed at promoting innovation and enhancing the competitiveness of products and services.

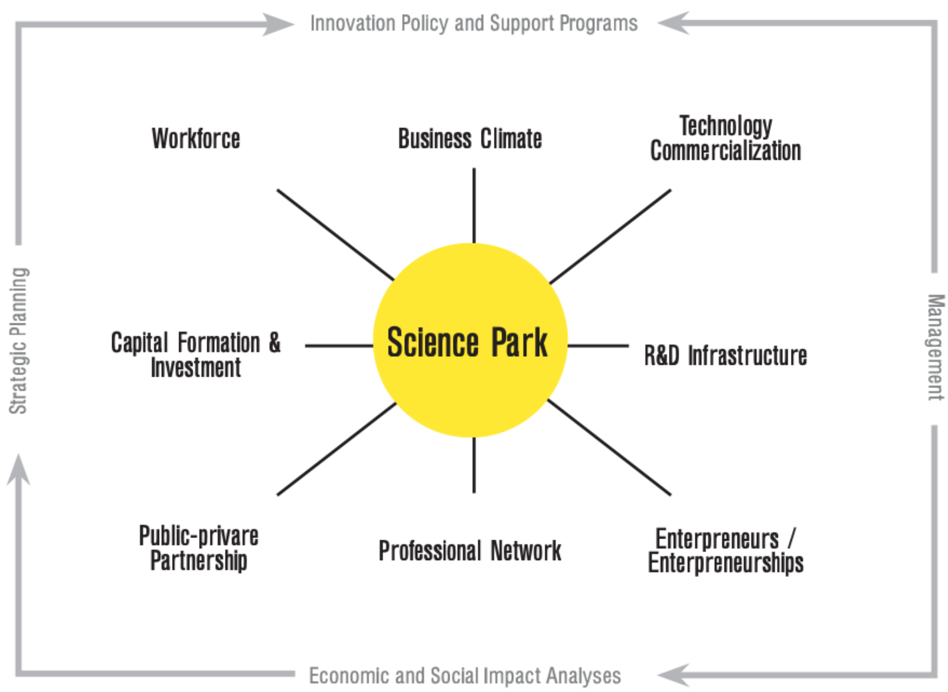

Figure 2.1 Collaborative network of science parks (Plaeksakul, 2013)

According to The International Association of Science Parks[1] (IASP), science parks stimulate innovation by managing the flow of knowledge and technology from and between universities, R&D institutes, and companies. As such,

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[1] ISAP International Board, 6th February 2002

science parks facilitate the creation and growth of innovation-oriented companies through incubation and spin-off processes and provide other value-added services together with high quality space and facilities. Science parks provide business support and technology transfer initiatives that: ‘(a) encourage and support the start-up and incubation of innovation-led, high growth, knowledge-based businesses; (b) provide the environment where large and international businesses can develop specific and close interactions with centers of knowledge creation for their mutual benefit; and (c) have formal and operational links with centers of knowledge creation, such as universities, higher education institutes and research organizations’ (International Association of Science Parks and Areas of Innovation, 2009).

Science parks are alternatively referred to as ‘techno-poles’, science cities, technology parks, research parks. They all, however, are similar to science parks as a useful mechanism for incubating and nurturing creative and innovative ideas that would contribute to technological progress and long-term economic growth through the development of innovative and competitive enterprises. Science parks have become sources of new entrepreneurs, talent firms and knowledge-based firms that are crucial for the development of knowledge economy (Nosratabadi, Pourdarab and Abbasian, 2011).

Currently, there are over four hundred science parks around the world, and the number is expected to increase. The US has more than 150 science parks; Japan comes second with 111 science parks; and China is third with 100 science parks. Europe as a whole has over two hundred science parks, followed by Asia, North America, the Middle East, Africa, Australia and New Zealand, and South America (United Nations Educational Scientific and Culture Organization, 2016).

2.2 Empirical studies of science parks.

In recent years, several studies have examined evidence regarding the innovative performance of firms located in science parks based on the assumption that on-park firms would have better innovative and business performance than off-park firms (Löfsten and Lindelöf, 2002; Löfsten and Lindelöf, 2003; Squicciarini, 2008; Bigliardi *et al*., 2006; Schwartz and Hornych, 2010). Most of the researchers conducted comparative analyses of business performances between on-park and off-park firms. Most indicators used in these studies were widely applied to compare whether or not on-park firms show better innovative and business performances than off-park firms. For example, the number of researchers used as metrics of science park performance include new products or processes, patents, total sales, profits, employment rate, investment in research and development (Löfsten and Lindelöf, 2002; Löfsten and Lindelöf, 2003; Squicciarini, 2008; Bigliardi *et al*., 2006; Schwartz and Hornych, 2010).

Gosselink (1996) designed direct and indirect methods to examine the innovative intensity of firms. The direct method relates to input indicators, such as innovation strategy, employee profiles and R&D expenditures. The indirect method is about output indicators relating to results of innovation, like, for instance, the number of new products and all visible innovative outcomes. Later, Van der Valk (1998) argued that a single metric is not adequate to measure innovative intensity; instead, he argued, multiple innovative indicators should be applied for better results. Such indicators would include the percentage of firms' R&D staff, expenditure on new machines as a percentage of production value, and expenditure of outsourcing as a percentage of production value etc. Moreover, the study suggests that the ability to transform innovative inputs into innovative outputs is a very crucial challenge of science parks as they seek to enhance the efficiency of the innovation processes of firms. Thus, both the direct and indirect methods can be applied to evaluate the innovative intensity of science park activities.

Earlier studies (Westhead, 1997; Siegel, Westhead and Wright, 2003; Fukugawa, 2006; Yang, Motohashi and Chen, 2009) have used innovative indicators to compare the innovative performances of on-park and off-park firms. These indicators include: linkages for knowledge and collaboration; number and skills of in-house researchers; number of employees; and R&D expenditures, which constitute "innovative inputs" (Zeng, Xie and Tam, 2010, Squicciarini, 2008). Indicators of "innovative outputs" are: sales; market share; patents; new products and processes, and intellectual property (Siegel, Westhead and Wright, 2003, Lai and Shyu, 2005, Squicciarini, 2008). These indicators were applied when conducting comparison between off-park and on-park firms which are different with respect to scale of operation or firm size, business sectors they come from, capital cost, and age of establishment.

Alternatively, ANGLE Technology (2003), commissioned by the United Kingdom Science Park Association (UKSPA), defines the performance of science parks in terms of: (1) the economic performance of tenants firms; and (2) the innovation and technology commercialization performance of on-park firms. Economic performance is measured by using the companies' productivity growth, sales turnover and profitability, while innovation and technology commercialization performance is evaluated by using the number of new products and new services launched; patent applications; patents granted; the proportion of qualified scientists and engineers in total employment; and the intensity of investment in R&D as a proportion of sales turnover.

Assessment of science parks started first in the United Kingdom by Monck and colleagues (1988). The investigation aimed to examine the impact of science parks on their tenants by comparing their performances with that of off-park firms using indicators relating to links with universities and higher education institutions (HEI), the intensity of R&D activities, patent applications and patent grants, the launch of new products and services, and the survival rate of firms. The findings show that generally, firms located in science parks have better performances than off-park firms (Löfsten and Lindelöf, 2002; 2003; Squicciarini, 2008; Bigliardi *et al*., 2006; Schwartz and Hornych, 2010).

The impact of science parks on regional development, including job creation, new business formation, and average wage and salary levels were examined by Luger and Goldstein (1991). A study comparing three mature science parks, including the RTP (research triangle parks), the University of Utah Research Park, and the Stanford Research Park show that research park growth widely differs depending on the regions where they are located. Regional factors are likely to contribute to the success of research parks if the parks have an existing base of R&D and high-tech activity; one or more research-active universities; medical schools and engineering institutes; a well-developed network of infrastructure and business services; and foresight and effective political, academic, and business leaders (Luger and Goldstein, 1991).

Westhead and Batstone (1998) undertook a study of UK science parks, covering a total of 47 on-park and 48 off-park firms. The study investigated the factors influencing the performance of firms located on-park and off-park. The results suggest that property-based science park initiatives would add more to the present value of new firms if they chose to locate on-park rather than off-park. Science parks provide space with flexible lease terms and proximity to technology-based firms, thus removing a critical barrier for start-ups to evolve as innovative and competitive firms. Small size firms would generally prefer to locate in science parks because of the trust and prestige they would earn from association with parks and the benefits they would derive as on-park firms from access to the benefits of interaction with higher education and research institutes.

Colombo and Delmastro (2002) studied 45 Italian NTBFs located in technology incubators in 17 science parks and 45 off-park firms. The results of the study suggest that the inputs and outputs of innovative activities are different between on-park and off-park firms, especially with respect to patented new products and processes, copyrights, growth rate, adoption of advanced technologies, aptitude of participation in international R&D programs, and establishment of collaborative arrangements with universities, and access to investment finance. Likewise, Bakouros *et al*. (2010; 2002) studied 17 firms located in three Greek science parks: Science and Technology Park of Crete, Science Park of Patras (SPP), and Technological Park of Thessaloniki. The results show that the modes of link between university and industry among the three science parks were different. Informal connections were developed between the firms and the local university. However, only firms located at SPP developed formal links, while in the other two cases, the links are informal and at the early stage of development.

Siegel *et al*. (2003) conducted another study by using data initially collected by Monck *et al.* (1989) and Westhead and Storey (1994). All the 177 firms in the sample - 89 on-park firms and 88 off-park firms - were all from the UK. The indicators used were the number of new products/services, number of patents applied for or awarded, the number of copyrights, R&D expenditures, the number of scientists and engineers. The results show that firms located in science parks have slightly higher research productivity in terms of innovation turnover than firms that are located off-park.

Link and Scott (2003c) studied the impact of science parks on the academic mission of universities. The survey covered 88 universities, but only 29 responded (33% rate of response). The survey aimed to investigate evidence about the effect of universities' engagement with on-park firms in terms of publication, patents, external research funding, research curriculum, placement of doctoral graduates, and ability of the universities to hire pre-eminent scholars. The results show a direct relationship between the proximity of science parks to universities and the probability of academic curriculum shift from primary toward applied research (Link and Scott, 2003c).

In 2001, Lindelöf and Löfsten examined the growth of sales, growth of employment, and profitability of 263 NTBFs (new technology based-firms) in Sweden, where 163 firms were on-park, and 100 were off-park. The results show that the science park environment has positive impact on the growth of firms in terms of sales and employment. The turnover rates of sales of NTBFs on-park firms and NTBFs off-park firms were 45.60%, 12.93% respectively in 1994-1996; and the employment growth rate between the two groups was 27.95% and 10.17% respectively. However, no evidence was found showing a direct relationship between science park location and profitability. This is because the academic-owned businesses were less profit-oriented when compared with the privately owned companies. NTBFs' profits are contingent on the age of firms, but some of the firms are too young to make any profit (Lindelöf, 2006).

Lindelöf and Löfsten (2002) surveyed 134 NTBFs on-park and 139 NTBFs off-park to investigate the added value science parks bring to NTBFs. The study showed differences between the experiences of on- and off-park firms with respect to innovation and marketing performance. The potential for growth was tested in terms of their market destination - whether firms are linked to local, national or international markets. One significant finding was that small on-park NTBFs have a much broader market distribution throughout Sweden and abroad than small off-park firms. Another significant difference was that on-park firms seem to be more engaged with universities than off-park firms. The difference in status between on-park and off-park firms is in large measure attributable to the role science park managers play in establishing links with triple helix institutions and in encouraging the development of formal relationships within a triple helix framework (Löfsten and Lindelöf, 2003).

Later, Lindelöf and Löfsten (2003) used the same data to evaluate the performance of science parks. They found that there were some differences between the experiences of on-park and off-park firms with respect to issues relating to location and strategy. However, they found no statistically significant differences between science park NTBFs and off-park NTBFs regarding patents and new products launched during the three year period preceding the survey (Lindelöf and Löfsten, 2004). On-park firms collaborate with univeritites less than off-park firms, but their technological and economic performance do not significantly differ from that of the latter as no single university can provide the full range of scientific or management skills required by the on-park NTBFs. Beside, the level of interactions in the innovation process between firms located on science parks and local universities is generally low. It is, however, still higher than the level of interactions exhibited by off-park firms. It was also found that proximity to universities is a significant factor, especially for on-park firms. On the other hand, infrastructure is found to be of high significance for both on-park and off-park firms, whereas the cost of facilities varies in importance across on-park and off-park firms (Hans Löfsten and Lindelöf, 2002; Lindelöf and Löfsten, 2003; Lindelöf and Löfsten, 2004; Lindelöf, 2006).

The above results are broadly corroborated by the study of Furguson and Olofsson (2004), which covered 66 NTBFs in Sweden: 30 on-park and 36 off-park. They also found that on-park firms have significantly higher survival rates than off-park firms; and that on-park and off-park firms differ significantly in terms of sales and employment. On the other hand, proximity of location to universities is found to be positively related significantly to growth of firms through engagement in cooperative initiatives.

Link and Scott (2006) surveyed 81 science parks to investigate the following factors: employment, age of the park, and proximity of science parks to universities. The results show the average growth rate of all parks in terms of the number of tenant firms, which is 8.4% per year. However, parks closer to universities, affiliated with universities, operated by private organizations, and with a specific focus are found to have grown faster than the average. Also, it was found that the growth rates of parks with incubator facilities are on average 3% slower per year than parks without such facilities. There is, however, no clear evidence about the growth of parks that are either university-based or are run as private or public enterprises.

Yet other comparative studies employing full-time staff and having more turnover rates as innovative indicators suggest that on-park firms perform better than off-parks firms as innovative and competitive enterprises (Lindelöf and Löfsten, 2003; Squicciarini, 2008). Similarly, Siegel *et al.* (2003) find that science park firms are more effective than off-park firms in terms of creating new products and services, and securing patents (Ferguson and Olofsson, 2004). On-park firms are also found to perform better in terms of sales and growth of employment than off-park firms. On-park firms also displayed a higher survival rate than off-park firms (Ferguson and Olofsson, 2004).

Geroski and Machin (2013) investigated the difference in the business performance of over 500 UK firms for a period of ten years. It was found that on-park firms were more profitable and experienced faster rate of growth in terms of business performance. Besides, it was found that off-park firms were less effective than on-park firms in terms of the use of knowledge resources (Siegel, Westhead and Wright, 2003).

Díez-Vial and Fernández-Olmos (2015) evaluated the effect of science parks on firms' innovation capacity in terms of the percentage of sales of new products launched by examining a total 11,201 firms drawn from the Spanish PITEC database over the period four years, from 2007 to 2011. The results confirmed that firms who developed cooperative agreements with universities and other research institutes (i.e. on-park firms leveraged by knowledge and market networks) were better able to exploit knowledge externalities to improve their innovative and knowledge sharing capacity than off-park firms. The longitudinal analysis was also used to explore the evolution of on-park firms engaging in cooperative agreements and building in-house R&D effort in comparison with off-park firms. Such findings give credence to the view that science parks play a role as an intermediary facilitating access to valuable resources via a triple helix system of collaboration, involving players from the spheres of knowledge production, knowledge use and wealth creation, and policy and governance.

However, there are also studies that argue that science park firms are not always better performers than off-park firms. For instance, Monck *et al*. (1989)

conducted a study, involving face-to-face interviews with the managers or key leaders of 183 on-park firms and 101 off-park firms. The results show off-park firms with higher level of employment than on-park firms. Likewise, Westhead (1997) conducted two surveys in 1988 and 1992-1993 using the match sample method of on- and off-park firms based on the sector of firms, age, ownership and location profiles to compare UK science park firms with off-park firms. The results showed no significant difference between the two groups of firms. Westhead and Cowling (1995) used sample data set from Monck (1989) and Westhead and Storey (1994) to evaluate the employment growth of British on-park and off-park firms over a period of six years (1986-1992). They found that in 1986, the mean of employment size of 46 independent science park firms was 11.3 employees compared with a mean of 21.4 employees in 31 off-park firms. By 1992-1993, science park firms had grown to employ on average 27 people, while the mean employment size for the off-park firms had risen to 38 employees. The mean employment increase in both groups of firms was alike (16 in both cases).

Shearmur and Doloreux (2000) studied 17 Canadian science parks during 1971-1997 from the vantage point of high-tech employment generated in the regions where they were located. They found no relationship between the establishment of science parks and employment growth. Science parks did not appear to have any distinguishable effect upon the regional industrial structure. In particular, they had no discernible impact on high-tech employment, whether in the manufacturing or in the service sector.

Lindelöf and Löfsten (2003) investigated 273 new technology-based firms (134 on-park, and 139 off-park firms). The results showed that patents/new products launched in the last three years of on-park firms did not evidentially do better than off-park firms. Similarity, the study by Hansson (2005) comparing on-park and off-park firms found no clear picture of the advantages afforded by science parks. The recommendation that followed this finding was to look into the factors that bear on the science-industry relationship and the role of science parks as platforms for the development of triple helix knowledge networks.

Findings that show on-park firms not performing as well as off-park firms suggest not only management failures on the side of science parks, but possibly also irregularities in the design of methods for selecting samples used for comparing the two groups of firms and the robustness of the data used for comparative analysis.

Table 1 shows a range of empirical studies comparing on-park and off-park firms. The pieces of evidence extracted from these studies are mixed; and the sample sizes range from 22 to 183 for on-park firms and 30 to 190 for off-park firms. Most of these studies use innovative indicators to compare, on-park and off-park firms with respect to the number of patents, new products, research and development expenditure, growth rate, number of researchers, sales, and employees.

The studies covered in Table 1 compare the effectiveness of science parks between: (1) on-park and off-park firms; and (2) before and after being tenants in science parks. The results in almost cases show firms located in science parks perform better than off-park firms.

However, how best science parks can promote tenant firms to be innovative and competitive is still not clear, particularly in developing countries like Thailand. Science park managers should, however, know what tenants expect and whether the services they provide are adequate and appropriate to enable the firms evolve as innovative and competitive enterprises. Albahari *et al*. (2019) have, for instance, queried how science parks create value to their tenant firms. The study is particularly beneficial to park managers as it gives a comprehensive analysis of how science parks should be designed and managed. Accordingly, the study argues that park managers should play an important role to ensure the provision of appropriate designs of both the configuration and process-oriented support systems in order to be able to effectively meet tenants' demands. It is, therefore, important that park managers understood the hard and soft mechanisms of support.

Table 2.1 Studies the measurement of science park performance.

Study	Country	On-park firms	Off-park firms	Methods	Result Variables	Results
Mock et al. (1988)	UK (1986)	183 F	101 F	Matching	Growth (employment), Links with HEI, patents, new products	No significant effects
Westhead (1997)	UK (1986-1992)	47 F	48 F	Matching	scientists and engineers, R&D expenditure, radical new research, patents, copyrights, new products	no significant effects
Löfsten and Lindelöf (2001)	Sweden (1994-1996)	163 NTBFs	100 NTBFs	Ordinary Least Squares	growth (sales), profitability	effect on growth. No significant effect on profitability
Löfsten and Lindelöf (2002, 2003); Lindelöf and Löfsten (2003, 2004);	Sweden (1996-1998)	134 NTBFs	139 NTBFs	Matching Factor Analysis	growth (sales), links with HEIs, profitability, product innovation, patents, motivations of location, strategies, Facilities Management (proximity -university, customers, competitors infrastructure, cost of facilities)	effect on growth, links with HEIs, proximity to universities, product innovation. No significant effect on other aspects.

Dettwiler et al. (2006)						
Colombo and Delmastro (2002)	Italy (1999)	45 NTBFs	45 NTBFs	Tobit Matching	growth (employment), research personnel, use of TICs, external R&D, links with HEI, public financing, patents	effect on growth, inputs innovation. No significant effect on patents
Siegel et al. (2003a)	UK (1992)	89 F	88 F	Negative Binomial, Two Step Negative Binomial, Stochastic frontier	new products, patents, copyrights	effect on new products and patents.
Ferguson and Olofsson (2004)	Sweden (1991-2000)	30 NTBF	36 NTBF	Matching	survival, growth (sales)	effect on survival. No significant effect on growth
Fukugawa (2006)	Japan (2001-2003) panel data	74 NTBF	138 NTBFs	Probit	links with HEI	effect on joint research with HEIs
Malairaja and Zawdie (2008)	Malaysia	22 HT-SME	30 HT-SME	Matching	links with HEI	no significant effects

Squicciarini (2008)	Finland (1970-2002) panel data	48 F	72 F	Before and after (duration model). Cox proportional hazard model	number of patents	effect on patents
Yang et al. (2009)	Taiwan (1998-2003) panel data	57 NTBF	190 NTBF	Sample selection model (Heckman)	R&D Productivity	effect on productivity

Remarks: F (firms); NTBF (new technology-based firms); HT-SME (high tech - small and medium-size enterprises); HEI (Higher education institutions)

Aliahmadi *et al*. (2015) identified critical factors affecting firms' evolution as innovative and competitive enterprises. These include employment of high-quality scientists and engineers; access to high-quality human resources in the fields of management and marketing; access to reference laboratories; communication with universities and R&D institutes; cooperation with similar companies; access to required technical information; customs and tax exemptions; financial support; provision of physical infrastructures; access to growing domestic market; high skill personnel; and access to required market information. These factors are set into four broad categories: human resources; R&D and technology transfer; facilities; and market development. Analysis of these factors showed the human resources category to be crucial for improving the total performance of parks. Likewise, Lin and Chia-Li (2009) explored the effects of industrial clusters in science parks and suggested human resources, technology, financial resources, and markets to be crucial factors for the development of on-park firms. Similarity, Zhu and Tann (2005) indicate that science parks mainly provide human resources and basic research infrastructure, and that these services could be used to assess the role of science parks in leveraging the evolution of tenant firms into innovative and competitive enterprises. The study, comparing two science parks in Taiwan, showed that factors including demand conditions, relevant and supporting industries, firm strategies, and competition among firms as essential drivers of the development of the innovation capacity of firms.

Sun (2009) also found six factors which play a crucial role in promoting tenant firms to be competitive – namely, condition of inputs; local demand conditions; relevant and supporting industries; competition; corporate strategies and structures; and government support and business culture. For Fukugawa (2006), forging links with universities and research institutes are found to be the most crucial form of assistance that science parks could provide to their tenants. This is because tenant firms can use research resources and technology linkages to assist their research and development effort aimed at product innovation.

The role of science parks in promoting the innovativeness and competitiveness of tenant firms cannot be overemphasized. It is upon this understanding that science parks are used as instruments of science, technology and innovation policy in many countries.

2.3 Science Parks as platform for triple helix Innovation

This study is set within the framework of innovation systems, in general, and the triple helix system, in particular. The concept of innovation as a system is defined by the interdependent activities of knowledge generation and knowledge use, which involve a network of players operating within the framework of regulated knowledge markets (Ray, 1980; Saad and Zawdie; 2011; Plaeksakul, 2010; Plaeksakul, 2013; Bessant, 2011; Carayannis, 2014; Crnogaj, Rebernik and Hojnik, 2015). Within this market framework, the knowledge suppliers are universities and the research centres they house; and knowledge users are the production actors or wealth creators in business and industry. The government is also a major player in the innovation system providing the resources for setting in place knowledge infrastructure, and also regulating and controlling the occurrence of irregularities in the knowledge market.

The triple helix innovation system, which involves knowledge actors producing knowledge, production actors using knowledge, and policy actors exercising regulation and control of the knowledge market, is based on the development of networks within and between institutional spheres. It is a system within which hybrid institutional cultures evolve through organisational and inter-organisational learning, and the dynamics of knowledge arising from the learning process, which is facilitated by network intermediaries (OECD, 1997; Nakwa and Zawdie, 2015).

The triple helix platform does not only encourage conjugation among the three institutional players – namely, government, academia, and private sector agencies - but also, it is at the heart of the concept of innovation systems (national and regional systems of innovation). Indeed, triple helix is presented in the literature as a heuristic for the implementation of innovation systems (Leydesdorff & Zawdie, 2010).

Unlike the concept of industrial cluster, the concept of innovation systems (IS) is broader in scope with geographical, sectoral, and institutional boundaries as units of analysis. The concept assumes that innovation is embedded in networks. Broadly defined, innovation systems (IS) cover all interrelated institutional actors which can create, diffuse, and exploit innovations. Narrowly defined, they address individual organizations and institutions – like R&D units, universities, and public and research institutes - that directly focus on searching and exploring technological innovations. This brings to focus the significance of the triple helix knowledge network for research initiatives geared at promoting innovation and interactive learning among actors representing knowledge producers and knowledge users across the economic system (Lundvall 1988, 1992; Johnson, 1992; Chung, 1996). It also brings to focus the geographical and sectoral dimensions of innovation systems – i.e. the national innovation system (Freeman,1984; Lundvall, 1992), regional innovation system (Cook and Morgan, 1988; Cooke 1996) and sectoral innovation system (Malerba, 2002).

Central to the concept of the national innovation system (NIS) is the process of knowledge generation, diffusion, and use, involving a wide range of players/actors with the firm or industrial enterprise at the centre of the process. NIS is ultimately concerned with national performance in terms of economic growth, job creation and international competitiveness. In the NIS scheme, it is important for players in the production (wealth creation) sector to be networked not only with one another – within and between sectors – but also with knowledge generating and other public and private sector institutions. Overbearing the network of actors engaged in the systemic process of wealth creation are: the macro-economic policy involving control and regulation mechanisms; the education and training system; the state of communication infrastructure; factor market conditions; product market conditions; and national/cultural idiosyncrasies underlying learning, management and organisation systems.

The NIS consists of three innovative actor groups: public research institutes and policy agencies; academia; and business and industries, all of which play essential roles in network building. Moreover, NIS can be understood as a matrix incorporating regional and sectoral innovation systems.

Regional innovation system (RIS) refers to innovation system at local or regional levels without focus on any particular industry. RIS involves institutional settings, path dependency, technological change and interaction among actors located in a specific region (Cooke, 1996). Cooke and Morgan (1998), define RIS as regionally based firms and organisations that are systematically engaged in interactive learning and processes through which knowledge is produced. A necessary requirement for regional innovation system to be implementable is the active role of local governance which can authorize policy that enables enterprises and organisations to engage in the development of innovative activities (Cooke et al., 1997).

Regional science park projects, as the ones promoted in Thailand, are in essence mechanisms for implementing RIS. The concept of innovation system is helpful as a framework for the enhancement of regional industrial competitiveness by activating interaction among innovative actors in the region.

Sectoral innovation system (SIS) is about “a system or group of firms active in developing and making a sector’s products and in generating and utilising a sector’s technologies” (Malerba, 2002). As such, it involves a network of institutional actors through which knowledge is articulated and innovation occurs in a specific industry. SIS is based on the principle of 'protected space' for promoting niche innovations (Barrie, et al., 2017).

While NIS and RIS are expressions of innovation systems (IS) defined within geographical boundaries, SIS is yet another expression of IS defined in terms of economic boundaries. On the other hand, as innovation system, the triple helix network is defined in terms of institutional spheres (Etzkowitz and Leydesdorff, 1995, 2000).

The principles underlying science parks draw on elements that constitute NIS, RIS and SIS, which uniquely find expression in the form of the triple helix platform designed to facilitate interactions between institutions of knowledge creation (academia), knowledge users or wealth creators (business and industry), and governance of the knowledge market (government/ policy circles).

Based on the above, Figure 2.2 below shows the configuration of the major players in the science park eco-system and the role of science parks as a platform for the development of the triple helix knowledge network from which innovative and competitive enterprises are expected to evolve.

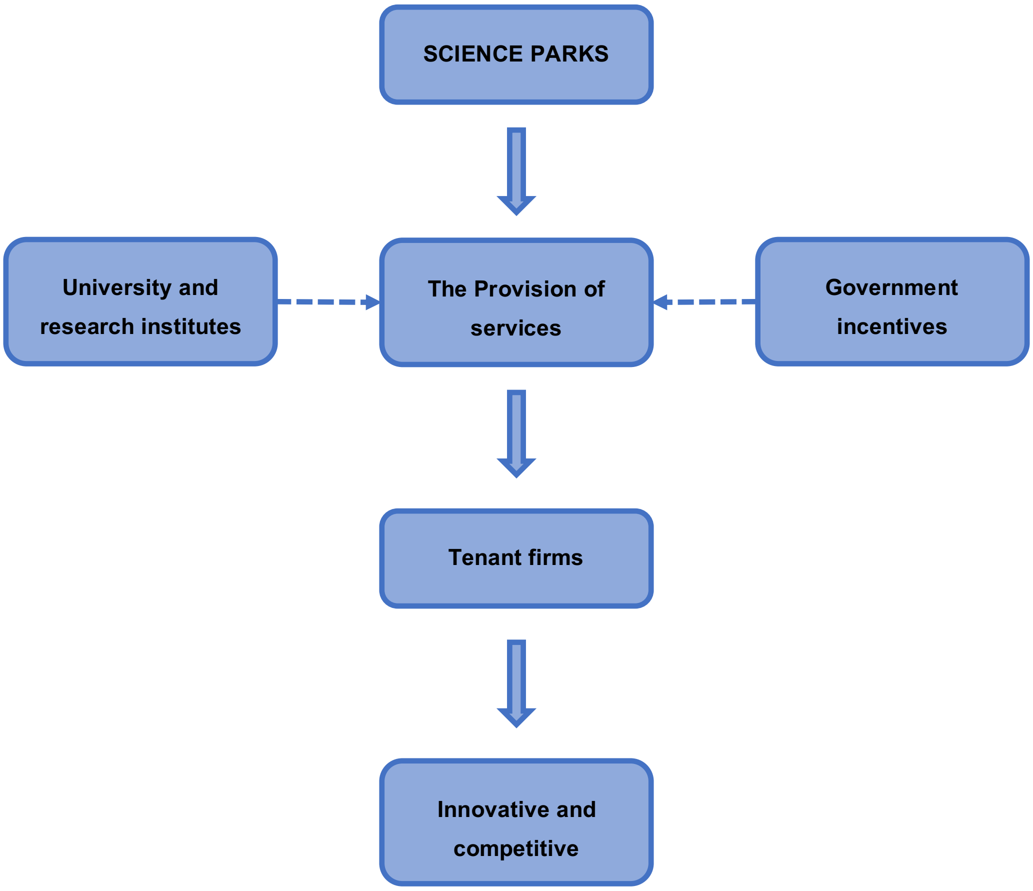

Figure 2.2 Triple helix actors as drivers of innovative activities of science parks.

Two major aspects of innovation systems, in general, are knowledge production and commercialization of knowledge. Science parks provide the forum for knowledge producers and knowledge users to closely interact, thus facilitating the occurrence of innovation and providing the basis for the emergence of innovative and competitive firms that could evolve even as 'global born' niche players.

Firms deciding to locate in science parks would expect to benefit from the services provided by the parks and improve their innovative and marketing performance. Conceptually, firms deciding to locate in science parks would be expected to have low capabilities in accessing and internalizing new knowledge, and in prospecting new market opportunities if left on their own off-park. When they become tenant firms located in science parks, they would be exposed to a learning environment that increases their awareness and capabilities to push their technology and market frontiers. Science parks would be effective in their performance if, after making use of the science park services provided, their tenants evolve with high awareness and capabilities for pushing technology and market frontiers. This depends, however, on how science parks are managed and oriented to meeting the learning and development needs of firms. In other words, how suited are the services of science parks to promoting the innovative (knowledge exploration) and marketing (knowledge exploitation) performance of tenant firms? (Barrie, Zawdie and João, 2017).

Conceptually, how firms evolve as a result of their experiences in the science park would depend on their technology and market orientation. Firms, which are presumed to experience a predominantly technology-oriented evolution, are those that are generally R&D-intensive. Market-oriented evolution would generally apply to those firms that are engaged in the exploitation rather than in the exploration of knowledge. Generally, SMEs would fall in the latter category. It can be presumed that R&D firms would evolve as global niche market players. On the other hand, the evolution of SMEs would generally be expected to have the mark of a market-bias, reflecting the behavior of firms that are locked in supply chain systems at local and global levels.

2.4 The science parks context for evolution of innovative and competitive firms

Figure 2.3 sets out science park firms according to the extent of their awareness of and engagement with technology and market systems that account for the making of innovative and competitive enterprises. Lichtenthaler (2008) draws on a similar matrix of knowledge exploitation and knowledge exploration to map the level of open innovation within networks. Barrie *et al*.

(2017) also used the matrix to show the configuration of firms according to their awareness of circular economy-oriented technology and market systems on the course of transition to circular economy. In the context of this study, the matrix is adapted to show the evolution of firms in terms of their innovativeness and competitiveness.

In Figure 2.3, the cluster of firms in space A are presumably least networked and hence least innovative and competitive as the extent of their awareness of and engagement with the prevailing technology and market systems is low. Firms in B and C are relatively more networked than those in A. Those in B are likely to engage in knowledge and technology exchange processes. They are, therefore, expected to show high innovative performance. However, these firms have low levels of knowledge exploitation as they may be either unaware or else are uninterested in new markets because of associated risks. Their performance with respect to competitiveness is therefore expected to be low. On the other hand, firms located in space C are presumed to have developed their market networks to exploit or commercialize their knowledge deriving from in-house R&D initiatives, but rarely engage in knowledge sharing and knowledge exchange exercises. They are therefore characterized as high performers on competitiveness and low performers on innovativeness.

The trait of innovativeness and competitiveness in firms is achieved in space D, where firms' awareness of and engagement with technology and market systems is high (Barrie, Zawdie and João, 2017). In this respect, policy would aim to provide the overarching strategic framework defining the direction along which the firms would be expected to evolve, while at the same time developing appropriate networks for knowledge/technology systems and market systems to develop, and for triple helix actors to freely interact on the platform offered by science parks, regularly, exchanging knowledge and exploring and exploiting opportunities (Barrie, Zawdie and João, 2017).

Most of the firms located in science parks would be expected to be found spread across A, B and C. This means that there are three pathways to D.

These are pathways to the position where the evolution of firms with respect to innovativeness and competitiveness would be expected to be complete. The first pathway is a 'quantum jump' from A to D, which poses a daunting challenge for science parks as firms in A have low awareness of and engagement with technology/knowledge and market systems. The second pathway is from B to D, where the task of science parks is to promote awareness of and engagement with market systems among firms in B that already have high awareness in technology systems but not in market systems. The third pathway is from C to D, where science parks would be expected to promote knowledge/technology systems through training and R&D support to firms in C.

When tenant firms find themselves in Region D, they would be expected to be innovative and competitive. Region D is where technology awareness and market awareness are maximized through the achievement of 'triple helix consensus' on the science park platform (Barrie, Zawdie and João, 2017). Transition from A to D directly through a quantum jump or indirectly through B and C takes a long period of learning and to get over the hurdles of innovation. While firms scattered all over in D are all labelled to be innovative and competitive, they would still differ in the trajectories they follow, as some would have a market-bias and others a technology-bias in their systems of evolution.

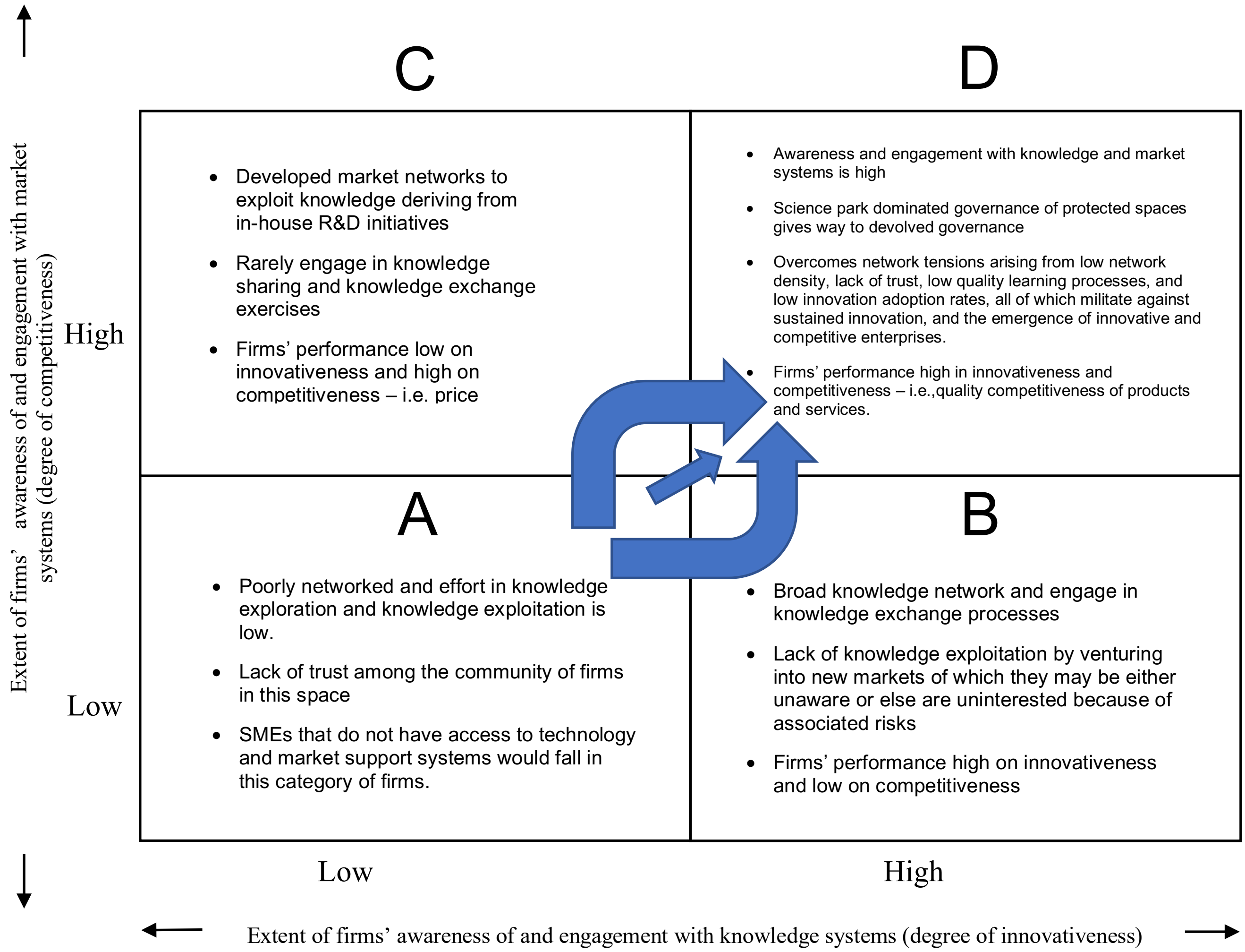

Figure 2.3 The role of science parks as a strategy for the emergence of innovative and competitive firms through improvements in the awareness of and engagement with knowledge/technology and market systems of tenant firms (Based on Barrie *et al.,* 2017).

In Figure 2.3, transition from regions A, B and C to region D require not only knowledge linkage on the science park platform, but also the ability of actors on the network to absorb knowledge through the mechanism of learning and to share knowledge among firms through the process of diffusion. This, in effect, implies that transition to D would turn on the development of absorptive capacity to enhance the shift from resource-based value system to knowledge-based value system. The development of absorptive capacity is enhanced by the development of knowledge network through the activities of science parks as triple helix platforms.

The triple helix system is led by academia and research institutions from where knowledge, once produced, spills over to the agencies of wealth creation, namely business and industry, to transform their production functions and make firms innovative and competitive. With increased absorption and accumulation of knowledge, the process of wealth creation would be expected to become resource-saving and increasingly knowledge-based. And the extent to which knowledge can spillover from firms to the wider public would contribute to the development of knowledge economy (Qian, 2013).

Cohen and Levinthal (1990) define absorptive capacity as the ability to recognize the value of new information, assimilate it, and apply it for commercial purposes. Absorptive capacity is crucial for the learning performance of particularly new entrepreneurs and firms who would use the knowledge they accumulate to look out for technology and market opportunities.

On the other hand, knowledge spillover depends not only on the speed of knowledge production, but also on the ability of entrepreneurial organisations to understand new knowledge, recognize its value, and commercialise it. A description of the absorptive capacity theory of knowledge spillover is displayed in Figure 2.4.

It is shown in the figure that entrepreneurial absorptive capacity is crucial for the emergence of knowledge-based value system either directly or through the production of new knowledge. The dashed double arrow shows that new knowledge and entrepreneurial absorptive capacity, which feedback into each other, are crucial for the emergence of knowledge-based entrepreneurial activities across the economic spectrum.

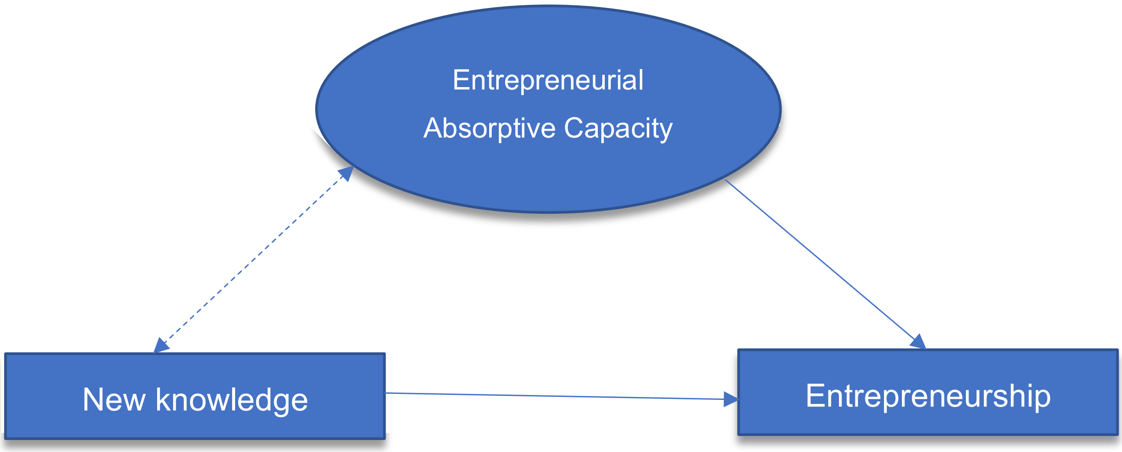

Figure 2.4 The systematic flow of the absorptive capacity theory of knowledge spillover entrepreneurship (Based on Qian and Acs, 2013).

2.5 Issues in the measurement of the innovative and competitive performance of firms.

There is a growing body of knowledge about the interactive process between innovation and wealth creation. The process of innovation includes market and non-market activities within institutional systems (Organisation for Economic Cooperation and Development, 2012). These activities relate to the research and development (R&D) and commercialisation components of the innovation process (Kusharsanto and Pradita, 2016). Successful innovations not only create new products or services, but also ensure that these new products and processes are commercialised (Peter Hall, 2000).

There are two aspects to the measurement of the innovation performance of firms. The first aspect relates to the input and output sides of the complex innovation process. The focus on input and output indicators, however, assumes the innovation process to be linear, whereas what is significant about innovation is the dynamics in the innovation process, which involves feedback loops from within and outwith the organizational system and reactions to these through learning, unlearning and producing creative solutions to problems (Andy Hall and Clark, 2010). The relationships that constitute the innovation process are often sidelined or relegated into a ‘black box’ as if they do not matter (Malairaja and Zawdie, 2004). The use of linear indicators to evaluate the innovation performance of firms is thus bound to hide a lot that occurs in the innovation process, and should, therefore, be taken with a pinch of salt.

The second aspect of the issue about measurement of the innovation process relates to the two components of the mission of science parks – i.e. innovation and commercialization of innovation. It is apparent from Figure 2.3 that the innovativeness and competitiveness of firms can occur as two sides of the same coin, thus reflecting the focus of science parks not only on innovation, but also on commercialization.

Attempts to measure innovative performance at the level of enterprises have largely focused on input and output indicators. Input indicators are based on the measurement of resources provided to feed into the innovation process - for example, human resources, infrastructure and facilities, knowledge linkage, funding, and market opportunity (Aliahmadi *et al.*, 2015). Output indicators reflect the results of organizational innovations and the success of innovative activities. The indicators explain the values of outcomes, such as the number of patents granted, the number of new products, sales, profit, market shares, business growth rate (Bigliardi *et al.*, 2006; Malairaja, 2006; Batabyal and Beladi, 2014; Meissner and Shmatko, 2017).

One of the earliest and classical methods used for the measurement of innovative intensity is the Input-Process-Output-Outcomes model (Jong, 2000). Using this method, the innovative activities of firms are systematically studied by factoring in a range of relevant inputs, like human resources, ideas, funding opportunities, and innovative outputs, such as patents, new product and process, sales, cost-saving, new market (Eric and Steven, 2013). For example, human resources constitute one of the essential innovative inputs because skilled workforce is crucial for the success of businesses. Hence the need for investment in human resources through the expansion of research-active universities. This can be done in the context of the development of the triple helix system underlying the operation of science parks.

However, in the case of the alternative innovation trajectories that take into consideration both technology and market awareness, as in the distribution of firms in space D shown in Figure 2.3, it can be reasonably assumed that firms that are innovative are *ipso facto* competitive (Barrie *et al*., 2017).

Jong (2000) developed a validated measurement scale for measuring the innovative intensity of small firms in the Netherlands. This exercise aimed to investigate whether the innovative intensity of small firms can be determined by combining the innovative input, process, and outputs. The input-process-output approach involving transformation scale was to apply 17 dichotomous questions administered from 2,042 small firms. It was found that a set of 13 dichotomous questions can be applied to measure the innovative intensity comprising of four innovative outputs, six to innovative processes, and three to innovative inputs. It was found that 13 of the 17 questions were capable to adopt the questionnaire used for eliciting robust data on the innovative input, process, and output.

In 2016, the Global Agenda Council on the economics of innovation looked into 45 indicators of innovation and found that most of these indicators (38) related to 'innovation inputs' (R&D expenditures, education level, infrastructure, technical skill), while only 7 were dedicated to indicating 'innovation outputs' (such as sales, number of patents, new products, etc.). This overemphasis on input indicators suggested the need for seeking more output indicators for a better innovation assessment. Besides, the lack of insight information on output indicators, particularly on new products and services, amounts to a blind spot-on innovation's impact on competitiveness and commercialization of products (World Economic Forum, 2016).

The Council subsequently developed a new innovation index to improve measurement of the innovation capability of firms. This new index was aimed at redressing the deficit of emphasis on output indicators, and hence on indicators of competitiveness. The new index involved three output indicators and five input indicators. The data was collected from 60 countries; and the results showed Switzerland ranking first when output indicators are used to gauge performance, while Japan ranked top when input indicators are used. The Council's study also established that only two input indicators (R&D expenditures and researchers in R&D) associated well with output indicators in terms of reflecting the innovation performance of firms.

The measurement of innovation is generally investigated by using input and output indicators. However, there are limitations to the use of such indicators, the major one being the linearity of the indicators in the face of the complexity of the innovation process itself. Some of the significant questions that arise are: (1) some input indicators do not adequately reflect innovation performance as a process and particularly the complexity involved in technological learning; (2) use of single indicators do not effectively reflect particularly the qualitative aspects of the characteristics and value of innovation; and (3) use of output indicators, particularly the number of patents, could be problematic because it is subject to considerable variation across countries; and what is more, not all innovations can be patented, and some patents created by large companies are shelved and not put to use or licensed out, particularly when companies seek to preempt innovation by competitors and assert a monopoly position (Sundbo, 1998; McDaniel, 2002; Bessant, 2011). Moreover, focus of output indicators on new products and patents has the effect of underplaying the market performance of innovated products - and hence the commercialization role science parks – which are often reflected by growth in market shares, export performance and profitability of firms.

Perhaps the most significant critique of input and output indicators of innovation, particularly in the context of science park firms, is that such indicators are not capable of reflecting the systemic nature of knowledge and market networks underlying the innovation and commercialization activities of science parks. Innovation is a systemic process and understanding it as such would call for a systemic approach in the form of analytical models or perspectives that take into consideration all factors that bear on the process.

Thus, to understand innovation as a process, it is important to look into the process of knowledge production, knowledge transfer and exchange, knowledge use, and the policy regimes under which knowledge is produced, transferred and used. This approach looks at the innovation process not in isolation but in relation to the commercialization of the innovated products and services. It also brings into the picture the interactions between a network of institutional players behind the activities of knowledge production (academia), knowledge use (the wealth creation actors from business and industry), and regulation and control of knowledge production and knowledge use (government or policy actors). It is on this that the triple helix system of innovation is based (Etzkowitz and Leydesdorff, 2000). When triple helix-based knowledge and market networks underpin the activities of science parks, tenant firms would be expected to realise their creativity and innovation potential and evolve as innovative and competitive enterprises. Hence the position of firms in Region D in Figure 2.3, where firms' achievement of innovativeness and competitiveness is maximized.

2.6 Conclusion

This chapter has discussed science parks as platforms for evolving innovative and competitive enterprises. Underlying the activities of science parks is the triple helix system, which involves interactions between institutional players in knowledge and market networks, including knowledge producers, knowledge users and regulators of the knowledge market.

The science park idea that was born in the Silicon Valley in the 1950s has since been widely adopted in many countries as a strategy for promoting the emergence of innovative and competitive enterprises. Science parks provide the infrastructure needed to enhance firms' innovative capacity - for example, human resources, infrastructure and facility, knowledge linkage, funding, and market foresight. Besides, science parks play the role of innovated products and processes. Because of all this, science park firms are often expected to have a competitive edge over similar firms located off-park. The evidence for this expectation is widely documented, as discussed in this chapter. The literature, however, also shows that while science parks can perform effectively to support and promote firms by directly exposing them to knowledge and market networks, as well as providing them with facilities and funding and incentives from the government, off-park firms can still perform comparatively better than on-park firms. This is often explained by deficiencies in the management of science parks. Indeed, the experience of science parks in developing countries is that more often than not, science parks operate more as real estate agencies than as platforms for the development of innovative and competitive enterprises. There is also evidence from Malairaja (2003) to show that the decision of firms to locate in science parks is driven by the desire to enhance their reputation and to take advantage of the rental benefits that would significantly reduce their overhead costs. It has, however, been shown in this chapter (see Figure 2.3) that if science parks are properly managed within the framework of the triple helix system, on-park firms can expect to evolve as innovative and competitive enterprises.

Another aspect of the literature is the question about measurement of the innovativeness and competitiveness of firms. There are, as discussed in this chapter, two aspects to the issue of measurement. The first aspect relates to the inadequacy of the linear and static approach to the measurement of the non-linear and complex concept of innovation in terms of input and output indicators. The use of linear indicators to evaluate the innovation performance of firms hides a lot that occurs in the dynamical innovation process. This problem of measurement can, however, be overcome by addressing the second aspect of the measurement question, which integrates the concepts of innovation and commercialization (the two missions of science parks) in the triple helix system.

A further dimension of the science park literature is the adoption of science parks as a strategy for the development of innovative and competitive enterprises in developing countries. If science parks succeeded in the Silicon

Valley, it does not follow that they would be a success in developing countries, particularly where they are implemented as a ‘top-down’ planning and policy exercise. The mixed experience of science parks in Malaysia is a case in point, where Malairaja (2003) found no evidence of any significant difference of performance between on-park and off-park firms. There is, however, no reason to presume that science parks are irrelevant as instrument of innovation policy in developing countries. Much would depend on how science parks are designed and managed, and no less important, on how their objectives are aligned to the objectives of the wider economy and the knowledge and market networks underlying it. It is in this context that this study has proposed to investigate the empirical question about the effectiveness of science parks in the light of the experience of Thailand.

Figure 2.5 below presents the variables that define the hypotheses of this study. The services science parks provide to their tenants are set in five groups of innovative service inputs: human resources, infrastructure and facility, knowledge linkage, funding, and market opportunities. These groups of service are set as independent variables in the quantitative model of this study. Thus, tenant firms are profiled according to their age, business scale, business sector of origin, capital cost, number of years of participation in NSP, R&D expenditure, and number of researchers.

The aim is to investigate the influence of the five service inputs of NSP on the perceived innovative performance of tenant firms. The dependent variables relating to perceived innovative performance are expressed in terms of the development of new products or processes; market development; cost reduction and environmental impact; and intellectual properties of tenant firms.

The hypotheses based on the variables set out in Figure 2.5 can help produce evidence to inform decisions of science parks to deliver the relevant services that would enhance the innovative performance of tenant firms. To set the research issue in empirical context, the next chapter will discuss the background to the development of science parks in Thailand.

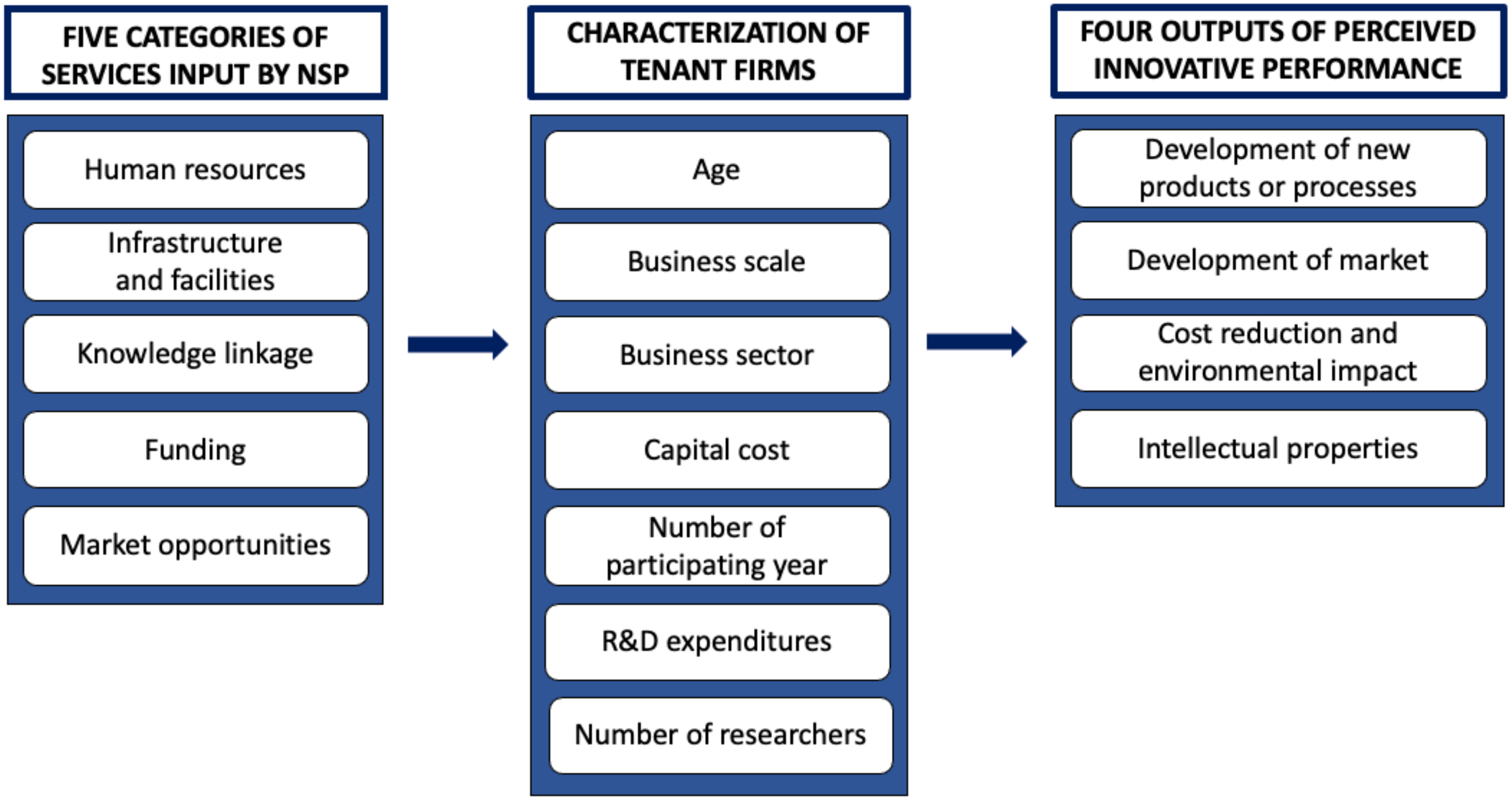

Figure 2.5 The relationship between science park services and the perceived output performance of tenant firms.

CHAPTER 3
THE DEVELOPMENT OF SCIENCE PARKS IN THAILAND

This chapter explores the development of science parks in Thailand since the first science park was established in 2002. The chapter is in four parts. The first part explains the establishment of the first science park and the other three regional science parks, including the objectives of the parks. The second part discusses the distribution of resource endowments in Thailand as basis for deciding on where in Thailand science parks should be located and what these parks should focus on. The third part discusses the key players in the development of science park activities and how these players interact to support tenant firms in their efforts to evolve as innovative and competitive enterprises. The last part summarizes and concludes the chapter.

3.1 The establishment of Science Parks in Thailand.

Interest in the establishment of science parks in Thailand first featured in Thailand's Sixth National Economic and Social Development Plan (1987-1991). The Plan aimed to set out a framework for Thailand to develop infrastructure to support education in science and technology and investment in research and development in the context of business development. Science park development was a major aspect of this overarching framework. The Government entrusted three agencies to look into the feasibility of science park establishment during 1986–1988. These agencies included the Ministry of Science and Energy[2]; the Ministry of Education; and the Office of University. In 1990, decision was made by the Government to proceed with the establishment of the first national science park; and the Ministry of Science and Technology was charged with the responsibility to develop the

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[2] This later changed to Ministry of Science and Technology (MOST) and subsequently became the Ministry of Higher Education, Science, Research, and Innovation (MHESI)

infrastructure required for the project. However, the establishment of the first national science park was delayed and took over ten years to complete partly due to delays in the completion of the feasibility study and in the construction plan, and partly due to the economic crisis in 1997, which had adverse impacts on the Thai economy at large. Upon completion of construction, the Park, known as Thailand Science Park (TSP), started operation in 2002 as a fully integrated hub for R&D in science and technology in Thailand. The Park was designated to operate under the management of the National Science and Technology Development Agency (NSTDA), one of the Government agencies under the Ministry of Science and Technology at the time.

TSP is the first science park located in the Pathumthani Province, in the northern outskirt of Bangkok. It stands on eighty acres of land adjacent to two academic institutes: Asian Institute of Technology (AIT) and Thammasat University (TU). The Park has in it three zones: research centers, an incubation space, and renting space for technology-based firms. Its mission is to create a dynamic S&T community comprising of successful companies, promising enterprises, innovative entrepreneurs and public institutions. The science park aims to support the S&T community in its R&D and business endeavors, and to encourage cooperation amongst universities, public agencies and industries. TSP has strived to create an environment that is conducive for R&D cooperation and commercialization; and to encourage joint research projects in which private sector agencies can share and exchange knowledge with national-level specialists, as well as sharing the use of laboratories and high-tech equipment. TSP is expected to provide an opportunity for firms and public laboratories to interact in R&D-related activities. TSP is as such considered to be a seedbed of innovation, helping to build closer links and collaborations between R&D-oriented businesses, relevant Government agencies, research centers and academic institutions.

The Park has a dual purpose of assisting technology-based start-up companies as well as encouraging large local and international companies to invest in research and development in Thailand. As such, it caters for all sizes of technology-based firms. It has small and medium rental spaces available for start-ups and established firms. Long-term lease land is also available for large companies to invest in their R&D units. There is also room in the Park for small scale pilot production or high value-added production in support of product and market development and innovation. TSP is expected to support collaboration between researchers and tenant firms. Such activities work together to promote innovation possibilities and enhance business performance that would boost prospects for economic growth and the development of triple helix knowledge networks to facilitate interactive cooperation among players from the government, university, and business and industry spheres in the triple helix framework (Plaeksakul, 2010).

The National Science and Technology Strategy Plan (2004-2013) set out provisions for the establishment of regional science parks in Thailand. Accordingly, in 2004, the Ministry of Science and Technology assigned the Thailand Institute of Science and Technological Research (TISTR) to implement the establishment of the Northern Science Park over a three-year period between 2004 and 2007. In 2007, the Government gave the go ahead for the establishment of the Northeastern Science Park and the Southern Science Park during 2007 – 2010; and assigned the National Science and Technology Development Agency (NSTDA) to manage these parks.

In 2008, the Office of Permanent Secretary (OPS), under the Ministry of Science and Technology, asked King Mongkut’s University of Technology Thonburi to explore strategies for appropriating the platform of regional science park management for S&T development in the context of Thailand. The report by King Mongkut’s University of Technology Thonburi was used as a basis for the establishment in 2011 of a new government agency under Ministry of Science and Technology, the Science Park Promotion Agency (SPA), to regulate, encourage, and support regional science parks.

While the necessary infrastructure for the three regional science parks was still under construction, the regional parks had started running their operation embedded at universities where they would obtain the relevant R&D and network and facility supports for their tenants. The Northern Thailand Science Park (NSP) has six-university members (Chiangmai university is the centre); the Northeastern Thailand Science Park has four-university members (Khon Kaen University is the centre); and the Southern Thailand Science Park has two-university members (Prince Song Kha University is the centre). The establishment of these regional science parks was driven by access to regional universities to provide the requisite knowledge chain through consultancy, incubation and project workshop programme. The Government would, in the meantime, provide the infrastructure and the facilities for setting up the parks.

Construction of the infrastructure and buildings for the Northern Thailand Science Park was started in 2014 and fully completed in late 2017; and the Park started operation in 2018. Work on the sites for the other two parks was expected to be completed by 2019, and they have been in full operation since. However, while these two sites were under construction, the respective regional parks were performing under the management of universities in the regions, providing consultancy support to local firms; and do not yet cater for 'in-wall' tenants.

NSP has currently 22 tenant firms of various scales drawn from multiple business sectors. NSP has been catering for firms engaged in rice and herb development and software and application. Northeastern Science Park is dedicated for poultry and agricultural products, and Southern Science Park for rubber-related products.

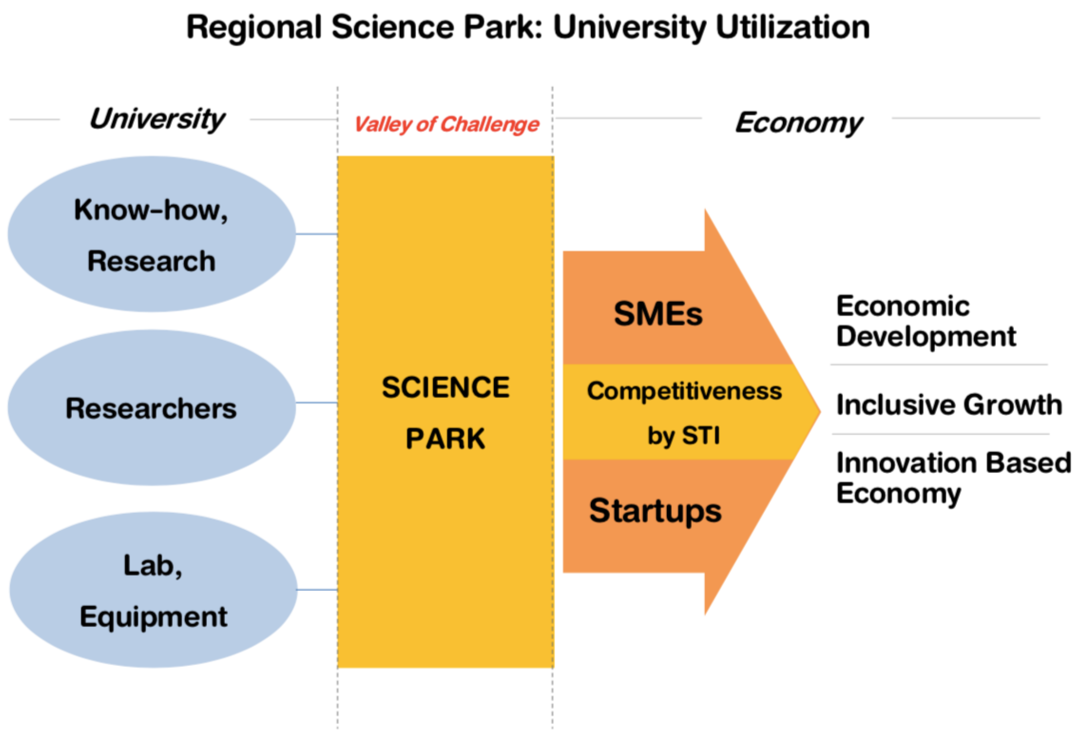

Figure 3.1 Concept of three regional science parks (Anantana, 2019).

The five areas of activity that science parks are engaged in are: (1) provision of human resources and R&D activities; (2) provision of space and facilities for R&D; (3) establishment of knowledge linkages among private sectors, the government, academia; (4) support and encourage innovative businesses; and (5) provision of professional management of science, technology, and innovation. Government support to science park development covers provision of incentives; capacity building at science parks; and provision of investment funds for the establishment of the parks.

Figure 3.2 Six regions in Thailand (photo by Asst. Professor Dr. Steven A. Martin).

Government incentives for promoting science parks comes in the form of tax privileges covering all actors participating in the parks, including tenant firms and researchers who invest in start-ups in the parks. Incentives are also provided to support collaborative projects between on-park firms and educational institutes, talent mobility between research centres, private sectors and government agencies; accommodate guest researchers working in the parks by providing visas and work permits. Incentives are also provided to encourage the service of science and technology, such as laboratory, testing centers, equipment, and services in the parks.

Capacity building support for science parks has focused on programmes for developing management and human resources; for promoting research and development initiatives; and for addressing issues about prototype and plant scale as constraints on the innovation and commercialization activities of tenant firms.

Science parks are established upon initial government funding with the aim to lay the foundation for creating a platform for the development of a triple helix network for promoting interaction between knowledge players from academia, industry and government. According to the science park development plan, during the first five years, investment in the development of infrastructure would be managed by the government. During the subsequent five years, government investment would be reduced as science parks would be expected to generate income from their activities. Ten years after establishment, science parks would be expected to engage in joint venture arrangements instead of relying on government funding. This investment plan, however, assumes that science parks, once established, would be effectively and efficiently managed to be innovative and competitive players. It is the task of this study to find out if there is any evidence that would give credence to this assumption.

3.2 Factors influencing distribution of science parks across Thailand.

In Thailand, the distribution of science parks is regional. The regions can be profiled according to population distribution, and the shares of the regions into the total GDP, total employment and the total amount of R&D investment in Thailand.

Figures 3.3, 3.4, and 3.5 below show the distribution of population, GDP and R&D investment across the different regions in Thailand.

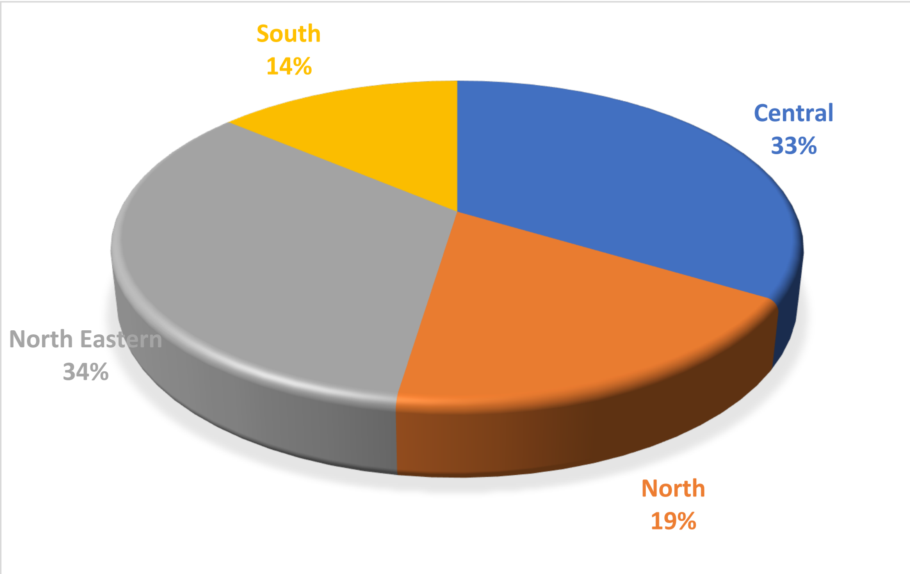

Figure 3.3 Population profiles by region in 2007

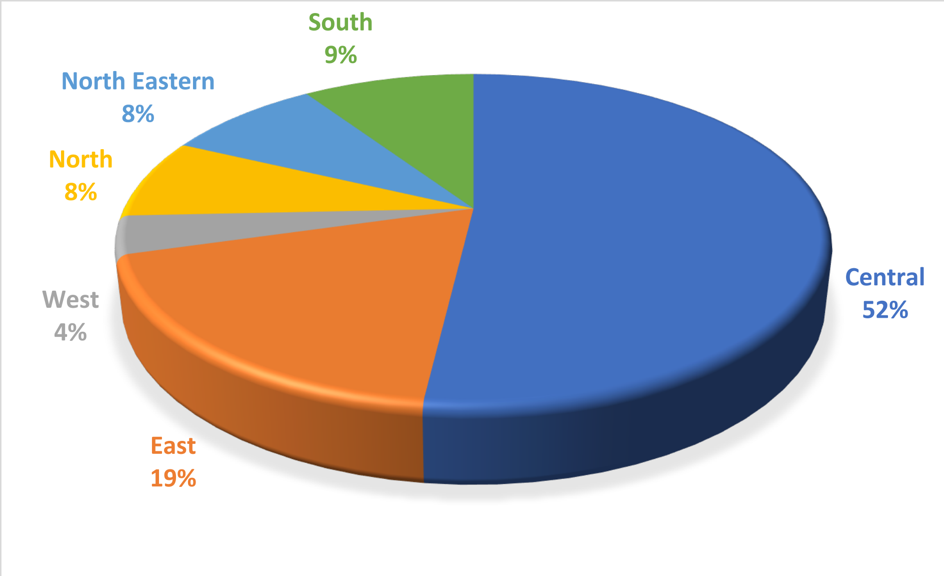

Figure 3.4 Gross domestic production profiles by region in 2007

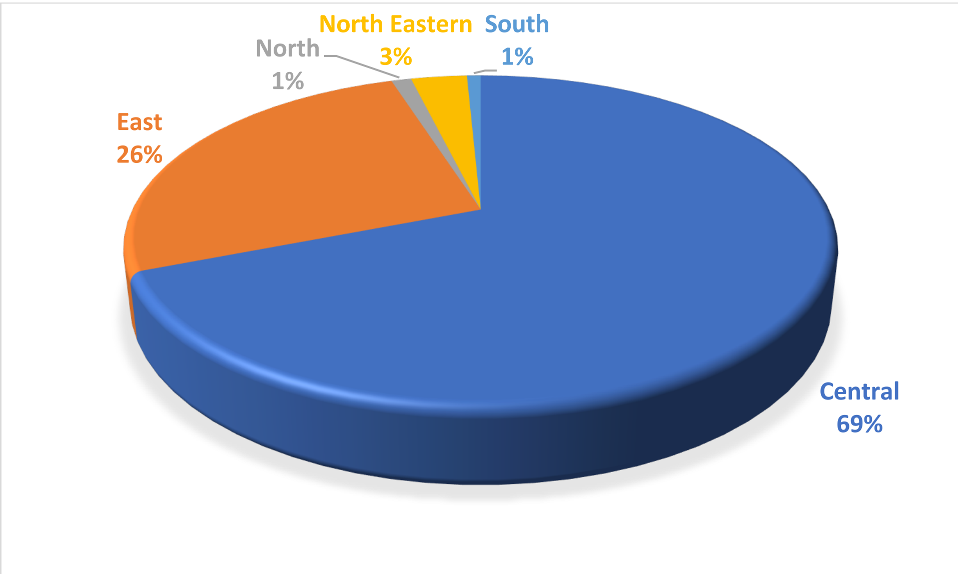

Figure 3.5 R&D investment profiles by region in 2007

The economy of the country depends on agricultural and industrial activities. Each region is different from the other in terms of climatic conditions, and endowment of local knowledge and natural resources. Science parks established in each region are based on the resource endowments of the regions, and on cooperation among universities, research institutes, a government agency.

3.2.1 The Central part

The central part around Bangkok is where the main economic activities in Thailand takes place. TSP is located in this part of Thailand. The economic structure in this region is dominated by manufacturing activities in which the plastic industry, electronic industry, engine industry catering for rice plantations, play a major role.

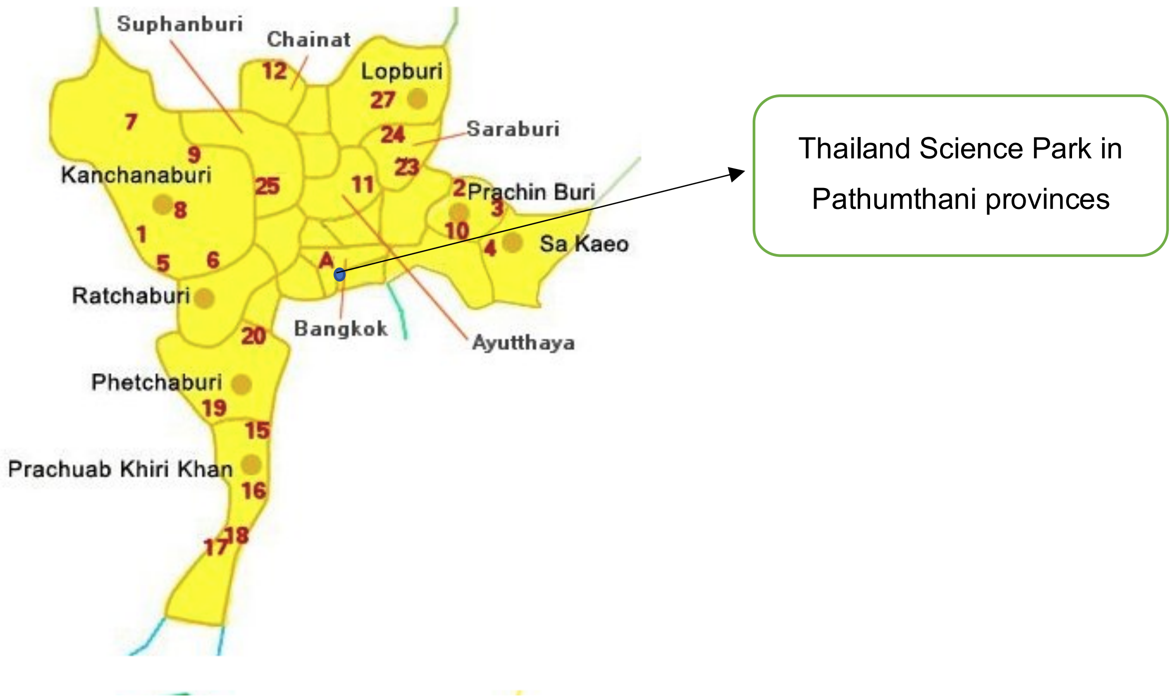

Figure 3.6 The Central Part of Thailand
"27 national parks in central Thailand" (https://blog.daum.net/thaistart/18311539) by Taecho's Thai Info is licensed under CC BY-NC-ND 4.0

Although TSP is the oldest science park in Thailand, its tenant firms have been lacking in the creativity to design new products worthy of IPRs (Science Park Promotion Agency, 2017) . The quality of agricultural products has not yet attained the level of global standards; and productivity is low because of lack of knowledge, business plan, and research and development projects that would have a transformative influence on irrigation system (Science Park Promotion Agency, 2017). TSP was established to provide the platform for cooperation among government agencies, academia, and private sector agencies. There are over one hundred institutes of education across the central region. However, there is as yet no strategy that would allow these institutions to be effectively involved in innovative activities through collaboration with business and industry.

3.2.2 The Northern part

The northern part of Thailand, including the Chiangmai province where the NSP is located, borders Myanmar and Laos. The climate is of tropical savanna type with milder winter than in other parts of Thailand. There are seventeen provinces across the northern part, of which Chiangmai is the largest.

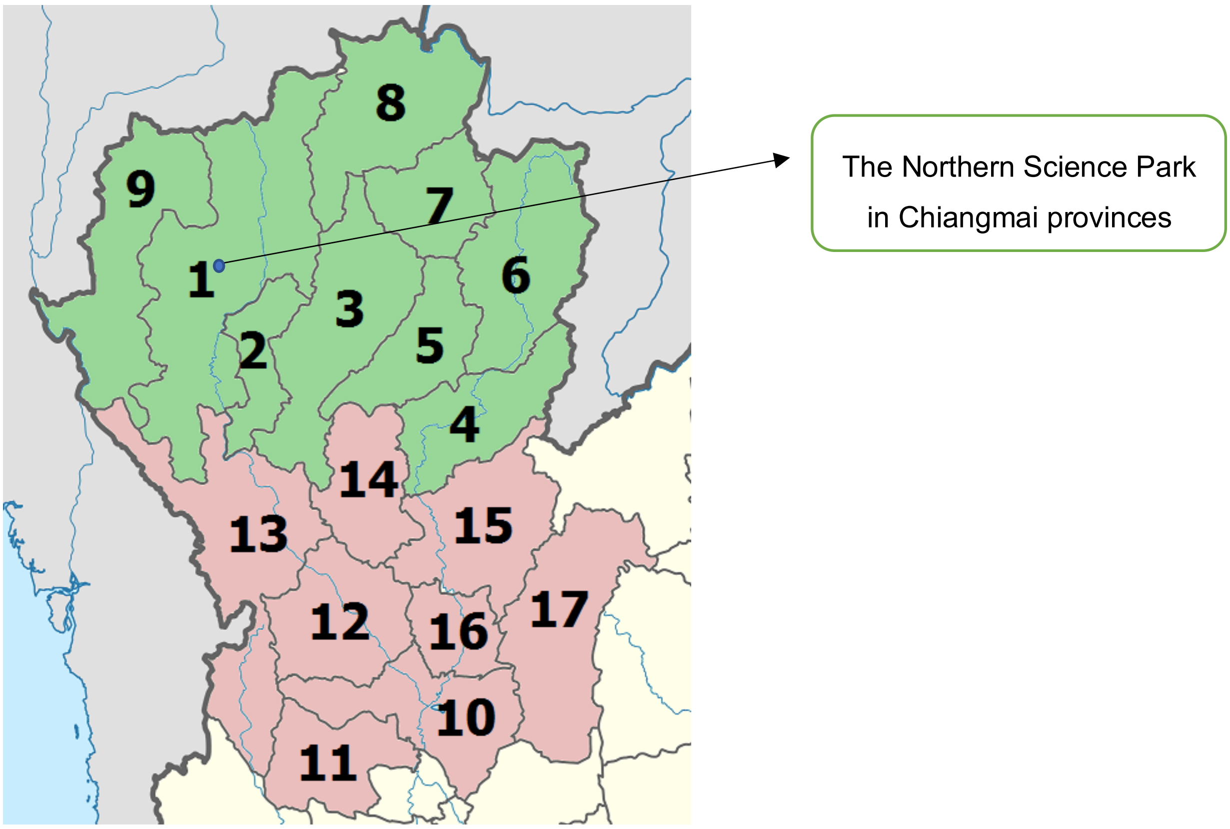

Figure 3.7 The Northern part of Thailand
“Upper and Lower Northern provinces of Thailand” (https://en.wikipedia.org/wiki/Northern_Thailand#/media/File:Thailand_Upper_Lower_North.png) by Paul_012 is licensed under CC BY-SA 3.0

The economy of Chiangmai thrives largely on agricultural and manufacturing activities, and on tourism. Rice and herbs constitute the main agricultural products. The major manufacturing activities are electronics and agricultural process industries, which occur in many of the provinces in the Northern part. One of the major concerns of policy in the region is enhancing the competitiveness of these activities through, for instance, improvements in product efficiency, cost reduction, yield increase per unit area, product validation, and development of a variety of products. The policy response to this challenge has been addressed through the establishment of NSP with the understanding that the widespread application of scientific knowledge to production would enhance productivity and growth.

In the Northern part, there are fifty-six institutes of higher education. Chiangmai university is the largest and the most popular; and it is in this university where NSP is embedded. Most of the universities in the region are linked with firms on knowledge networks through, for example, research consultancy schemes, product analysis, matching funds, co-research programs, and incubation programs. The target industry in the Northern area is the creative sector, such as information technology, software and application, digital, and ceramics. Ago-industry and food processing industries are next on the line of priority of the region's development strategy, followed by rice, tourism, and medical and health-related industries.

3.2.3 The Northeastern part

The Northeastern part is a region in Thailand endowed with rich biodiversity, including endemic species, especially valuable hardwood trees. Agriculture is the most critical sector of the economy. Major agricultural products include Jasmin rice, sticky rice, sugarcane, cassava, silk, and rubber. These local agricultural products provide the throughput for manufacturing and processing industries producing such products as sugar, and alternative energy derived by transforming cassava into ethanol. Most enterprises are of medium and small-scale type. The region is also active in collecting and distributing products across the country.

Agriculture and the industrial sectors in this region are known to have problems, such as low yield of production, insufficient reservoirs, weak irrigation systems, high acidic soil that has bearing on rice breed, and the standard of Jasmin rice (Science Park Promotion Agency, 2017). In the circumstances, it is thought that implementation of science and technology-based knowledge would help improve the quality of products and their competitiveness in the global market.

There are fifty-seven institutes of education in this region; Khon Kaen University is the leading university where the Northeastern Science Park (NESP), which started full operation in 2019, is located.

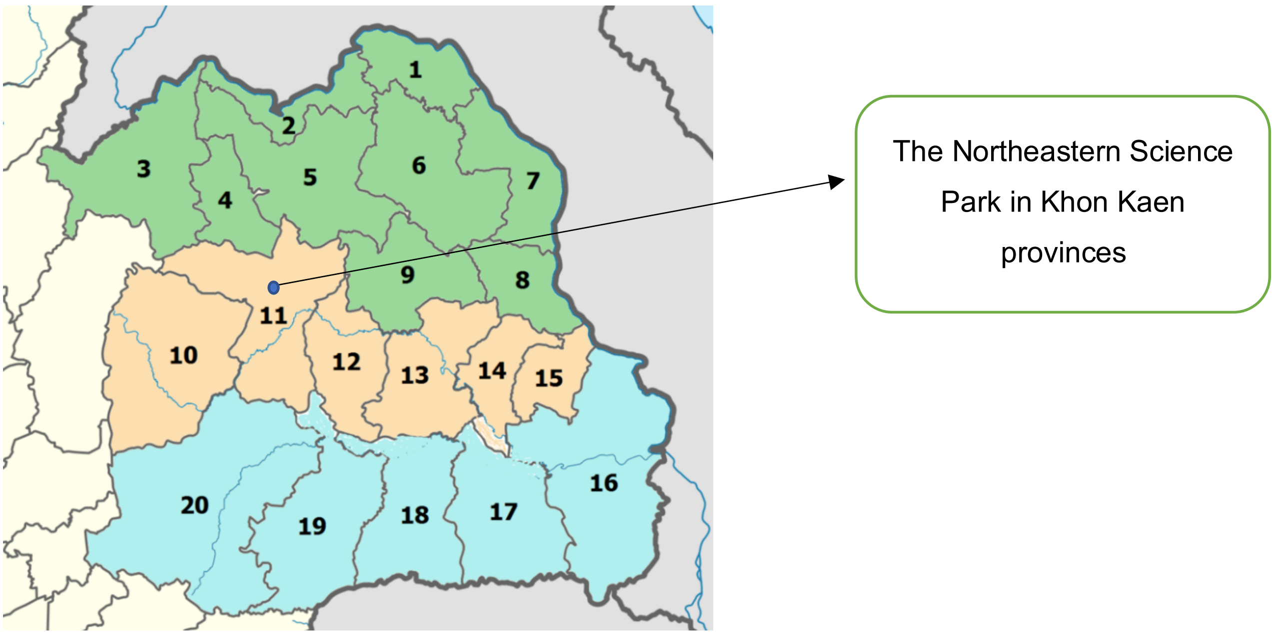

Figure 3.8 The North Eastern part of Thailand
Modified from "Northern Thailand according to the four-region grouping system" (https://en.wikipedia.org/wiki/Northern_Thailand#/media/File:Thailand_Upper_Lower_North.png) licensed under CC BY-SA 3.0

NESP has an incubation program and has its focus on the processing industry (particularly food and beverage), medical and health, technology and information industry, electronics, rice, and sugarcane and cassava.

3.2.4 The Southern part

The southern part is geographically the narrow and long peninsula of Thailand. Its economy is based on tourism, palm oil, rubber, coconut, tin mining, the seafood industry, and halal industry. The region has fourteen provinces; and the Southern Science Park (STSP) is located at Prince Song Kha University in the Song Kha province.

The southern park is established to cater for the effective exploitation of the natural resources of the region through the development of knowledge-based enterprises that have the technological capability of resolving the problems firms encounter in plant propagation, harvesting, and maintaining high quality standards in the processing of palm and rubber products, and seafood products. The concept of science park establishment in the south is aimed to support firms overcome problems that would impair the price and quality competitiveness of products in the global market.

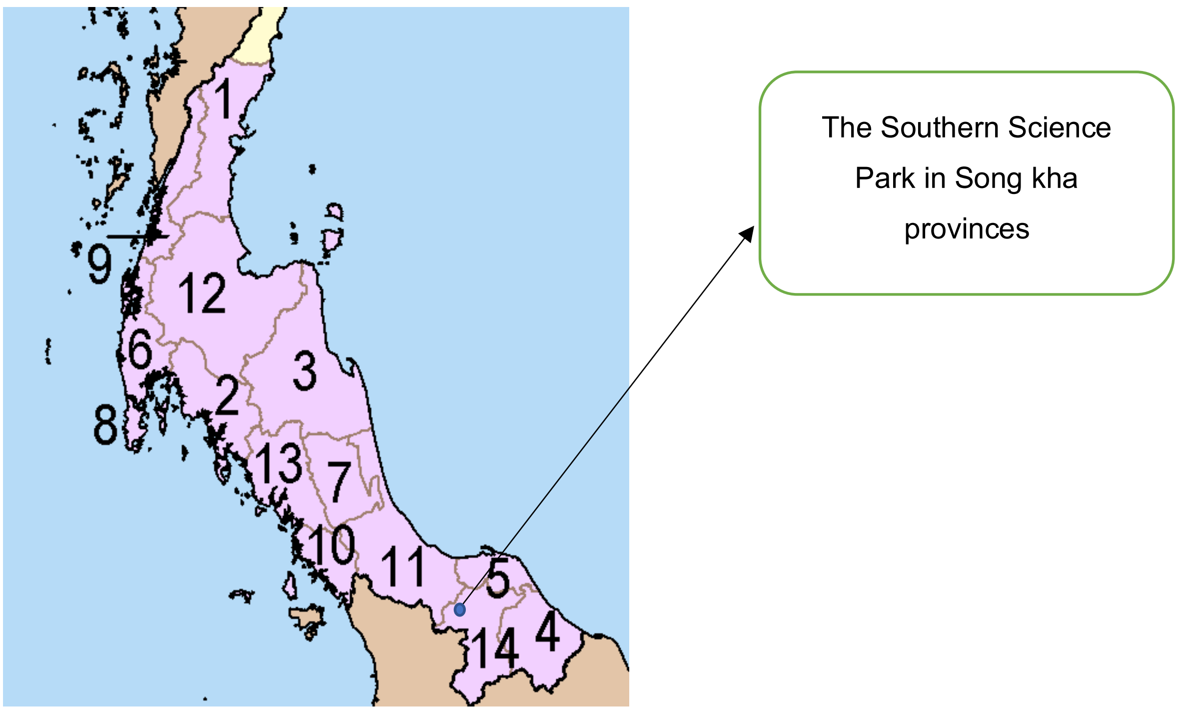

Figure 3.9 The Southern part of Thailand
Modified from "Northern Thailand according to the four-region grouping system" (https://en.wikipedia.org/wiki/Northern_Thailand#/media/File:Thailand_Upper_Lower_North.png) licensed under CC BY-SA 3.0

There are forty-four institutes of higher education in the southern region. Prince Song Kha University, where the science park is planned to be established, is the leading university in the region with the educational and research capabilities that would make it attractive for government and private sector agencies to forge cooperative arrangements with it as its research and educational environment offers the potential for the development of innovative enterprises. Major areas of industrial activities in the region include information technology and communication, the manufacturing of rubber and palm, processing of seafood and halal products and manufacturing of medical equipment.

3.3 Major players in science park development in Thailand

This part brings to light the major players in the development of science parks in Thailand.

3.3.1 Planning and policy agencies

Several government agencies closely related to the formulation and implementation of science, technology and innovation policy were involved in the development of science parks in Thailand. Chief among these are the Office of the National Economic and Social Development Council (NESDC); the Office of National Higher Education Science Research and Innovation Policy Council (NXPO); and the National Research Council of Thailand (NRCT). The Prime Minister of Thailand is the chairman of the Board that brings together these agencies to work on issues relating to technology policy and draw up plans and strategies for the short term, medium term, and long-term periods. The major problem envisaged is not so much in the development of plans and policies but in their implementation of these, which is contingent on the provision of adequate funds through the budget system. Budget allocation for science, technology and innovation projects and programmes has not been consistent, and budget shortfalls have been a major challenge for the development of science parks in the country.

The Science Park Promotion Agency (SPA) was established to address the responsibility of developing plans and development guidelines for science parks by reviewing and evaluating their performance on regular basis and developing science park strategies in collaboration with government and local private sector agencies. SPA is also engaged in providing consultancy to stakeholders of science parks and in coordinating the stakeholders to form a collaborative network.

3.3.2 Science park developers

As noted above, the key players involved in the development of science parks include universities, government agencies and private sector agencies.

3.3.2.1 Academia

Universities are where knowledge is produced through education and research and development. Science parks are often established near universities to exploit the facilities of universities and the research capabilities of their academic staff members. Co-research programmes between academic researchers and firms are coordinated by science parks. Where there is collaboration between universities and private sector agencies, there is scope for the development of new products. This is supported by the Government insofar as it is considered to be a crucial initiative for increasing the growth of competitive firms. The Government of Thailand has subsidized universities for infrastructure and facility development, and also for promoting programmes of co-research between academic staff and industry counterparts through, for example, the creation of academic positions for industry staff.

3.3.2.2 Government agencies

The Government is primarily interested in the establishment of science parks as a strategy for transforming the economy through the application of science, technology, and innovation to production systems. This would oblige it, among other things, to commit adequate budget provisions to support science parks on regular basis, as well as adopting policy instruments, including, for instance, tax reduction, incentives, government procurement, patent application, talent mobility, for stimulating firms to engage in innovative activities.

3.3.2.3 Private sector agencies

Privates sector agencies, particularly industry and business enterprises, are significant players in triple helix functions. The success of science parks is measured, among other factors, by the survival rate of tenant firms independent of the support of science parks. How to persuade firms to locate in science parks as tenants is a primary task of science park management. Increase in the number of firms in parks would increase the chance of collaboration between firms with a wide range of experiences that are actively participating in the parks.

3.3.3 Supporting and encouraging research and development agencies

Agencies that provide support to the activities of science parks play a major role in the development of science parks. Such agencies are responsible for coordinating, supporting, implementing, and facilitating the operation of science parks. As well as providing benefits and incentives to firms actively participating in science parks as tenants, they also play a crucial role that helps increase the number of tenant firms by persuading off-park firms to choose to locate in science parks. The Board of Investment (BOI) is one of these supportive agencies in Thailand providing benefits and incentives in the form of funding to firms that would be prepared to invest in research and development within the purview of science parks. The Revenue Department also provides incentives in the form of tax reduction on account of the research and development expenditures of tenant firms. Other agencies that provide funding support for the development of research include: the National Innovation Agency (NIA), Thailand Science Research and Innovation (TSRI), National Science and Technology Development Agency (NSTDA), and banks and mutual funds. These agencies provide support to science and technology related projects in the form of free grants, low-interest loans, investment funds and contribution funds.

Also, agencies like the Management System Certificate Institute (Thailand), the Thai Industrial Standard Institute (TISI), the Department of Science Service, the National Bureau of Agricultural Commodity and Food Standards, and the National Food Institute, play a crucial role in creating product quality standards and validity that would be acceptable in the global market.

In addition, agencies such as the Department of International Trade Promotion (DITP), the Department of Intellectual Property (DIP), the Department of Business Development (DBD) play significant roles in servicing marketing information, encouraging exports and services, and prospecting new markets.

3.4 Current situation of Northern Thailand Science Park (NSP)

NSP was established under the regional science parks programme approved by the Government of Thailand in May 2012. The Government of Thailand agreed to have Chiang Mai University to be at the helm of the management of the Park, involving six other universities in the Northern area: Maejo University, Mae fah Luang University, University of Phayao, Naresuan University, Uttaradit Rajabhat University, and Pibulsongkram Rajabhat University. NSP receives funding support from the Office of the Permanent Secretary of Higher Education, Science, Research, and Innovation through the Science Park Promotion Agency as a liaison body.

Figure 3.10 Landscape of the NSP (Anantana, 2019).

NSP engages in providing the infrastructure needed for education and research in the area of science and technology and for the application of knowledge accruing from these to industrial development. The infrastructure is provided in the form of platforms. There are five service platforms operating in the NSP: science park services; science, technology and innovation incubation; industrial research and technology capacity development platform (IRCT); collaborative research; and science, technology and innovation infrastructure. These are briefly discussed in the following parts of this section.

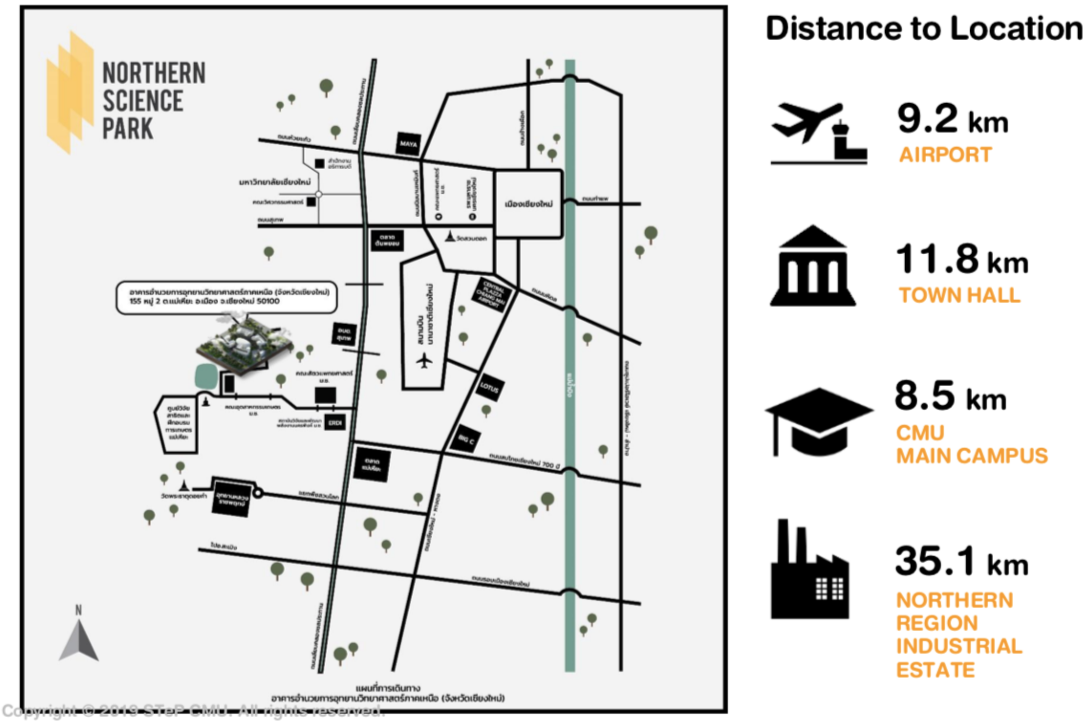

Figure 3.11 Strategic location (Anantana, 2019).

3.4.1 The Science Park Service Platform

This park service platform is provided to tenant firms to help them to meet the essential business infrastructures. The platform's emphasis is on the development and readiness of human resources; the provision of equipment and facilities; and the promotion of worthwhile utilization of existing infrastructure in universities.

Laboratory service is one of the services provided under this platform which also provides consultancy for testing, testing services, and equipment and facilities services for researchers. For instance, 11 laboratories across six member universities of the NSP were used over 250 times in 2019 (Northern Thailand Science Park, 2019). This relates to the smart material laboratory for construction industry at Chiangmai University; the HPLC laboratory, the analysis of residue in pesticide unit and the microbiology laboratory at Maejo

University; the centre of excellence for innovative products at Maefhalaung University; and the laboratory for cosmetic, medicine and food implements at Naresuan University.

Innovation design center is another service in this platform. It provides services relating to publicizing businesses, marketing, and providing consultancy for the design and development of products. There are five main missions to the innovation design centre: design for development, design for value adding products, design for innovation, design for business organisation, and design for community relations. In 2019, there were a total of 438 designs: 21 of product designs, 133 of package designs, 137 of information designs, 81 of logo designs, and over 60 other designs (Northern Thailand Science Park, 2019).

Intellectual property rights (IPRs) management is the third service of this platform. The service is aimed to enable tenant firms to attain recognition for their creative and innovative efforts by providing the mechanisms for commercializing their innovated products. The service on this platform also encourages increased cooperation and collaboration between businesses and researchers from academia. It is this collaboration that is promoted at science parks to enable tenant firms to evolve as innovative and competitive global players. The service covers consultancy, document registration, patent acquisition to commercialize products widely, and business negotiations. There were 546 consultancy events about patent registration, 314 offers for intellectual property protection, and 80 pieces of research outputs put through for commercialization since establishment of the Park (Northern Thailand Science Park, 2019).

Science and technology infrastructure databank (STDB) is the fourth service of this platform. It provides 24 hours of searching to update science and technology information from recognized sources; and, as such, it acts as a centre for collaboration among researchers. The databank covers information about researcher profiles, research portfolios, publications, science and technology instruments, and laboratory facilities.

A fifth service on this platform is provided by the office of industrial liaison. The office of industrial liaison plays the role of delivering and receiving cases to and from appropriate service units in the NSP.

3.4.2 Science, Technology and Innovation Incubation Platform Service

The aim of this platform is to strengthen firms to achieve business competitiveness through incubation programme. Firms qualifying for this platform service are legal entities and are knowledge-based; and would be expected to have business plans. The platform has three categories of processes: pre-incubation, incubation, and acceleration.

Pre-incubation involves assessment of firms aimed at identifying if they have the potential to grow and survive in competitive markets. This could help firms seek other business models should they discover that their initial business model is prone to high business risk. The incubation process can reduce the rate of business failure of firms particularly during the early phase of the life of firms, following their establishment. Acceleration is the process of firms achieving fast success. This process enables firms to grow fast and be competitive by making use of the multi-services, infrastructure, business environment, human resources, knowledge linkage, and facilities for funding and market access provided by parks like the NSP.

Table 3.1 Process of business incubation platform (Anantana, 2019).

PRE-INCUBATION	INCUBATION		ACCELERATION
• Idea generation	• Product/ Process/ Design improvement	• Branding	• International market expansion
• Technology identification	• Certification	• Business & Growth assessment	• Product/ Process/ Design improvement
• Concept definition/ Concept prototype	• Product launch	• Training & Networking	• Business support networking
• Entrepreneurship	• Business plan	• Production expansion	• Fund raising
• Awareness and development training	• Fund raising	• International networking	
• Skill set development training	• Patent/ Trademark		
• Business canvas			
Entrepreneur with Brief Business Plan	Business Plan High Value SMEs + Start-ups		Ventures Growth (VC) or Venture Exit (M&A)

NSP manages the incubation programme taking into consideration firms' readiness, business models, capacity and capital costs. However, all firms are provided access to incubation services, including working space with convenient facilities such as meeting rooms, training rooms, central printing, copy machines; technology consultancy services such as expert advice, testing services, laboratory facilities and research support. Business consultancy is provided to help firms find niche markets. Access to funding is contingent on the delivery information of funding sources, both venture capital and business matching, through the funding institute created to support businesses in this respect. Packaging and branding of incubated products benefit from the provision of consultancy aimed at enhancing the market appeal of product designs and brands.

The incubation programme is conducted over three years; and firms are evaluated for their success by considering their business plans, particularly with respect to sales turnover and the profits that accrue to the firms. Since the establishment of the NSP, 171 firms have participated in the programme, creating 615 jobs deriving from total investment value of over £2.5 million (Northern Thailand Science Park, 2019).

3.4.3 Industrial research and technology capacity development (IRCT).

Forging university-industry linkages (UIL) is one of the ways for technology and innovation development. To equip firms to be competitive, the NSP has a platform for industrial research and technology capacity development (IRCT). In addition, IRCT is one of mechanisms used for raising the level of research and development capacity to enhance the science and technology support provided to firms. As such, the IRCT platform is expected to impact firms to be innovative and competitive. The IRCT is reported to have created 72 projects in 2019 (Northern Thailand Science Park, 2019).

It was found that firms with initial round experience on the IRTC platform would prefer to be on the platform for another round (Northern Thailand Science Park, 2019). The platform creates opportunities for firms to engage in co-research programmes with other companies and use the services of the NSP, such as the innovation design center, and its laboratory services. Similarity, some firms can develop core technology for further commercialization by spinning-off to set up new companies. This is known to have the effect of drawing more and more tenant firms in the park to participate in knowledge sharing activities, thus giving credence to the usefulness the IRTC platform.

Figure 3.12 Examples of firms participating in IRTC platform (Anantana, 2019).

3.4.4 Collaborative research programme (co-research).

The Collaboration Research Programme is designed to stimulate tenant firms conduct research with university staff on the NSP network, given the readiness of universities in terms of adequacy of human resources, knowledge base, research facilities and access to funding support through the park. However, for firms to be able to join this platform, they must have in-house R&D, research personnel, and funds earmarked for R&D. Participating firms would be allowed to use university space and facilities to conduct research. This arrangement is supportive of talent mobility among instructors, researchers and graduates in the course of promoting co-research and the sharing of research experiences between research communities and business and industrial communities. In this respect, the Park is playing a role as an intermediary for the development of a triple helix knowledge network and as a platform for activities that would lead to open innovation.

The co-research platform is a flagship programme of the Northern Science Park, which is dedicated for agro-industrial research based on such products as rice, vegetables, fruit, and herbs. It also covers research on Information technology and digital content industry, medical and biotechnology industry, and renewable energy technology and environmental issues. The programme is supported as innovative initiative by government policy that was launched as ‘Thailand 4.0’ in 2017.

Since the establishment of the Park, a total of 41 private sector firms have joined the platform on which 46 research projects have been adopted. The total value of joint research project conducted on the park since establishment amounts to over £3.5 million; and the project has created employment for over 60 persons (Northern Thailand Science Park, 2019).

3.4.5 STI infrastructure management.

Yet another platform created in the Park is dedicated for the management of STI infrastructure. This platform is aimed to promote efficiency and, through this, to support the four main platforms in the Park: the science park service platform; the science, technology and innovation incubation platform; the industrial research and technology capacity development platform (IRTC); and the collaborative research platform. The mechanism of this platform aims to assist and promote innovation initiatives in the Park among start-ups and small, medium and large scale enterprises (SMLs). These participants are essential actors the driving innovation ecosystem in which the science park plays an intermediary role supporting tenant firms to have access to research-based knowledge from universities and funds and incentives from government agencies. This platform provides the services of STI infrastructure, matching business and funding service, and provision of space and essential support facilities.

3.5 Conclusion

This chapter has presented the development of science parks in Thailand since the first park was established in 2002, and the other three regional science parks were set up in subsequent years in different parts of the country. It has reviewed the emergence of science parks in Thailand, including the objectives of setting up both TSP and regional science parks, to set the background to the empirical analysis of questions as to how effectively established science parks like NSP serve as a platform of services to their tenant firms. The chapter has also highlighted the significance of regional science parks for the economy of the regions where they are located – i.e. the northern part; the north eastern part; and the southern part. Each region has its own characteristics deriving from the specificities of its resource endowment. The regional science parks were set up to encourage the development of enterprises that would exploit the resource potentials of the regions. It is against this policy context that the effectiveness of the NSP in promoting the emergence of innovative and competitive enterprises is explored in this study.

The next chapter sets out in detail the method for testing the hypotheses of the study.

CHAPTER 4

RESEARCH DESIGN AND METHODOLOGY

This chapter discusses the research design and methodology used in exploring data from the survey of a target population of on-park firms. The study is based on the mixed-method approach, which combines quantitative and qualitative methods. The data was obtained from resident firms in the NSP and involved administration of a questionnaire and face-to-face semi-structured interviews with open-ended questions. The survey questionnaire was conducted with the objective of capturing insights from management of the firms. The face-to-face interview consisted of open-ended questions to elicit detailed qualitative data relating to the pattern of the behavior of firms as science park residents. Many public policy documents, reports, and other relevant documents were reviewed and utilized as information sources to create the questionnaire.

The chapter is divided into the following six sections: the first one briefly sets out the context for the research. The second section discusses the research hypotheses. The third section is devoted to the discussion of the research design, including that of the survey questionnaire and the framework of the face-to-face interviews with tenant firms of various categories and with the Park's management team. The fourth section describes the survey process in the course of data collection. In the fifth section, the question of data analysis, the statistical techniques that would be used for investigating evidence from the survey data are discussed. The sixth section concludes the chapter highlighting the conceptual and practical problems that limit the robustness of survey data, the method of analysis, and the significance of the findings deriving from the data analysis.

4.1 Setting context for the research

The study aims to explore evidence on how science parks perform in promoting and supporting their tenants to be innovative and competitive. This study used a mixed-method approach based on quantitative and qualitative methods. This involved administering a questionnaire and conducting face-to-face interviews. Most of the data were obtained from the administration of questionnaires, while the interviews aimed to acquire in-depth information about the firms and their requirements for support. The questionnaire explored a cross-sectional view, while the face-to-face interviews addressed a longitudinal view. Both these approaches are widely applied in the study of social sciences because of their respective advantages.

The ability of the basic eco-system in science parks to generate innovative ideas and to promote reasonably knowledgeable activities among tenant firms is widely documented, as shown in the chapter on literature review (Minguillo, Tijssen and Thelwall, 2015; Squicciarini, 2008; Carayannis and Mike, 2007; Siegel, Westhead and Wright, 2003; Lai and Shyu, 2005). The empirical aspect of this study is based on the case of the NSP in the north of Thailand, which was established as Thailand’s first regional science park in 2014. The objective of this establishment was to provide support to local firms through the provision of soft services such as funding and knowledge linkages that would help boost their technological marketing prowess as emerging enterprises. The NSP started as a small office at the Faculty of Engineering at Chiangmai University specifically geared to providing administrative support to local firms. The building, infrastructure, and facilities of the park were completed by the end of 2017, and services were initially offered in the form of space for rent at the beginning of 2018. A total of 22 firms decided to locate in the NSP; all of them receive a variety of support services that would presumably help them evolve as innovative and competitive enterprises.

The Thailand Science Park (TSP) in Pathumthani is not covered in this study as management of the Park was not willing to cooperate with the proposal to survey the experiences of resident tenant firms. The NSP is smaller in scale and younger in age than the TSP. The inclusion of the latter would have helped as a comparative basis to show the performance of science parks elsewhere in Thailand with respect to the task of providing support to local firms, particularly in terms of provision of soft services such as access to funding and knowledge and market networks.

There is to date no conclusive evidence to show that as STI policy instrument, science parks constitute the necessary and sufficient support that would help tenant firms to become innovative and competitive in their market performance. Nor is this study an attempt to settle this question. Indeed, limited by the nature of the data solicited from the resident firms based on their one-year experience in the park, the focus is on how resident firms perceive the variety of services offered by the park would possibly influence their pursuit to emerge as innovative and competitive players. Perceived improvements in innovative performance would imply the extent of technology awareness induced by the services provided by the science park, while perceived improvements in competitive performance have implications for awareness of market opportunities. The responses of firms to the services of the park would be expected to vary, with some inclined more to technology awareness; others inclined more to market awareness, and some inclined to a balanced view as between technology and market awareness. This is essentially an empirical question, which is better investigated in the light of the experiences of the resident firms and the nature of the wider industrial and market eco-systems they relate to.

Because the Park has been operational for no more than a year, there has been no research on how tenant firms feel about the services offered by the Park, and on the benefits, they expect to derive from these services. Therefore, this study is more of behavioral research in expectation. In this respect, the data sought are meant to serve the following purposes of the study:

- to obtain general information about the firms located in the NSP, including age of establishment; their on-park experiences; the scale of their businesses in terms of employment and capital value and their role in the business sector they come from;

- to determine the reasons why the firms choose to locate as tenants in the NSP; and what sort of support they expected when they decided to locate in the NSP. This information is useful to determine whether different types of firms (categorised by age, scale, sector, capital costs) would need different types of support;

- to understand the perception of firms about the support services in the NSP, and to solicit if they feel that the NSP would help them in their effort to emerge as innovative and competitive enterprises;

- to investigate the various aspects of the response of tenant firms to the services provided by the Park - for example, the types of R&D expenditure; the purpose of engagement in R&D investment; factors firms feel would prevent innovative activities; frequency of participation in activities involving universities and public research institutes;

- to empirically determine the relationship between the support provided by the NSP as innovative inputs (i.e., human resources, infrastructure and facilities, knowledge linkage, funding, and market opportunities), and the potential for innovative performance as perceived by tenant firms. This involves application of ordinal logistic regression, in which perceived innovative performance is explained independently by the five categories of support services firms receive while in the park. The aim is to determine the park services that are significant in their influence on the perceived innovative performance of resident firms;

- to explore the factors underpinning the triple helix mechanism of science park functions involving the generation and application of new ideas as well as their commercialisation and diffusion; and

- to explore using SWOT analysis areas of strengths, weaknesses, opportunities, and threats for the development of regional science parks in developing countries, in general, and in Thailand, in particular.

To this end, the method of investigation involves the following tasks.

- to draw up a questionnaire to be administered to all the tenant firms in the NSP. The questionnaire is designed to elicit general information about the tenant firms, such as how long they had been established at the NSP, capital costs, size of the business, and business sectors; and to enquire why the firms chose to participate in the NSP, the benefits they have derived from park services, and their recommendations for improving science parks;
- to conduct face-to-face semi-structured interviews with firm management to elicit their expectations from the NSP and how they have been supported. Ten questions were prepared as a guideline for an in-depth interview focusing on the system of the triple helix network that underpins the operation of the NSP to use the information obtained through the questionnaire administration and interviews in an analysis that seeks to bring out the strengths, weaknesses, opportunities, and threats underlying the operation of the NSP; and how weaknesses could be translated into strengths and threats into opportunities. This would help not only in developing strategies for the development of the science park but would also provide lessons from the firms' experiences, which would be useful for the future.

4.2 Setting the hypotheses of the research

The following points emerge from the discussions in Chapter 1 – 3:

- Science parks are supposed to play an important role in facilitating and supporting tenants to be able to develop products and commercialize them;
- Science parks are usually located near universities to be able to have to the vital resources, including R&D expertise, research-based knowledge, technology, and experimental equipment;
- Triple helix networks underlying the system of science park operation provide opportunities for creative collaboration between participants from government, university, and business and industry sectors. Government provides funding as well as regulatory and control mechanisms and policies; universities are the sources of specialist knowledge and as such they can be considered as knowledge producers; and business and industry in the private sector use knowledge for wealth creation;
- NSP is the first regional science park in the north of Thailand. Another two regional science parks in the Northeastern and the South of Thailand are under construction. Prior to the establishment of regional science parks, the national science park was established in 2002 near Bangkok. Firms in this park are not included in this study because the park management were not willing to be covered in the survey conducted for this research project.

Based on these points, the following hypotheses are proposed for empirical investigation in the light of the experiences of tenant firms in the NSP.

H1: Science parks are effective in their mission as cradle of innovation when the services they provide are of the type that would assist tenant firms to be creative in developing their inputs and outputs;

H2: Firms with varying attributes and characteristics are likely to have varied perception about the benefits to be derived from the support services offered to them by science parks;

H3 The existence in science parks of a properly functioning triple helix network provides the social capital that is crucial for the ability of tenant firms to transform the services the Park provides into innovative outputs, including product development, market development, cost reduction and intellectual property or patent rights.

H4: The decision of firms to locate in science parks is driven by the belief that triple helix-based science park services, properly administered by parks and properly received by the tenant firms, would trigger the innovative and enterprising potential of firms to be realised.

4.3 Research Design

As noted above, the study focused on a survey of tenant firms located is the NSP. The survey involved administration of questionnaires to all 22 firms in the Park and face to face interviews with representatives of the firms. The aim of the survey is to explore the experiences of firms since they have been supported with a variety of services the Park provided as a resident. The survey also explores the views of the NSP tenants on the adequacy of the support they obtain from the Park to innovate, scale up and commercialise, and on the opportunities the Park offers them to engage in a triple helix-based system of knowledge exchange and knowledge transfer.

The 22 firms that populated the Park in 2018 came from various business sectors, such as energy, design experience, food and agriculture, herbs and cosmetics, software and applications, material science, and medical devices. The survey was designed to generate data that would be analysed using the mixed method involving both quantitative and qualitative approaches.

The quantitative analysis was conducted using a five-point Likert scale, which categorically measured the perception of the firms regarding the significance and relevance of the support services offered to them by the Park. The Likert scale was also used to investigate the reasons for participation of the firms in the NSP; the intimacy of the firms with the innovative transformation model; and the extent of their engagement in innovative activities.

The qualitative analysis was based on information deriving from the semi-structured interviews. The face-to-face interview involved ten questions which explored in-depth the opinions and experiences of the NSP firms regarding how they were supported by the NSP. These ten main questions were designed to bring out information that would complement the information elicited by the survey questionnaire. Also, interviews were conducted with the NSP management team to elicit information about problems regarding administration of support services, and about strategic plans to improve the effectiveness of the science park in supporting and encouraging their tenants to be innovative and competitive.

The qualitative analysis was based on information deriving from the semi-structured interviews. The face-to-face interview involved ten questions which explored in-depth the opinions and experiences of the NSP firms regarding how they were supported by the NSP. These ten questions were designed to bring out information that would complement the information elicited by the survey questionnaire. This study applies the methodological triangulation approach involving the use of multiple qualitative methods such questionnaire and semi-structure interviews to collect data on the same topic. The aim is to check and establish the validity in the study. Thus, triangulation not only helps to cross-validate data, but also to capture the different ways in which the same phenomenon is viewed by different observers. While this method is popular, it, however, requires more time to analyze the data.

Interviews were conducted with the NSP management team to elicit information about problems regarding administration of support services, and about strategic plans to improve the effectiveness of the science park in supporting and encouraging their tenants to be innovative and competitive.

Quantitative and qualitative approaches were adopted to explore the innovative performance of the NSP firms to evaluate the role of the NSP in contributing to their effort and desire to emerge as innovative and competitive enterprises. The outcome could be used for informing policy about management of existing science parks and science parks to be established in the future. The design of the methodology for this study is divided into three parts:

4.3.1 Design of the questionnaire

Much of the literature since the establishment of the first science park has focused on the indicators used in the analysis of the performance of science parks by comparing firms located inside and outside science parks – for example, the number of patents, the number of researchers, revenue, total sales, and research and development expenditure (Minguillo, Tijssen and Thelwall, 2015; Squicciarini, 2008; Carayannis and Mike, 2007; Siegel, Westhead and Wright, 2003; Lai and Shyu, 2005).

This study on the NSP tenants is not, however, aimed at a comparison of performance between on-park and off-park businesses, mainly because comparison of like with like is not empirically plausible when the number of on-park firms is low and some of them are new which means they do not yet have any financial and technical reports from which data for key performance indicators can be sourced. In addition, finding similar on-park and off-park firms that can be readily compared proved a rather daunting challenge as sample firms corresponding to a range of business sectors would vary with respect, for example, to scale, age, and capital cost factors. In view of this, the study has had to focus on investigation of the on the 22 on-park firms with aim to bring out their reflections on their experiences in the park in relation to their ambition to emerge as innovative and competitive enterprises. In other words, the investigation would seek to obtain data and information that would provide the basis for indicating the extent to which the support services provided by the NSP have been considered to be in alignment with firms’ expectations for their perceived innovative and competitive performance.

There are 28 questions in the questionnaire are set in five parts. The first part of the questionnaire elicited general information about the firms, such as when they were first established, their business structures, capital costs, size of the businesses and the business sector the firms come from. The second part intended to explore the factors that prompted the firms to locate in the NSP – i.e. how they found out about the NSP, when they joined the NSP, the reasons for their participation, and why they chose to participate in the NSP. The third part of the questionnaire explores awareness of the on-park firms about the parameters of the ‘innovative model’ including innovative inputs, innovative processes, and innovative outputs. The fourth part of the questionnaire asks questions about the innovative activities of firms. In the last part of the questionnaire, firms are asked for their recommendations as to how the management of the science park can be improved. The types of questions varied according to the data requirements for investigating the issues raised by the study. Some of the questions asked the participants to fill in the blanks, some were of the binary type, and others called for multiple answers based on the five-point Likert scale. There were also provisions for alternative answers if none of the options provided elicited a comprehensive response.

4.3.2 Face to face semi-structured interviews the NSP firms.

There are currently 22 firms in the NSP, 11 SMEs, 10 start-ups, and 1 large enterprise. Face to face interviews were arranged with all firms which required permission from the high-level management of the NSP. After approval, the interviews were conducted between January and March 2019. The face-to-face interviews did not take more than one and half hours, including completion of the questionnaires (See the appendix for further details of the arrangements). The interviews were held in a meeting room at the NSP. The interviewees were asked for their permission to allow audio recordings of the interviews. All the interviewees were asked to read the instructions carefully and to sign the participant form before the interviews. The ethics arrangement for conducting the survey is that after use, the interview and questionnaire data and the audio voice recording would be safely stored where they would not be accessed by third parties.

4.3.3 In-depth face to face interviews with the NSP management.

In-depth interviews were conducted with the NSP management team. The information elicited through the in-depth interviews was used for a qualitative analysis of the effectiveness of science parks in nurturing the NSP firms. The interviews explored the system of the triple helix mechanism underpinning the functions of science parks in relation to the generation and application of new ideas as well as their commercialization and the development of knowledge networks to foster knowledge exchange and innovation. The interviews also explored the lessons deriving from the NSP's experiences, and in particular, the areas of strengths, weaknesses, opportunities, and threats for the development of regional science parks in developing countries, in general, and Thailand, in particular.

4.4 Methodology: the survey process in data collection

The empirical aspect of this study drew on the 22 firms currently located in the NSP. Appointments were made with all the NSP firms for conducting face to face interviews and for administering the questionnaires. Permission was obtained from the firms for making audio recording of the interviews. The reason for making audio recording was to ensure accuracy in transcription (Lomer, 2019).

4.4.1 Target firms for the study

The target firms for this study covered all the 22 tenant firms in the Park. The firms are of various sizes and came from different business sectors. All the face-to-face interviews were conducted using a set of ten questions. All the interviews were conducted during the period, January – March 2019.

Table 4.1 shows number of tenant firms in the NSP.

Type of tenant firms	Number	Percentage (%)
Start-up	10	45.45
SMEs	11	50.00
Large enterprise	1	4.55
Total	22	100

Source: Survey data

The questionnaire and interview-based survey covered all the 22 firms on the NSP database.

Table 4.2 Shown the detail of 22 tenant firms

No. of tenant firms	Year of establishment	Business scale	Business sectors	Capital cost* (million baht)
1	1990	SME	Materials Science & Chemicals	5
2	2017	SME	Herbs & Cosmetics / Materials Science & Chemicals / Food & Agriculture	5
3	2016	Startup	ICT & Software	1
4	2017	Startup	ICT & Software	5
5	2016	SME	ICT & Software	1
6	2014	SME	Food & Agriculture	1
7	2017	Startup	ICT & Software	0.3
8	2017	Startup	ICT & Software	1
9	2000	Large	Materials Science & Chemicals	906.5
10	2005	SME	Food & Agriculture	1
11	2018	Startup	Food & Agriculture	1
12	2017	Startup	ICT & Software	1

No. of tenant firms	Year of establishment	Business scale	Business sectors	Capital cost* (million baht)
13	2018	Startup	Medical Device & Pharmaceutical	1
14	2016	SME	ICT & Software	1
15	2015	SME	ICT & Software	5
16	2004	SME	Experience Design Service	2
17	2005	SME	Food & Agriculture	3
18	2018	Startup	Energy	2
19	2018	Startup	Medical Device & Pharmaceutical	1
20	2014	SME	ICT & Software	13
21	2017	Startup	ICT & Software	1
22	2005	SME	ICT & Software	5

Source: Survey data

*Remarks; thirty-eight baht equal to one pounds (20th October 2019)

4.4.2 The data collection process

The fieldwork for this study was conducted in Thailand in two phases. The first phase is a preliminary study (pre-survey interview to help a draft of questionnaire). This was carried out between February and March 2018. The second phase is a formal survey involving questionnaire administration and the conduct of face-to-face semi-structured interviews with either owners or managers of the NSP firms. These were conducted between January–March 2019. The interviewees were anonymized using number codes. The maximum length of the interviews was limited to one and a half hours.

4.4.2.1 Phase I: Pretesting the questionnaire

The pretest was conducted from 15 February to 18 March 2018, covering 10 expertise in Thailand. The preliminary fieldwork involved informal interviews with the Director of the Thailand Science Park and representatives of the science park management team, including personnel at the management level of the Ministry of Science and Technology. The objective of this interview was to discuss the importance of the study from the point of view of the national policy of science and technology, and also to elicit feedback from the interviewees that would contribute to a useful revision of the questionnaire.

It transpired from these interviews that the study would be useful for policy if the questionnaires and interviews sought to bring out the strengths and weaknesses of science parks as reflected by the experiences of resident tenant firms. The focus on science parks was considered all too important for Thailand, in particular, as it is transitioning to knowledge economy. It was felt, however, the questionnaire was too complicated and would take too much time to answer, and that it would need to be revised to be effective in eliciting useful information and data.

The questionnaire was subsequently reviewed by individuals from the Office of the Permanent Secretary of Science and Technology, the National Science and Technology Development Agency, and the National Science Technology an Innovation Policy Office. The following feedback points were obtained:

1) The questionnaire should meet the objectives of the study.

2) The questionnaire should obtain the data required for the study.

3) The words used in the questionnaire should not be redundant or ambiguous.

4) The questions should be clear and intelligible.

5) The questions should be relevant to the respondents e.g., the owners, managers, or employee.

6) The structure of the questionnaire should be clear and not too long.

These points were considered in the revision of the questionnaire.

4.4.2.2 Phase II: Questionnaire survey and semi-structured interviews

Prior to administering the questionnaire, it was necessary to ensure that the questionnaire was clear and that it involved a minimal risk of confusion. The final draft of the questionnaire was reviewed and trialed by eight experts who had previously worked in this field (3 from the NSP; 2 from the National Science and Technology Development Agency; 2 from the Office of the Permanent Secretary of Science and Technology; and 1 from the National Science Technology and Innovation Policy Office). Following the recommendations and suggestions that were made, the questionnaire was revised and developed to make it simpler, clearer, brief, and with little or no use of jargons.

The questionnaire was divided into five parts covering questions eliciting information about the NSP firms (for example, how long they had been in operation, capital costs, the business sectors they come from, and size of their businesses, etc.); and also about the attitude of firms towards the role of the NSP in promoting and encouraging the tenant firms to be innovative and competitive.

A formal field work, involving a questionnaire-based survey and face-to-face semi-structured interviews, was carried out between 1 January and 31 March 2019. The questionnaires were administered to owners or managers of firms located in the NSP. There are in all 22 firms in the NSP that have been fully operational since 2018. All of these were covered in the survey. However, the population of firms in the Park is too small to warrant a viable sampling procedure. This calls for mitigating measures as discussed below.

The interview method is used as an instrument for complementing the questionnaire-based survey. The schedule for the interviews was arranged by the NSP administration and the interviews were conducted in a private meeting room at the NSP. The duration of the interviews was approximately one and a half hours; and, in accord with the ethics requirement for conducting questionnaire as well as interview-based surveys, permissions were obtained from the interviewees to make an audio recording of the interviews; and all the interviewees were asked to read an information sheet designed for the participants and to sign a consent form before the interviews were conducted. The questionnaire administration and interviews were carried out together face-to-face with participants, with the interviews following the completion of questionnaires, so that issues arising from the questionnaire with respect to individual forms can be explored through the interviews.

4.4.2.3 Phase III: Follow up of the survey a year after completion of Phase II

The aim of this phase is to investigate evidence of any changes in the performance of tenants a couple of years after the Phase II interview was conducted. This is because, as mentioned above, a one-year long experience of tenants after establishment of NSP would not provide adequate data for a satisfactory experiment. Therefore, a follow up investigation was considered after a year or so to mitigate the limitation of the data collected at Phase II. Accordingly, a follow-up investigation was planned by conducting interviews face to face or by phone or Zoom sessions with some of the tenant firms in the Park to monitor changes in their views about the usefulness of their on-park location for their prospects to evolve as innovative and competitive enterprises. Points that would be investigated in this respect relate to changes in the performance of firms with respect to productivity, employment rate, company scale up, sales growth, joint venture partnerships, R&D investment, and grants of patent rights.

4.4.3 Questionnaire structure and contents

This section discusses the structure and content of the questionnaire and details relevant to the literature. The questionnaire used in this study was organized in five parts. The five parts are on: (1) general information; (2) the firms in the NSP; (3) innovative transformation model; (4) innovative activities; and (5) firms' recommendations. The details of the questionnaire are outlined in Table 4.3.

Table 4.3 Questionnaire structure

Questionnaire structure	Questions
Part 1 General information	• name of firms, year of establishment, ownership structure, capital costs, R&D units and R&D activities, company activities, type of business, and main products.
Part 2 Tenant firms in NSP	• year of participation in the NSP • reasons for participation • engaging in triple helix • continued residence in the NSP
Part 3 Innovative transformation model	• innovative input • innovative process • innovative output • how the NSP improves firms' innovative and business performance
Part 4 Innovative activities	• innovative information • type of R&D expenditure • purpose of R&D investment

	• reasons for outsourcing R&D services • outsourcing of R&D services • factors in preventing R&D and innovation • information sources for R&D and innovative activities • reasons for co-operation with other firms for R&D and innovation • frequency of engagement with universities and public research centres
Part 5 Recommendation	• expectations from the NSP

Interviewees were asked in part 1 to provide basic information about their businesses to determine which categories they would fall into. These independent variables were used to categorize the role of the NSP in promoting and supporting firms differently: how long they had been established, capital costs, business sectors, and size of businesses. Open-ended questions, multiple choice questions, and binary questions were used to obtain the data.

The questions in part 2 were used to elicit a variety of reasons for participating in the NSP and for how long they had participated. There was an option for other reasons firms may have for participating in the NSP, if the reasons were not already on the list. The NSP firms were also asked whether they would continue to remain in the NSP and, if not, why they decided not to extend their tenancy. In addition, the firms were asked if their activities included the use of the triple helix interactions on regular basis and to give examples of such interactions. Multiple choice questions and five-point Likert scale-based questions were also used.

In part 3, the questions focused on an innovative transformation model to explore the effectiveness of the NSP in giving encouragement and support to their firms. This model consisted of three separate parts: innovative input was investigated on the basis of what the NSP provided and how the firms were helped in the beginning and whether these resulted in any changes. For example, did the firms increase the number of researchers, and improve researcher skills, employees' skills, their workspace and facilities. Next, the innovative process was considered in terms of the support they were given and how the process developed – like, for example, by exploring potential business ideas, developing prototypes, seeking customer preferences, and creating an environment for the exchange of knowledge. The last part of this model, which is about innovative output, focused on what the NSP firms were able to achieve after being helped and supported by the NSP - like, for instance, new products, new processes, new markets, increases in market shares, and new patents. The final question in this part was to rate the NSP on a five-point Likert scale for their contributions to the improvement of the firms' innovative and business performances.

The fourth part of the process examined the innovative activities of the firms by asking the interviewees to provide information for the period 2014 – 2018 in terms of new products/processes, number of researchers, number of employees, R&D expenditure, and new patents. This information was applied in a longitudinal study which compared the firms' performances in terms of whether they had made any changes since participating in the NSP. Furthermore, a number of questions explored the innovative perspectives of the firms by, for example, R&D expenditure, the purpose of engagement in R&D investment, reasons for outsourcing R&D services, and factors preventing R&D activities and innovation. These views would be beneficial in implementing a policy to meet the expectations of the firms. Respondents were asked to fill in their information and the five-point Likert scale was used for data recording and analysis.

In the last part, of the questionnaire, respondents were asked to make recommendations based on what they expected from the NSP. Such recommendations would help the NSP management team to know which issues needed to be improved and implemented. There was also an option for the interviewees who wished to give additional information to their previous answers. Five-point Likert scale-based questions were used in this section to elicit the information.

4.4.4 Face-to-Face Interviews

The interviews attempted to elicit in-depth information based on the role of the NSP and how it supported their firms and led to innovative and competitive activities. The purpose of the interviews was to explore the impact on the NSP firms and how they benefitted from the NSP's activities. In addition, the interviews examined the evidence for determining from the views of on-park firms whether there were any significant differences between those firms in the NSP and those outside the NSP. The owner, the Chief Executive Officer (CEO), the senior manager and the other managers of the company were interviewed face-to-face. All the interviewees were asked to answer the questionnaire and another ten similar questions related to general information about the companies, the experience of being a firm in the NSP, the innovative transformation model, innovative activities, their recommendations, and the role of the NSP as a mechanism for the operation of the triple helix system to promote innovative behavior among the NSP firms.

Thus, the information elicited through the in-depth interviews was used for a qualitative analysis of the role of the NSP in supporting and developing the NSP firms. The interviews would explore the system of the triple helix mechanism underpinning the functions of science parks in relation to the generation and application of new ideas as well as their commercialization;

and the development of knowledge networks to foster knowledge exchange and innovation. The interviews also explored the lessons deriving from the NSP's experiences, and in particular, the areas of strengths, weaknesses, opportunities and threats for the development of regional science parks in developing countries, in general, and Thailand, in particular.

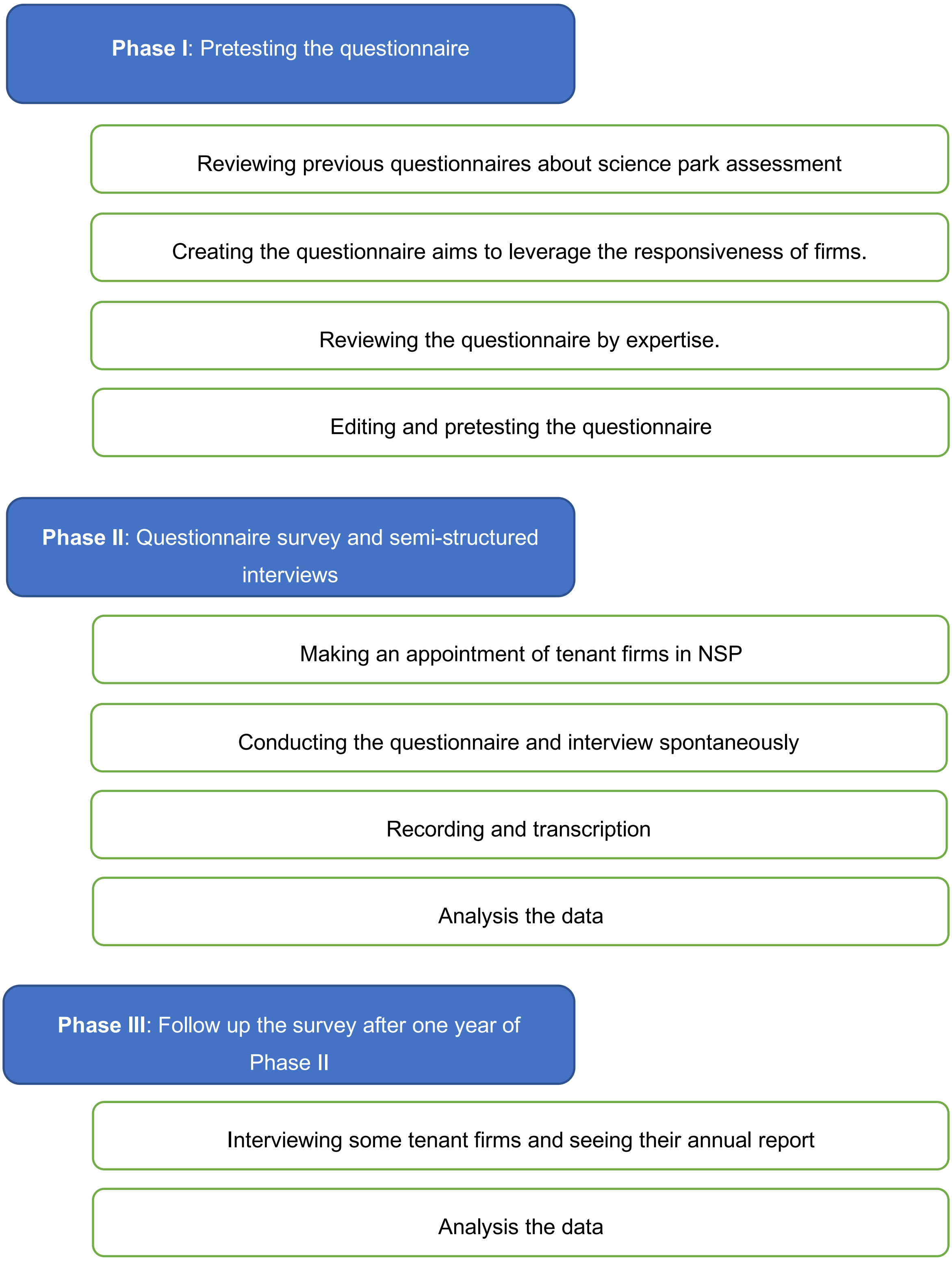

Figure 4.1 The diagram of different stages of methodology.

4.4.5 Adequacy of the questionnaire

An internal consistency and reliability test (Cronbach's alpha coefficient) of the five-point Likert scale used in the questionnaire is shown in Table 4.4. Cronbach's alpha coefficient ranges from 0 – 1. The higher the score of this coefficient the more reliable the results. If the score is greater than 0.7 it is considered robust. A low Cronbach's alpha, however, is normally found if the questions contain few items. In this case, the Cronbach's alpha test in part 4 shows a moderate score for the topic on purpose of engagement in R&D investment and reasons for outsourcing R&D services at 0.57 and 0.54, respectively (see Table 4.4).

Table 4.4 Cronbach's alpha of the five-point Likert scale used in the questionnaire.

Questionnaire sections	Topic	Items	Cronbach's alpha	Robust
Part 2	Reasons of participating in the NSP	11	0.81	Yes
Part 3	Innovative input	11	0.79	Yes
	Innovative process	9	0.88	Yes
	Innovative output	12	0.87	Yes
Part 4	Type of R&D expenditure	6	0.81	Yes
	Purpose of engagement in R&D investment	6	0.57	Moderate
	Reasons for outsourcing R&D services	5	0.54	Moderate
	Outsource of R&D company services	7	0.81	Yes
	Factor in preventing R&D activities and innovation	9	0.87	Yes
	Information source of R&D activities and innovation	15	0.85	Yes

	Reasons for co-operation with other firms for R&D activities and innovation	6	0.8	Yes
Part 5	Recommendation	12	0.77	Yes

4.5 Methods for data analysis

Data obtained from this formal field work can be categorised into two groups: quantitative and qualitative data. Interviewees were asked to provide information about innovations and business performance. The quantitative data were obtained from the actual numeric values of new products or processes, number of researchers and employees, R&D expenditure and patents. The study also used rating scales (five-point Likert scale) for attitude measurements to quantify non-numeric issues such as reasons for participating in the NSP, services received, innovative processes and innovative outputs, innovative activities and recommendations. The qualitative data was obtained through face-to-face interviews and from the answers to open-ended questions of the questionnaire about the support and encouragement provided by the NSP.

Data from the questionnaire-based survey were translated into nominal and ordinal scales for analysis (Long, 2014). Nominal scale is a quantitative reflection of the profiles of firms; business sectors; investment in research and development, and research and development activities. The ordinal scale is used to measure the level of perception, attitude, feeling by rating on a 1 – 5 Likert scale: very low, low, moderate, high, and very high. The use of the five-point Likert scale facilitates an ordinal scale in this study to weigh the degree of perception of a category of service supports offered by the NSP. Also, views of the reason for participating in the NSP, research and development activities, and recommendations were elicited by the use of five-point Likert scale.

The SPSS statistical package was used for quantitative analysis of data on the attitudes of tenant firms set on five-point Likert scale, and for ordinal logistic regression. The qualitative information obtained from face-to-face semi-structured interviews was analysed using version 12 of the NVivo software package[3]. The aim of the analysis is to reflect on the confidence of tenant firms in the supports and facilities provided by the NSP and on the implication of this for the innovative performances of the NSP firms based on the survey of the firms' attitudes towards the NSP.

4.5.1 Descriptive statistics

Descriptive statistics is used to measure the distribution of some factors relating to the general characteristics of the NSP firms - for example, age of firms including years of establishment, capital costs, size of business and the business sectors the firms come from. The distribution of these variables across the population of tenant firms in the NSP is not normal as the population size (n=22) is too small. Nevertheless, these variables were used as parameters for profiling the NSP firms according to frequency distribution, arithmetic means and standard deviation for further statistical analysis of tenants' responses to questions about their association with the NSP.

Tenants' attitudes were recorded for analysis using five-point Likert scale (1 – 5) to elicit on how respondents would rate issues relating to aspects of their association with the NSP as expressed by each statement under the various questions covered in the survey questionnaire. The rating scale is as follows:

5 score	Very high
4 score	High

[3] NVivo is a qualitative data analysis software. It has been designed for text-based analysis allowing user to sort, arrange, classify the qualitative data.

3 score	Moderate
2 score	Low
1 score	Very low

Based on the above, the average score for the responses to each question is determined by taking the difference between the highest score and the lowest score for all respondents and dividing this by the number of layers of the chosen Likert scale, which is 5 for the five-point Likert scale. Thus:

$$\text{Range of layers} = \frac{\textit{highest score} - \textit{lowest score}}{\textit{number of layers}}$$

$$= \frac{5-1}{5}$$

$$= 0.8$$

The scores are then set in five layers, with 0.8 as the range for each layer, as shown below:

Average score	Interpretation
1.0 – 1.80	Very low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.0	Very high

Each layer allows variations in the response of firms to each question. Firms would vary in their specification of the reasons for participating in the NSP; their disposition towards the innovative transformation model as basis for innovative activities; and their recommendations. Differences may also occur between older and younger firms in terms of needs for support services. The latter point is particularly important to determine evidence as to whether the NSPs' services assist firms to be innovative enough to design and develop their inputs and outputs (Hypothesis 1).

4.5.2 Inferential statistics

The research involves testing hypotheses using ordinal logistic regression, so that evidence on the influence of various characteristic features of firms on the development of innovative inputs supported by the NSP, and evidence on the influence of support services by the NSP on probable development of innovative outputs can be examined. The regression model is aimed to show how the probability of changes in the dependent variables (i.e. probability of the occurrence of innovative outputs) is influenced by changes in the independent or explanatory variables (see the five categories of innovative inputs in Table 4.5 below).

Regression models such as linear models, logistic models, and ordinal regression models are advantageous tools in exploring the association between independent and dependent variables. The ordinal logistic regression, however, allows investigation of the effect of the explanatory variables on the outcome or dependent variables when the data come in a categorical order. Also, the ordinal logistic regression model is suitable when there are serval factors that need to be taken into consideration.

There are several statistical approaches, which have been extensively applied in research: for example, the probit model (in binary cases); the ordinal logistic regression model (where more than two ordered variables are involved). The outcome variables obtained from five-point Likert scale are ordinal variables that should be used in investigating the association in which independent variables are influencing the dependent variables. In this case, the ordinal logistic regression model becomes an appropriated tool. It is unreasonable to consider normality and homogeneity of variance for ordered outcome variables.

The questionnaire for the survey covers a total of twenty specific innovative input components under the five categories of innovative inputs emerged from the support services provided by the NSP: human resources, infrastructure and facilities, knowledge linkage, funding, and market opportunity. These cover the preliminary requirements of firms seeking support from science parks (Aliahmadi *et al.*, 2015).

Table 4.5 Components of categories of innovative inputs emerged from the support services provided by the NSP.

Specific innovative input components developed by the NSP services	Category of innovative inputs development
Increase number of researchers	Human resources
Improve researchers' skill	
Improve employees' skill Specific skill needed	
Recruit high skill employee	
Provide space for research and development	Infrastructure and facilities
Support facilities for research and development	
Increase the interaction among participants	
Create knowledge exchange environment	
Assist consultancy for research and development	Knowledge linkage
Enhance knowledge linkage with university and research institute	
Provide external knowledge exchange	
Creating forum and network for learning the experiences' others	
Help to access to funding source	Funding
Help to improve market skill	Market opportunities
Explore potential business idea	
Set of blueprints	

Develop of prototype
Seek customer preferences
Support product fully functional in real word

Table 4.6 shows categories of independent and dependent variables used to test Hypothesis 2: whether firm characteristics (such as the age of firm, the business scales, business sectors, and other firms' profiles) have any significant bearing on the innovative performance of firms as perceived by the firms themselves. The eight independent variables used in this analysis are measured in terms of interval scale, category scale, and dichotomous values. The development of innovative capability as a consequence of support provided by the NSP is represented as dependent variables measured in terms of ordinal scale.

Table 4.6 Independent and dependent variables used in ordinal logistic regression for testing Hypothesis 2 (H2).

Abbreviation	Definition	Value/Units	Measurement
Independent variables: characterizations of firms in the NSP			
AGE	Firms age	years	Interval scale
RENU	Number of researchers	persons	Interval scale
PART	Number of years participating with NSP	years	Interval scale
CAPC	Investment cost (pounds)	1 = less than 50,000 2 = 50,000 – 100,000 3 = more than 100,000	Nominal scale – multiple categories (three groups)
SCAL	Size of business	1 = startup 2 = SME 3 = Large	Nominal scale – multiple categories (three groups)
BUSS	Business sectors	1 = software & application 2 = food and herb 3 = science & energy	Nominal scale – multiple categories (four groups)

Abbreviation		Definition	Value/Units	Measurement
			4 = medical devices	
CONR		Conducting research and development	0 = No 1 = Yes	Nominal scale – binary category (yes/no)
RDEX		Expenditure of research and development	0 = No 1 = Yes	Nominal scale – binary category (yes/no)
Dependent variables: The innovative inputs of firms developed from the NSP services.				
Development of Innovative inputs	Human resources (HURE)	Increase number of researchers	Five-point Likert scale on each component of innovative inputs supported by the NSP. Finally, the score of each component in each firm was arranged to seek the median of development of innovative	Ordinal scale (1 - 5) – median was used for statistical analysis
		Improve researchers' skill		
		Improve employees' skill		
		Specific skill needed		
		Recruit high skill employee		
		Provide space for research and development		

Abbreviation		Definition	Value/Units	Measurement
	Infrastructure and facilities (INFA)	Support facilities for research and development	inputs derived by the NSP's supports.	
		Increase the interaction among participants		
		Create knowledge exchange environment		
	Knowledge linkage (KNLK)	Assist consultancy for research and development		
		Enhance knowledge linkage with university and research institute		
		Provide external knowledge exchange		
		Creating forum and network for learning the experiences' others		
	Funding (FUND)	Help to access to funding source		

Abbreviation		Definition	Value/Units	Measurement
	Market opportunity (MAOP)	Help to improve market skill		
		Explore potential business idea		
		Set of blueprints		
		Develop of prototype		
		Seek customer preferences		
		Support product fully functional in real word		

In hypothesis 3 (H3), the five categories of innovative inputs of firms developed from the NSP services are set as independent variables to explain the benefits tenant firms perceive to derive in terms of innovative outputs. Tenants' attitudes about possibilities of innovative outputs resulting from their participation in the Park are explored through twelve components of innovative outputs (see Table 4.7 below). Tenants were asked about the likelihood of success in terms of innovative outputs on a five-point Likert scale: very low (1), low (2), moderate (3), high (4), and very high (5). The twelve components about the innovative performance of firms as perceived the firms (or the likelihood of firms emerging as innovative and competitive enterprises) are represented by the development of technological capability in four areas of innovative development: i.e. products or processes; market development; cost reduction; and intellectual property (Díez-Vial and Fernández-Olmos, 2015; Diez-Vial and Montoro-Sanchez, 2016; Squicciarini, 2009a; Löfsten and Lindelöf, 2003; Vásquez-Urriago, 2014) as shown in Table 4.7.

Table 4.7 shown independent and dependent variables used in ordinal logistic regression for Hypothesis 3 (H3).

Abbreviation	Definition	Value/Units	Measurement
Independent variables: categories of innovative inputs of firms developed from the NSP services			
HURE	Increase number of researchers	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
	Improve researchers' skill		
	Improve employees' skill		
	Specific skill needed		
	Recruit high skill employee		
INFA	Provide space for research and development	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
	Support facilities for research and development		
	Increase the interaction among participants		
	Create knowledge exchange environment		
KNLK	Assist consultancy for research and development	Five-point Likert scale	

	Enhance knowledge linkage with university and research institute		Ordinal scale (1 - 5) – median was used for statistical analysis
	Provide external knowledge exchange		
	Creating forum and network for learning the experiences' others		
FUND	Help to access to funding source	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
MAOP	Help to improve market skill	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
	Explore potential business idea		
	Set of blueprints		
	Develop of prototype		
	Seek customer preferences		
	Support product fully functional in real word		
Dependent variables: Development of innovative outputs.			

Development of innovative outputs.	Development of product or process (DEVP)	new products or processes	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
		increase range of products or processes		
		improve quality of products or processes		
	Development of market (DEVM)	increase market share	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
		enter new market		
		meet customer demands		
	Cost reduction and environmental impact (CREI)	reduce cost per unit output	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
		reduce environment impacts		
		improve health and safety standards		
	Intellectual property (INPT)	increase number of patents apply	Five-point Likert scale	Ordinal scale (1 - 5) – median was used for statistical analysis
		increase number of patents granted		
		increase number of other intellectual property		

The data obtained from Likert scale are ordinal and discrete without distribution as they are not spaced out in ranges at regular intervals. In contrast, if data are measured in intervals or on ratio scale, the distance among intervals is equivalent across the range of measurement and the measures of central tendency can be statistically determined. However, since the Likert scale is treated as ordinal data; the median is used as the average reading of central tendency (Osinowo, 2018).

To suit the data at hand, the ordinal regression method, which uses the logit function, is adopted. The logit link is widely applied for the analysis of ordered categorical data that are distributed in equal distance among the categories (Elamir and Sadeq, 2010). The ordinal logistic (logit) regression model is used to examine whether firms are convinced about the potential innovative gains to be derived from the support services (innovative inputs) provided by the NSP.

The ordinal logistic regression was run for testing hypotheses 2 and 3 (see below) using SPSS 26 with median-centered variables (Osinowo, 2018).

Hypothesis 2; Responsiveness of firms in terms of developing innovative inputs (as indicator of development of technological capability):

$$\begin{aligned} Y_{H2} = {} & \alpha_i + \beta_1 X_1(AGE) + \beta_2 X_2(RENU) + \beta_3 X_3(PART) + \beta_4 X_4(CAPC) \\ & + \beta_5 X_5(BUSS) + \beta_6 X_6(SCAL) + \beta_7 X_7(CONR) + \beta_6 X_6(RDEX) + \varepsilon \end{aligned}$$

where

Y_{H2} = Development of innovative inputs supported by NSP

χ = Predictors (see Table 4.6)

β = Regression coefficients

α = Constant or intercept

ε = Error term

Hypothesis 3; Responsiveness of firms in terms of developing innovative outputs inputs (as indicator of development of technological capability):

$$Y_{H3} = \alpha_i + \beta_1 X_1(HURE) + \beta_2 X_2(INFA) + \beta_3 X_3(KNLK) + \beta_4 X_4(FUND) + \beta_5 X_5(MAOP) + \varepsilon$$

where

Y_{H3} = Perception of innovative outputs development of firms

χ = Predictors (see Table 4.7)

β = Regression coefficients

α = Constant or intercept

ε = Error term

The different statistical techniques used in this study for analysis of data are shown in Table 4.8 below. More techniques were applied than the ones discussed above. For instance, the t-test was used to compare the frequency of joint activities between universities and public institutes. The purpose of this is to explore which types of resources would be most relevant and useful for the NSP firms. Furthermore, this study also investigated how the linkage between the NSP, and its firms could be strengthened. The Friedman test was used to test the differences between more than two variables in each group of fundamental development services and facilities provided by the NSP, like for example, human resources (HURE), infrastructure and facilities (INFA), knowledge linkage (KNLK), funding (FUND) and market opportunities (MAOP). The aim of the Friedman test is to explore differences between the variables which relate to the range of support services and facilities provided by the NSP. Where evidence of difference is established, the Wilcoxon Signed-rank test was used to show those pairs of variables to which the differences can be attributed.

The aim of the quantitative analysis and the statistical tests is to find out if tenants received appropriate support and encouragement as would be expected of the implementation of an innovative transformational model to be exercised by the Park. Using ordinal logistic regressions, the analysis sought to show how the category of fundamental development support services and facilities provided by the NSP transforms into innovative outputs as measured by innovative development perceived by tenant firms.

The role of the NSP as a microcosm of the triple helix system of innovation was also analyzed using SWOT analysis. The SWOT analysis not only specified the strengths and weaknesses, and threats and opportunities, but also how any weaknesses could be translated into strengths and threats into opportunities for firms to achieve innovation and competitiveness.

The SWOT analysis was applied to explore how the process of the triple helix mechanism operates between the government, the universities, and the NSP firms as a result of using the science park as an intermediate sector linking and strengthening them (Hypothesis 4). The results of these analysis could provide valuable lessons to be learned from the NSP's experiences for science park development in Thailand and other developing countries.

Table 4.8 Summary of statistical techniques used in this study.

Statistical technique	Features	Application in this study
Quantitative study		
Descriptive statistics: frequency, mean, percentage, standard deviation. (*Objective 1*)	Compare numerical data among tenant firms' profiles	Characteristic of firms

Likert scale analysis: Spider graph, bar graph (*Objective 1 and 2*)	Compare among firms' attitude in term of expectation, innovative transformation model, and view of innovative activities.	Reasons for participating in the NSP, innovative transformation model, innovative activities, and recommendations.
Friedman Test (non-parametric)	Test for differences more than two groups in ordinal measurement	Test the differences among variables in each category of innovative inputs development.
Wilcoxon Signed-rank Test (non-parametric)	Test whether two variables having same distribution	Test which pair of variables are different
Ordinal logistic regression (*Objective 3*)	Estimate of ordinal regression model of innovative inputs development supported by the NSP and groups of perception of innovative outputs development	Analysis factor effecting innovative inputs development supported by the NSP and groups of perception of innovative outputs development
Comparative study: t-test (*Objective 4*)	Compare mean of two independent variables	Compare activities provided by universities and public research institute
Qualitative study		
Thematic content analysis and SWOT analysis (*Objective 4 and 5*)	explore the 'system of the triple helix mechanism underpinning the functions of science parks and explore the lessons to be learned from the NSP's experiences in the light of global science park experiences	areas of strengths, weaknesses, opportunities and threats for the development of regional science parks in developing countries

4.6 Conclusion

This chapter has set out the method used for eliciting data from the survey of science park firms undertaken in Thailand. The fieldwork was organized in two phases: the first phase focused on the groundwork, including design and development of the survey soliciting the views and advice of experts. The second phase was the survey, which was conducted during the period between January and March 2019. The survey generated quantitative and qualitative data that will be analysed using the mixed approach. The data collected cover details of the 22 tenant firms in the NSP.

Table 4.9 below summarizes the hypotheses of the study and the methods used for investigating the corresponding hypotheses.

Table 4.9 Summary of hypotheses in the study.

Hypotheses	Methods of Analysis
H1: Science parks are effective in their mission as cradle of innovation when the services they provide are of the type that would assist tenant firms to be creative in developing their inputs and outputs;	- Descriptive analysis - Five-point Likert scale on firms' perception since being supported by the NSP.
H2: Firms with varying attributes and characteristics are likely to have varied perception about the benefits to be derived from the support services offered to them by science parks;	- Descriptive analysis - Statistical analysis: Ordinal logistic regression
H3: The existence in science parks of a properly functioning triple helix network provides the social capital that is crucial for the ability of tenant firms to transform the services the parks provide into innovative activities, including product development, product scaling and commercialisation;	- Statistical analysis: Non-parametric method; Friedman' test and Wilcoxon's test. - Statistical analysis: Ordinal logistic regression

H4: The decision of firms to locate in science parks is driven by the belief that triple helix-based science park services, properly administered by parks and properly received by the tenant firms, would trigger the innovative and enterprising potential of firms to be realised.	- Five-point Likert scale on firms' perception since being supported by the NSP - Thematic content analysis from the interviews - SWOT analysis

The methodology on which the research study is based is not without limitations. Firstly, the number of firms located in the NSP is small, even when the survey covers the total population of firms in the Park. This would reduce the robustness of key findings. However, attempts have been made to mitigate this deficiency by limiting the scope and method of data analysis. Secondly, at the time of the survey, the NSP has been in operation for just one year, which means that tenants cannot be expected to have gained enough learning experience, still less innovative practice. During this short period, not all firms could be expected to have been supported with all services the Park could provide. However, it can safely be assumed that the experiences the firms have had in the Park would still enable some, if not all, of them to have a clear vision of the way forward, particularly with respect to possibilities for realizing their innovative potential. Thirdly, this study does not provide comparison of the performance of on-park firms before and after of participating in the NSP; nor between on-park and off-park firms, however important and interesting these may be as areas of research and policy focus. In the former case, inter-temporal comparison of the innovative performance of firms could not be considered as most of the firms in the park are at the early stage of their life cycle without time series data on products, sales income, and even without financial reports. This would make it impossible to quantify the innovation performance of firms (in terms of price and quality competitiveness) before and after participation in the NSP. In the latter case, comparison between on-park and off-park firms was not considered because of the multiplicity of practical and conceptual problems envisaged in drawing up a sample of off-park firms that would satisfy the ‘like-with-like’ condition for inter-firm comparison.

Nor could the study focus on comparison of firms located in different science parks, as there are not many science parks in Thailand with many years of experience, in the first place; and even in the case of the Thailand Science Park, which has been in operation for about 12 years, the management staff were not willing to cooperate when asked to be included in the survey. In the circumstances, the study has had to be limited to the task of exploring tenant firms located in the NSP for their perception of the likelihood that their limited participation in the NSP would enable them to emerge as innovative and competitive enterprises, and even niche players in the global market. In other words, would their experiences as tenant firms in the park to date give credence to the presumption that the support services and facilities provided by the NSP are effectively administered and ‘mission-oriented’? The subsequent chapters of this study will address this question and its wider ramifications.

CHAPTER 5
PROFILE OF SURVEY DATA

This chapter explores profile of the survey data and discusses the range of observations reflected by these data. Results of the data analysis show the variety of information that science park management and policy makers would need to implement strategies that would make effective use of science parks as intermediary agencies for supporting firms in the development of innovation-based ‘global born’ competitive enterprises in countries like Thailand.

The chapter is in six parts. The first part is on the various aspects of tenant firms (age of firms, business scales, business sectors the firms come from, etc.) populating the NSP. The second part discusses use of the five-point Likert scale for investigating and interpreting the reasons firms gave for participating in the NSP, and their preparedness to exploit the Park’s support in the form of R&D services, and external knowledge and market networks that together would enable them to emerge as innovative and competitive enterprises. The third part discusses the innovative transformation model as an analytical framework that is used to explore the extent of the benefits (in terms of the development of innovative capabilities) that tenant firms derive from Park services. The fourth part addresses questions about the linkages universities and public research institutes forge with science parks and the extent to which tenant firms are involved in the triple helix network within the Park. In the fifth part, the recommendations of firms for improving the NSP services are profiled. The last part summarizes and concludes the chapter.

5.1 Survey of on-park firms at the NSP.

The survey conducted through face-to-face interviews and questionnaire administration covered 22 tenant firms that are residents in the NSP. A response rate of 100% was achieved with all the 22 tenant firms having responded to the questionnaires administered to them as well as making themselves available for interviews. The survey data was used for quantitative and qualitative analyses of the role of the NSP as a bridge to support, provide, incubate, and contribute tenant firms to be innovative and competitive in their business performances.

Science parks generally provide their tenants with support systems, like basic infrastructure and facilities, access to knowledge networks and funding sources, and marketing opportunities. The question being queried in this study is how effectively science parks operate in countries like Thailand to ensure that innovative ideas resulting from research and development (R&D) activities reach business enterprises and transform their technology and market profiles.

Quantitative and qualitative data and information were elicited through interviews and questionnaires administered face-to-face to 22 tenant firms. The questionnaire included 28 questions covering general company information; companies' reasons for participating in the NSP as tenants; the innovative transformation model applying to the activities of tenant firms over the course of their residence in the Park; and companies' views about the Park as well as their recommendations for improvement of its facilities and services. Interviews were conducted with all the 22 resident firms for in-depth information about the kind of support tenant firms received and how these could help them to be innovative, including the recommendations from them to improve the NSP's services.

In this chapter the data obtained through the survey are sorted and categorized to make them useful for investigating the research questions. In this part, the chapter explores the characteristics of tenant firms in terms of age, scale, capital cost, and business sectors, as per objective 1.

The data obtained from the survey of resident firms in the NSP are used to set up profiles of tenant firms in terms of business characteristics, including age profiles; period of residence (or length of experience) in the NSP; ownership structure; financial status; business scale; capitalized value of firms; and business sectors the tenant firms come from. These are shown in Tables 5.1 – 5.6 below.

5.1.1 Year of establishment of tenant firms.

Table 5.1 Data on years of establishment of tenant firms.

Year of establishment	Frequency	Cumulative Frequency	Percentages	Cumulative percentages
1990	1	1	4.55	4.55
2000	1	2	4.55	9.10
2004	1	3	4.55	13.65
2005	3	6	13.65	27.30
2014	2	8	9.09	36.39
2015	1	9	4.55	40.94
2016	3	12	13.65	54.59
2017	6	18	27.27	81.86
2018	4	22	18.18	100
Total	22		100	

Source: Survey data

Table 5.2 Age profiles of tenant firms.

Age range (years)	Frequency	Percentages	Cumulative percentages
0 - 3	10	45.46	45.46
3 < x < 5	6	27.27	72.73
More 5 years	6	27.27	100

Total	22	100
MEAN	5.49	
STD.DEV.	5.77	
MEDIAN	3	

Source: Survey data

Table 5.3 Number of years of firms participate since the NSP embedded at Chiangmai University in 2014 (the NSP was completed infrastructures in 2018).

Years	Number of tenant firms participating in the NSP	Percentages	Cumulative percentages
2014	8	36.36	36.36
2015	1	4.55	40.91
2016	3	13.65	54.56
2017	6	27.27	81.83
2018	4	18.18	100
Total	22	100	

Source: Survey data

Table 5.2 shows that tenant firms in the NSP are mostly new firms with the average age at 5.5 years. In fact, 45.5% of tenant firms are less than three years old, while the oldest tenant firm is 29 years old. Interestingly, 72.7% are young tenant firms falling in the age range between one and five years. These are start-up and small and medium enterprises (SMEs). This age profile of the majority of tenant firms is in keeping with the *raison d'etre* of science parks as the place of incubation for new business enterprises. Such firms are expected to benefit from residence in science parks where they would be nurtured with knowledge and ideas that would help them to develop marketing and technology perspectives, and where they can have access to accommodation space, facilities, support systems and funding opportunities.

Table 5.3 shows differences in the duration of participation with the NSP while the NSP infrastructure and building project was being constructed. Prior to its operation at its present location, the NSP operated embedded in the Faculty of Engineering at Chiangmai University for five years. The building projects were completed, and the Park started full operation early in 2018. The survey data show that of the 22 tenant firms in the NSP, eight firms have been resident for five years since their establishment; four firms have been in the Park for a year; three firms have been residents for three years; and one firm has been in the park for four years. Tenant firms that have the longest period of participation generally have more experience in the NSP. These are medium and large enterprises, while the less experienced tenant firms are start-ups, which are newborn firms joining the NSP for incubation. The role of science park management is to provide different supports to tenant firms, depending on their age and experiences.

5.1.2 Ownership structure of tenant firms.

Table 5.4 shows that the majority of tenant firms in the NSP (about 91%) are wholly owned by Thai nationals. There is one tenant firm largely owned by German nationals with Thais having only 1.5% stake in it. Another tenant firm, which qualifies as a large enterprise, is wholly Japanese-owned. The firm operates as a subsidiary in Thailand, under a Thai manager and manned by Thai employees. Another feature of the ownership structure is that there is no joint-venture tenant firm in the Park where the majority stake is held by Thais. The practice with international firms operating in Thailand is that if they do not wholly own the firm, they would settle for a share of 50% or more in the firm.

Table 5.4 Ownership profiles of tenant firms.

Ownership structure	Frequency	Percentages	Cumulative percentages
Wholly owned by Thais	20	90.92	90.92
51-99% owned by Thais	0	0	90.92
1-50% owned by Thais	1	4.55	95.47
Wholly owned by foreigners	1	4.55	100
Total	22	100	

Source: Survey data

5.1.3 Capital cost of tenant firms.

Table 5.5 shows that 50% of the tenant firms in the Park have capital value less than £50,000. About 32% of the tenant firms have capital value over £100,000; but only one tenant firm - a large enterprise from Japan wholly owned by Japanese - has capital value over £350,000. The individual capital costs are shown in the Appendices of this study.

Table 5.5 Capital cost profiles of tenant firms.

Capital cost	Frequency	Percentages	Cumulative percentages
Less than £50,000	11	50.00	50.00
£50,000 – £100,000	4	18.18	68.18
More than £100,000	7	31.82	100
Total	22	100	

Source: Survey data

5.1.4 Business sector profiles of tenant firms.

Table 5.6 shows that about 50% of tenant firms in the NSP are engaged in software production and application. This is in part a reflection of Thailand catching on the world-wide phenomenon of exponential growth in information and communication technology (ICT) and knowledge-based technologies over the last two decades, as has been the case in neighbouring Malaysia (Malairaja, 2006). This type of business typically requires small number of employees and small working space; and is able to operate everywhere with high-speed networks. It should be noted that tenant firms engaged in food & agriculture and herbs & cosmetics constitute a relatively low proportion (22.73%) of the NSP residents. This is in spite of the fact that Northern part of Thailand is traditionally a major source of agricultural products, particularly rice and herbs. Other business types in the NSP are energy and environment, experiences design[4], material science, and medical device, together represented by about 27% of the total number of tenant firms in the Park.

Table 5.6 Business sector profiles of tenant firms.

Business sectors	Frequency	Percentage
Energy and Environment	1	4.55
Experience Design	1	4.55
Food & Agriculture	4	18.18
Herbs & Cosmetics	1	4.55
Software & Application	11	49.99
Material Science	2	9.09
Medical Device	2	9.09
Total	22	100

Source: Survey data

[4] Collaborative design approaches for every life challenge combining with architecture, service design, brand experience, lifestyle-product and public behavior.

5.1.5 Business scale profiles of tenant firms.

Based on the data in Table 5.7, there are 11 tenant firms that qualify as small and medium enterprises (SMEs). These constitute about 50% of the population of tenant firms in the Park. There are 10 tenant firms (45% of the firms in the Park) registered as start-up firms. SMEs and start-ups are not the same, though, quite often, both may generically be categorized as small firms. There are a few differences between them. SME is basically defined as an independently owned, managed and operated firm organized for profits. They are normally engaged in conventional activities producing and marketing products that bear little or no technological and market risks (Baskerville, 2015). On the other hand, start-ups are younger than SMEs and seek to trail-blaze new market and technological opportunities. They are based on innovative ideas and aspire to grow fast in competitive markets. They bear a high-risk element and are established on the venture capital model of business funding. According to Harris (2016), one in ten of start-ups might succeed to evolve as 'global born' multinational firms.

Most of tenant firms in the NSP are SMEs (50%) and start-ups (45%). This is the general pattern across science parks around the world. As noted above, there is only one large enterprise, which Japanese-owned.

Table 5.7 Business scale profiles of tenant firms.

Business scale	Frequency	Percentages	Cumulative percentages
Start-up	10	45.45	45.45
SME	11	50.00	95.45
Large enterprise	1	4.55	100
Total	22	100	

Source: Survey data

5.1.6 How tenant firms came to know about the NSP.

Tenant firms were asked as to how they came to know about the NSP. According to Table 5.8, most of them (about 30%) knew about the Park from news and social media. Some (16%) came to know about it through visits and invitation (32%). Exhibitions and availability of incubation facilities attracted only 3% of the resident tenant firms. This shows that news and social media served most effectively to promote the science park. From the experience of the NSP reflected by the survey data, social media appears to have taken over the role of exhibitions in promoting the visibility of science parks to entrepreneurs, and companies.

Table 5.8 The distribution of tenant firms known about the NSP.

Type of known	Responses	percentages
News and social media	11	29.73
Visiting	6	16.21
Invitation	6	16.21
Government agency	5	13.51
Recommended by other firms	5	13.51
Word of mouth	2	5.41
Exhibition	1	2.71
Incubated	1	2.71
Total	37	100

Source: Survey data

5.2 Tenants' attitude to the NSP, innovation and scope for the development of technological capabilities.

5.2.1 Reasons for participating in the NSP.

Table 5.9 shows the Likert's scale results indicating the reasons of tenant firms for deciding to participate in the NSP. The table shows the means and standard deviations for the distribution of factors accounting for the participation of firms in the NSP based on scores averaged across all the firms surveyed.

The reasons for firms to be on Park were explored from the relevant literature and the degree of importance each reason was assigned points on the Likert scale 1 – 5, i.e. correspondingly ranging from strongly unimportant to very important (1=strongly unimportant, 5=very important). Interviewees were asked to rate the degree of importance of their respective reasons for participating in the NSP. They were also asked to prioritize their reasons in order of importance from 1 – 3. The results of the response for this are shown in Table 5.10.

Table 5.9 Distribution of Likert's scale data on firms' reasons for participating in the NSP.

No.	Details	Degree of Importance					Means	S.D.	Interpret
		Strongly unimportant	Unimportant	Undecided	Important	Strongly important			
1	Government incentives	0	2	6	6	8	3.9091	1.0193	Important
		(0.00%)	(9.09%)	(27.27%)	(27.27%)	(36.36%)			
2	Space utility and facilities	0	0	3	5	14	4.5000	0.7400	Strongly important
		(0.00%)	(0.00%)	(13.64%)	(22.73%)	(63.64%)			
3	Prefer to develop R&D	0	0	4	7	11	4.3182	0.7799	Strongly important
		(0.00%)	(0.00%)	(18.18%)	(31.82%)	(50.00%)			
4	Company reputation purpose	0	2	1	10	9	4.1818	0.9069	Important
		(0.00%)	(9.09%)	(4.55%)	(45.45%)	(40.91%)			
5	Innovative improvement; new products/ new processes	1	0	0	12	9	4.2727	0.8827	Strongly important
		(4.55%)	(0.00%)	(0.00%)	(54.55%)	(40.91%)			

6	Accessing research center	1 (4.55%)	1 (4.55%)	5 (22.73%)	7 (31.82%)	8 (36.36%)	3.9091	1.1088	Important
7	Knowledge linkage	0 (0.00%)	0 (0.00%)	3 (13.64%)	9 (40.91%)	10 (45.45%)	4.3182	0.7162	Strongly important
8	Company interaction and exchange idea	0 (0.00%)	0 (0.00%)	4 (18.18%)	7 (31.82%)	11 (50.00%)	4.3182	0.7799	Strongly important
9	Research consultancy	0 (0.00%)	1 (4.55%)	6 (27.27%)	12 (54.55%)	3 (13.64%)	3.7727	0.7516	Important
10	Market opportunity	0 (0.00%)	2 (9.09%)	0 (0.00%)	6 (27.27%)	14 (63.64%)	4.4545	0.9117	Strongly important
11	Business performance; sale growth, cost reduction	0 (0.00%)	0 (0.00%)	1 (4.55%)	8 (36.36%)	13 (59.09%)	4.5455	0.5958	Strongly important

Source: Survey data

Overall, the views of all respondents on each reason was scored above 3.4, which means that in the eyes of the respondents, factors were either important (as in the case of government incentives, companies' drive for reputation, access to research centers and research consultancy); or strongly important (as in the case of attractions of accommodation space, utility and facilities in the Park, interest to develop R&D capability and make innovative improvements to existing products and processes; prospects for developing new products/ new processes; forge knowledge linkages; engage in knowledge sharing and knowledge exchange through interactions with other companies; develop marketing strategies; and enhance business performance). The highest average score is for the 'business performance' factor (4.54), implying that tenant firms joined the NSP in the belief that it would enable them to contribute to improvements in their business and commercial capabilities. The second highest average score (4.5) is for the 'space utility and facilities' factor. The lowest average score (3.77), which falls in the category of important factors, is for the 'research consultancy' factor.

The radar graph method is used below to show the relative importance of the various reasons given by firms for participating in the NSP, according to profiles relating to the age, capital value, business scale, business types, and the NSP experience of tenant firms. The average score of each tenant firm on each reason for participating in the NSP is used as a basis for improving the management of the science park.

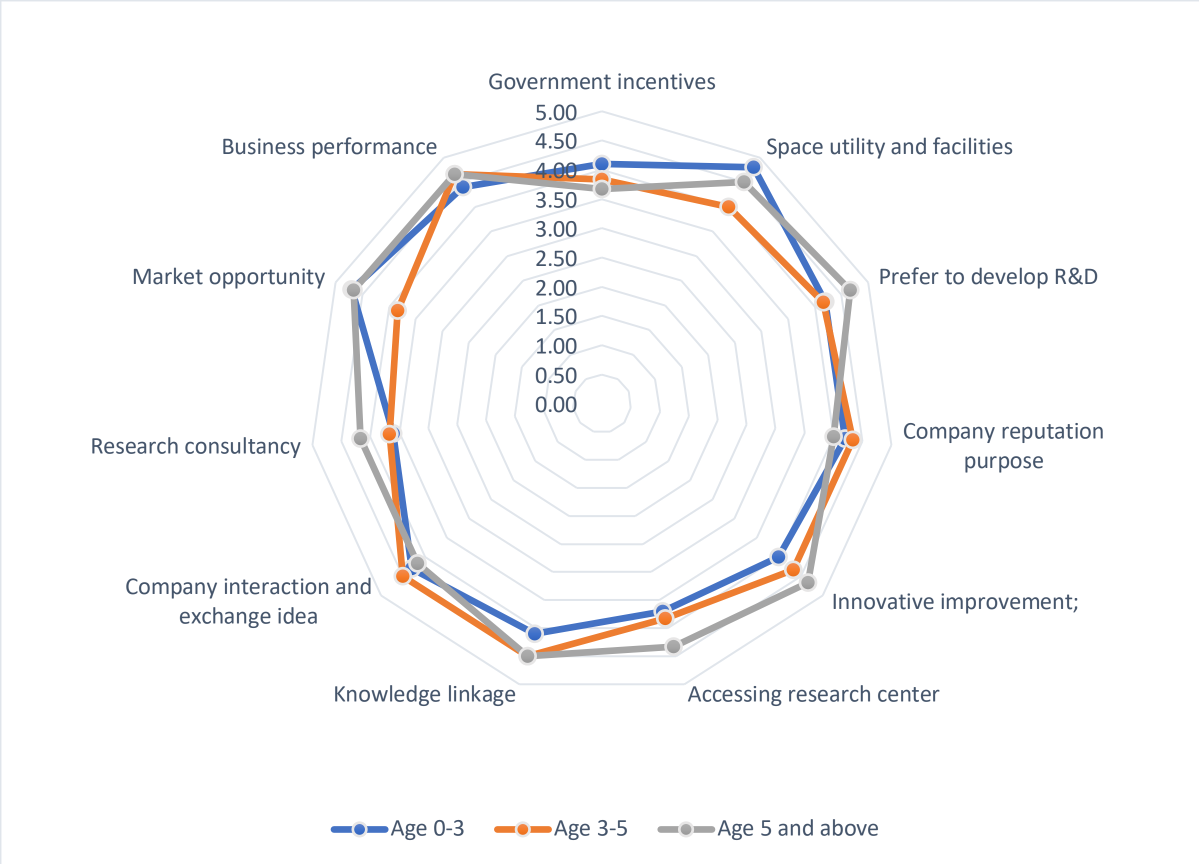

Figure 5.1 Distributed radar graph by age groups of tenant firms.

The radar graph on figure 5.1 states that for all firms in the sample, the age group '5 years and above' is associated with high average factor scores compared with other age groups, particularly the youngest age group, except in the case of factors like government incentives and space utility and facilities. This can possibly be explained by the fact that the more mature firms, unlike the younger ones, have more business and market experiences, and more developed business capacity and healthy financial positions. Therefore, they are more likely to be keen on opportunities for new ideas and for tapping their potential for innovation through research and development activities; accessing knowledge centers, innovative experiences, research consultancy services; and so, learning how to engage in knowledge networks within and out-with the Park.

In contrast, firms in the highest age group have low average scores for company reputation, government incentives, and company interactions. This is because they have long-term experiences and customer trust in the market. On the other hand, firms in the lowest age group (i.e. firms below 5 years of age) have higher average scores for some factors like space, utility and facility. Because younger firms have limited budgets, they are constrained in their production and marketing activities let alone directly engage in innovation schemes; they would therefore be happy if the science park provided them with accommodation space and facilities, as this would release resources that would allow them to invest in activities that could serve in the development of innovation and technological capability.

Provision of Government incentives is the other reason that attracts younger firms into science parks. Such incentives would allow on-park firms to benefit from tax relief and other promotional benefits that are granted to firms only if they locate in science parks. Not surprisingly, space, utility and facility and incentives feature as important factors particularly for younger and new-born firms with limited budgets to prefer on-park rather than off-park location. The NSP appears to play dual roles when looked at from the perspective of the age profile of firms. To the new-born and younger firms, the appeal of the NSP is for the space and facility it offers. This role relates to the 'real estate management' of science parks. To more mature firms, the appeal of science parks is for the environment of interaction and sharing knowledge and experiences among tenants. Generally, science parks are expected to focus on the latter role to be able to cater for the needs of tenant firms to acquire the skills and knowledge that would enable them to enhance their potential to be innovative and competitive.

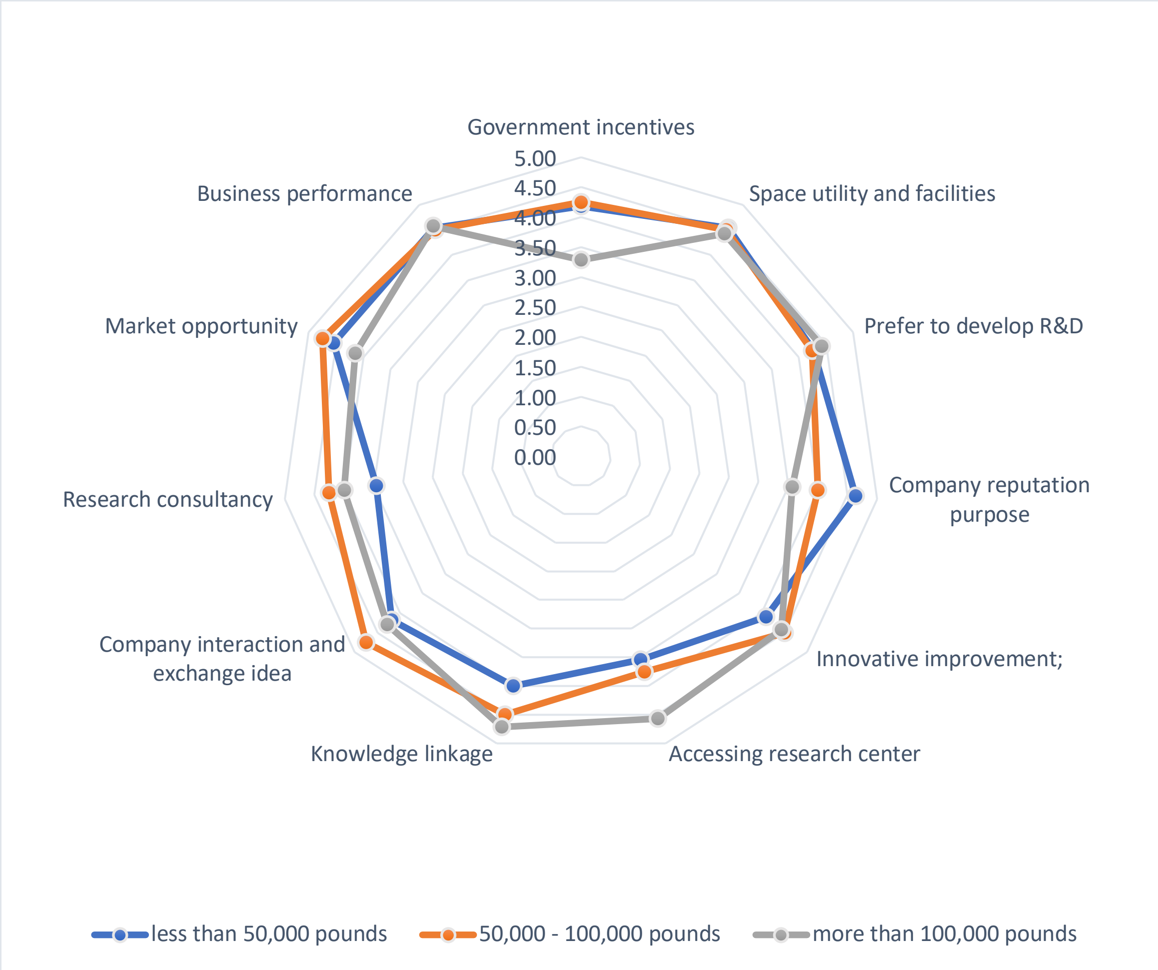

Figure 5.2 Distributed radar graph by capital value of tenant firms.

Figure 5.2 shows how the various reasons respondents gave for their firms' participation in the NSP feature on the capital value profile. The group of firms with lowest capital value appear to prefer promotion of company reputation as a reason for locating on-park, while the group with the highest capital value attribute their participation in the park to a variety of factors, such as opportunities for developing R&D capability, making innovative improvements, accessing research centers, forging knowledge linkages, and enhancing business performance. This might be explained by the fact of their healthy financial status, which gives them the leverage to develop their products by addressing multiple factors that could contribute to the betterment of their business. On the other hand, firms in the group with the lowest average score for capital value give few reasons for seeking residence in the Park, like, for example, interacting with other companies to exchange ideas; improving their reputation, accessing space, utility and facility, and benefiting from government incentives. These reasons might not, however, be of much significance to firms in the group with high capital value because they are financially strong enough with viable cash flows.

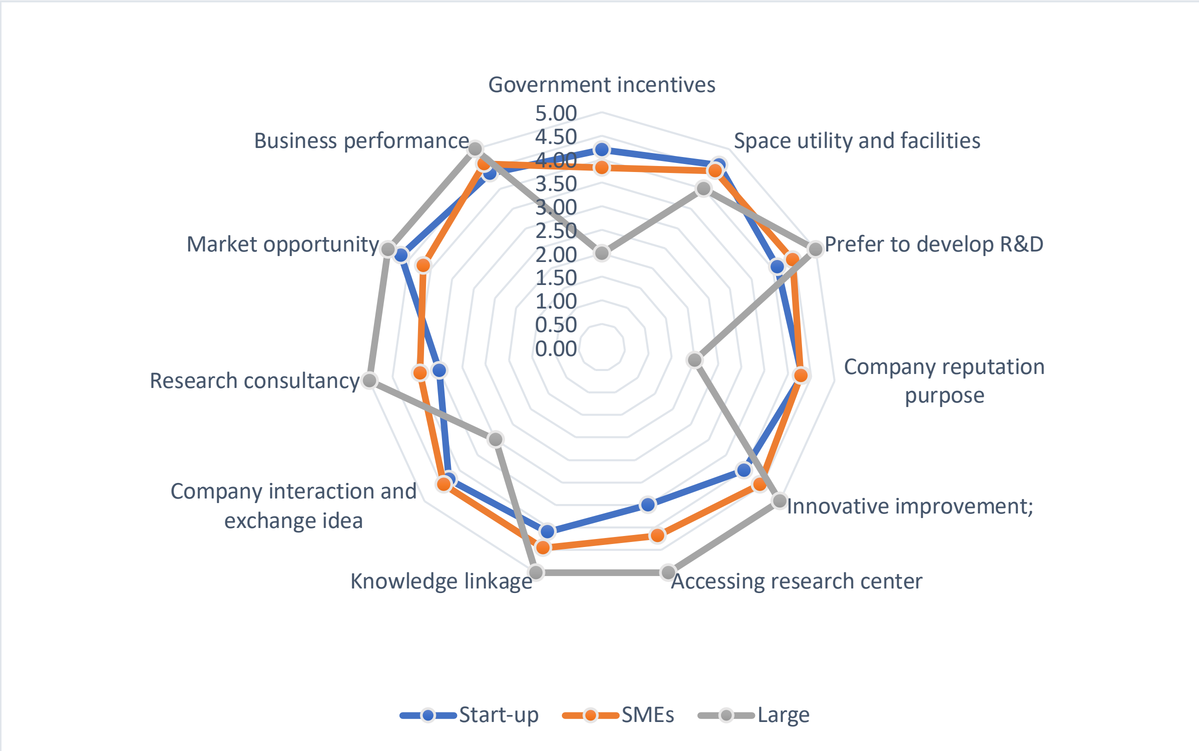

Figure 5.3 Distributed radar graph by the scale of tenant firms.

Figure 5.3 shows the reasons for participating in the NSP across firm categories in terms of business scales – i.e. start-ups, SMEs, and large enterprises. For large scale companies, reputation and government incentives do not feature as important factors for participating in the NSP, apparently because they have strong enough financial position to be in need of government incentives. On the other hand, new and small companies like start-ups and SMEs prefer any provision which could help them reduce cost of investment. It is apparent from Figure 5.3 that factors like space utilities and facilities, government incentive, and company reputation have had significant role in determining decision of firms to locate on park not only from the point of view of reducing investment costs, but also from the vantage point of launching their businesses in the market. Another factor which distinguishes small and medium firms from large firms, with respect to the decision to locate on-park, is the opportunity the Park offers for company interaction and exchange of ideas. This is because, as firms with little or hardly any technological and marketing expertise and experience, they would be keen to network with partners in the park, sharing knowledge and learning from the experiences of others. This provides the basis for SMEs to be creative and innovative; and is very important for them to grow and survive in the market as competitive and even potentially global niche players.

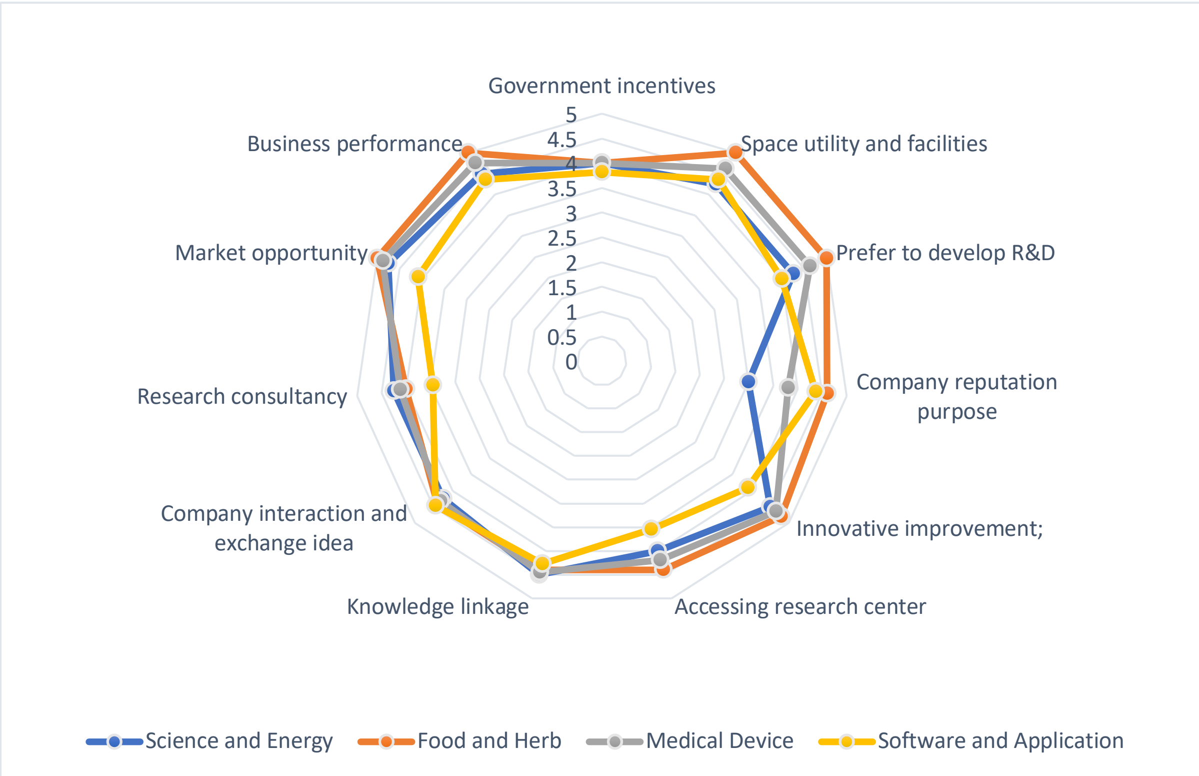

Figure 5.4 Distributed spider graph by business types.

Figure 5.4 illustrates the reasons for participation of firms in the NSP when they are grouped on the profile of the business sectors they come from. The software & application business sector is represented by 50% of the tenant firms in the NSP. However, when compared with the firms in the Park originating from other business sectors, software and application related firms do not appear to feature prominently on most of the factors that influenced the decision they made to participate in the Park. On the other hand, the factors including government incentives, company reputation, knowledge linkage and knowledge exchange appear to have equally appealed to them as they did to firms in the other sectors. But this comparison is clearly uneven since most of the firms are in the category of software & application business sector, while firms from the other business sectors are few and far between in their occurrence across the spectrum of factors influencing firms' decision to locate on-park. For instance, there is only one tenant firm in the energy & environment and experience design business sector, which, being an outlier, is not included in the exercise of comparison between firms coming from different business sectors.

Tables 5.10 and 5.11, and Figure 5.5 show the results of tenant firms indicating their first, second, and third important reasons for participating in the NSP. The purpose of this exercise is to calculate an aggregate score that can be used for extracting the most important reason which accounts for firms joining the NSP as tenants. On the basis of the data in Table 5.10, the first selected reason is multiplied by three, the second by two, and the third by one. Then, the total scores are shown in Table 5.11.

Table 5.10 Ranking of reasons for participating in the NSP.

Reasons for Participating	1st		2nd		3rd	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Government incentives	4	18.18	1	4.55	2	9.09
Space utility and facilities	5	22.73	2	9.09	2	9.09
Prefer to develop R&D	2	9.09	4	18.18	1	4.55
Company reputation purpose	1	4.55	6	27.27	2	9.09
Innovative improvement; new products/ new processes	4	18.18	2	9.09	2	9.09
Accessing research center	0	0.00	1	4.55	3	13.64
Knowledge linkage	1	4.55	0	0.00	1	4.55
Company interaction and exchange idea	2	9.09	1	4.55	2	9.09
Research consultancy	0	0.00	0	0.00	0	0.00
Market opportunity	2	9.09	3	13.64	2	9.09
Business performance; sale growth, cost reduction	1	4.55	2	9.09	5	22.73
Total	22	100	22	100	22	100

Source: Survey data

Table 5.11 Total score added of reason for participating in the NSP.

Reasons for Participating	Total score	Ranking
Government incentives	16	4
Space utility and facilities	21	1***
Prefer to develop R&D	15	5
Company reputation purpose	17	3*
Innovative improvement; new products/ new processes	18	2**
Accessing research center	5	9
Knowledge linkage	4	10
Company interaction and exchange idea	10	7
Research consultancy	0	11
Market opportunity	14	6
Business performance; sale growth, cost reduction	12	8

Source: Survey data

Table 5.11 shows the total scores for each factor alluded as reason for joining the Park. The highest total score is for the 'space, utility and facilities' factor; the second for the 'innovative improvement' factor; and the third for the 'company reputation' factor.

This corresponds to the Likert scale finding that it is the 'space, utility and facilities' factor that matters for most tenant firms - particularly firms that are new and with low capital value - as this factor would reduce the heavy overhead costs they would be landed with for developing infrastructure and facility if they did not choose to locate in the NSP. While this is the immediate concern for these firms, they do not appear to be limited in their aspiration as they also show concern for the 'innovative improvement' that has implications for long-term business growth. This, indeed, is an essential objective for their participation in science parks. This is particularly the case with firms engaged in activities involving, for example, agricultural products, food supplements, and cosmetics that call on the development of in-house research and development capabilities. Company reputation ranks third. This factor is important as it has implications for the ability of firms to increase their market share. This view is usually entertained by firms when considering location in science parks as a long-term benefit to be derived as a result of locating on-park (Phillips and Yeung, 2003). Science parks would be preferred by tenant firms since they are usually expected to increase firms' reliability and trust in the eyes of customers. This is particularly true of newborn firms that lack the experience of finding their feet in the market.

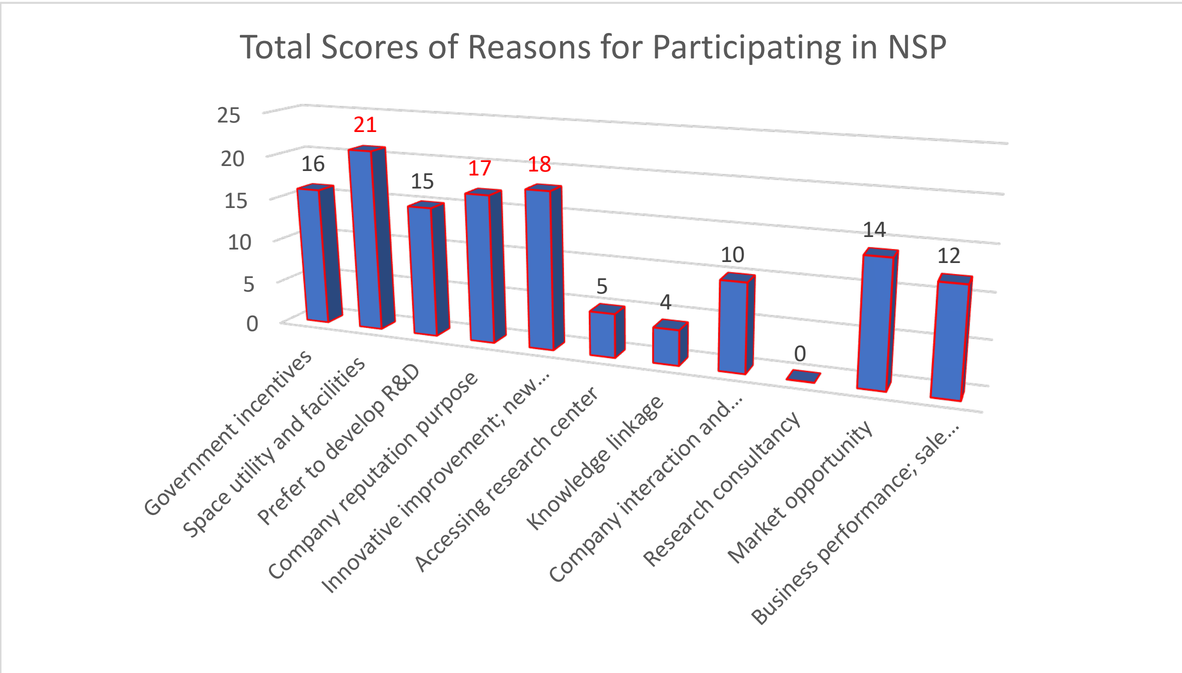

Figure 5.5 Graph of total scores of reasons for participating in the NSP.

Figure 5.5 above shows the reasons why tenant firms believe participation in the NSP could be supportive and helpful to them. It is apparent that tenant firms have multiple reasons for participating in science parks, although the principal factor for many tenants, particularly start-up firms, remains space and facility. This is important as it provides the infrastructural basis, which would allow them to plan for the way forward and engage in the development of innovative products or processes that are capable of being commercialized. The ‘company reputation’ and ‘market opportunity’ factors are also important considerations of tenant firms seeking to have competitive edge in the market.

The survey involving 11 reasons for participating in the NSP are condensed and categorized into three groups as shown in Table 5.12 - space and facilities, knowledge linkage, and market reputation and business growth.

Table 5.12 Categorizing factors for participating in the NSP into three generic groups.

Reasons for participating	Generic factors
Space utility and facilities	Infrastructure & networking factor
Company interaction and exchange idea	
Prefer to develop R&D	Research and development factor
Innovative improvement; new products/ new processes	
Accessing research center	
Knowledge linkage	
Research consultancy	
Government incentives	Business development factor
Company reputation	
Market opportunity	
Business performance; sale growth, cost reduction	

The management of science parks recognize the stage of development tenant firms are at the point of entry into the Park and would therefore be expected to provide proper advice and the kind of support firms need while on-park. The challenge facing most science parks in developing countries, in general, is one of extending their services beyond the provision of infrastructure and facilities. In principle, however, there is more to the function of science parks than real estate management.

Table 5.13 Details of tenant firms (year establishment, business types, scale).

No. of tenant firms	Year of establishment	Business scale	Business types
1	1990	SME	Materials Science & Chemicals
2	2017	SME	Herbs & Cosmetics / Materials Science & Chemicals / Food & Agriculture
3	2016	Startup	ICT & Software
4	2017	Startup	ICT & Software
5	2016	SME	ICT & Software
6	2014	SME	Food & Agriculture
7	2017	Startup	ICT & Software
8	2017	Startup	ICT & Software
9	2000	Large	Materials Science & Chemicals
10	2005	SME	Food & Agriculture
11	2018	Startup	Food & Agriculture
12	2017	Startup	ICT & Software
13	2018	Startup	Medical Device & Pharmaceutical
14	2016	SME	ICT & Software
15	2015	SME	ICT & Software
16	2004	SME	Experience Design Service
17	2005	SME	Food & Agriculture
18	2018	Startup	Energy
19	2018	Startup	Medical Device & Pharmaceutical
20	2014	SME	ICT & Software

21	2017	Startup	ICT & Software
22	2005	SME	ICT & Software

Source: Survey data

Table 5.14 Calculation of each main category for individual tenant firms.

Number of Tenant firms	Infrastructure & networking factor		(Sum*10) / total score	Research and development factor					(Sum*10) / total score	Business development factor				(Sum*10) / total score
	Space utility and facilities	Company interaction and exchange idea		Prefer to develop R&D	Innovative improvement	Accessing research centers	Knowledge linkage	Research consultancy		Government incentives	Company reputation	Market opportunity	Business performance	
1	5	5	10	5	5	5	5	4	9.6	5	5	5	5	10
2	5	5	10	5	5	5	5	4	9.6	5	5	5	5	10
3	3	5	8	4	5	3	5	3	8	5	5	5	5	10
4	5	5	10	4	4	5	5	4	8.8	5	5	5	5	10
5	5	5	10	5	5	5	5	5	10	4	5	5	5	9.5
6	5	4	9	5	4	4	4	4	8.4	4	5	5	5	9.5
7	5	4	9	5	4	4	4	4	8.4	4	5	5	5	9.5
8	5	4	9	4	4	3	4	3	7.2	4	4	5	5	9
9	4	3	7	5	5	5	5	5	10	4	4	5	5	9
10	5	3	8	5	5	4	3	4	8.4	3	5	5	5	9
11	5	5	10	5	5	5	5	4	9.6	5	5	5	3	9

Number of Tenant firms	Infrastructure & networking factor		(Sum*10) / total score	Research and development factor					(Sum*10) / total score	Business development factor				(Sum*10) / total score
	Space utility and facilities	Company interaction and exchange idea		Prefer to develop R&D	Innovative improvement	Accessing research centers	Knowledge linkage	Research consultancy		Government incentives	Company reputation	Market opportunity	Business performance	
12	5	4	9	4	4	3	4	3	7.2	3	4	5	5	8.5
13	4	4	8	5	5	5	4	5	9.6	5	4	4	4	8.5
14	3	5	8	3	4	3	4	3	6.8	5	3	4	5	8.5
15	3	5	8	3	4	3	4	3	6.8	4	4	4	4	8
16	4	5	9	4	4	4	5	4	8.4	5	2	5	4	8
17	5	5	10	5	5	4	5	4	9.2	3	4	4	4	7.5
18	4	4	8	3	4	2	3	4	6.4	3	4	4	4	7.5
19	5	3	8	4	4	4	4	3	7.6	2	2	5	5	7
20	5	3	8	5	4	5	5	4	9.2	2	4	4	4	7
21	5	5	10	3	1	1	3	2	4	3	4	2	4	6.5
22	4	4	8	4	4	4	4	4	8	3	4	2	4	6.5

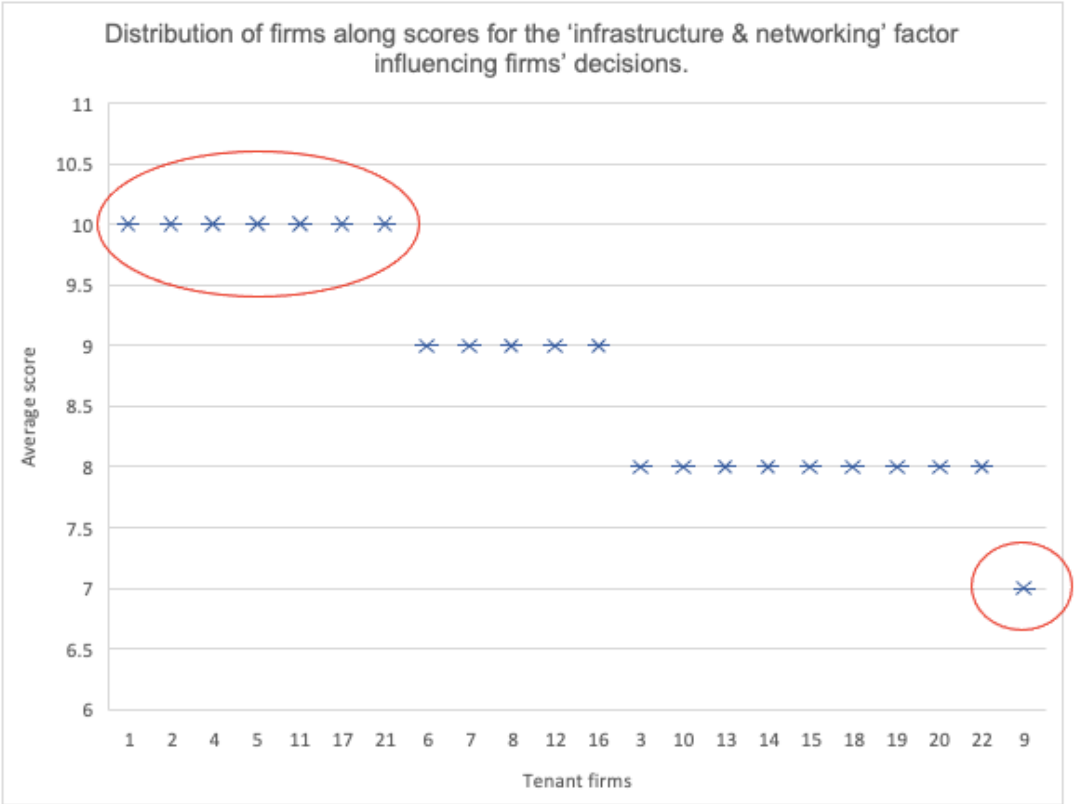

Figure 5.6 Distribution of firms along scores for the ‘infrastructure & networking’ factor influencing firms’ decisions.

Figure 5.6 shows the distribution of tenant firms along scores for the ‘infrastructure and networking’ factor (which covers space and facilities, company interactions and exchange of ideas). There are four groups of average scores, 10 for 7 tenant firms, 9 for 5 tenant firms, 8 for 9 tenant firms, and 7 for only 1 tenant firm. The group with highest score shows members of tenant firms, including firms 1, 2, 4, 5, 11, 17, and 21. Of these, three are SMEs and four are start-ups. It might be argued that SMEs and start-up firms prefer basic park services, like infrastructure (space and facilities) to be able to find their feet as business enterprises. If science parks provided basic infrastructure and networking opportunities, firms would be happy to participate. This is not the case for all firms, however. For instance, firm number 9 scores 7 on this, which is the lowest score for the population of firms covered in the survey. Firm number 9 is a large enterprise wholly owned by

Japanese investors. Large enterprises, unlike small enterprises rarely experience cash flow problems, and have, therefore, little to worry about basic infrastructural support to make the factor significant for their decision to participate in science parks.

Figure 5.6 shows assorted business types in the group of highest score (firms number 1, 2, 4, 5, 11, 17, 21). This group includes: one tenant firm from the sector of herbs and cosmetics; one from material science; two from food and agriculture; and three from software and application. From analysis of firms categorised on this basis, the 'infrastructure & networking' factor influencing decision for participating in the NSP does not appear to feature in any significant way. This is possibly because the 'infrastructure & networking' factor applies to firms across all business categories. In other words, firms in any business category would prefer to be provided with infrastrucure facilities and opportunities for networking as a basis for choosing to locate on-park.

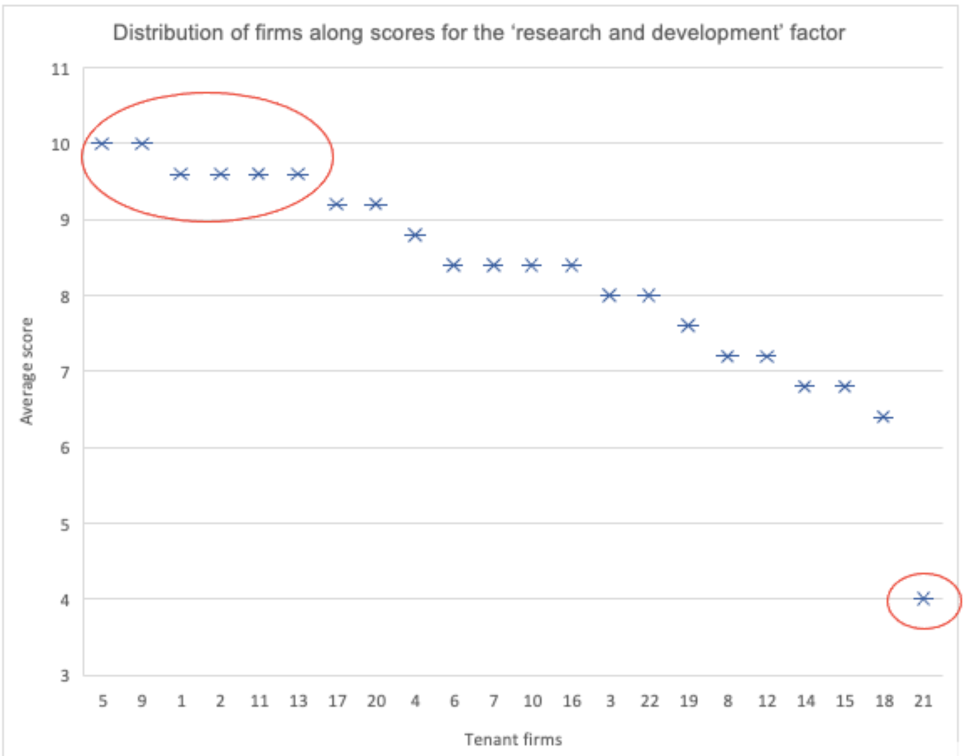

Figure 5.7 Distribution of firms along scores for the ‘research and development’ factor

Figure 5.7 shows the distribution of tenant firms on scores for the ‘research and development’ factor (i.e. engagement in R&D development; innovative improvement; accessing research centers and research consultancy; and developing knowledge linkages) influencing firms’ decision to participate in science parks. The highest scoring group shows 6 tenant firms with scores ranging between 9.6 and 10. One of these is a large enterprise; 3 are start-up firms; and 2 are SMEs. The group of tenant firms with the lowest average score of 4 includes start-up firms who do business in software and application. They design mobile applications for shop management; take stock of products, look after the financial accounting of the business and make daily financial reports, which can be accessed by mobile application. This application has also been used by over twenty shop owners. Because of the finished form of the end-product, the relevance of research and devlopment was not considered significant in this case. This was clearly brought out in the interviews.

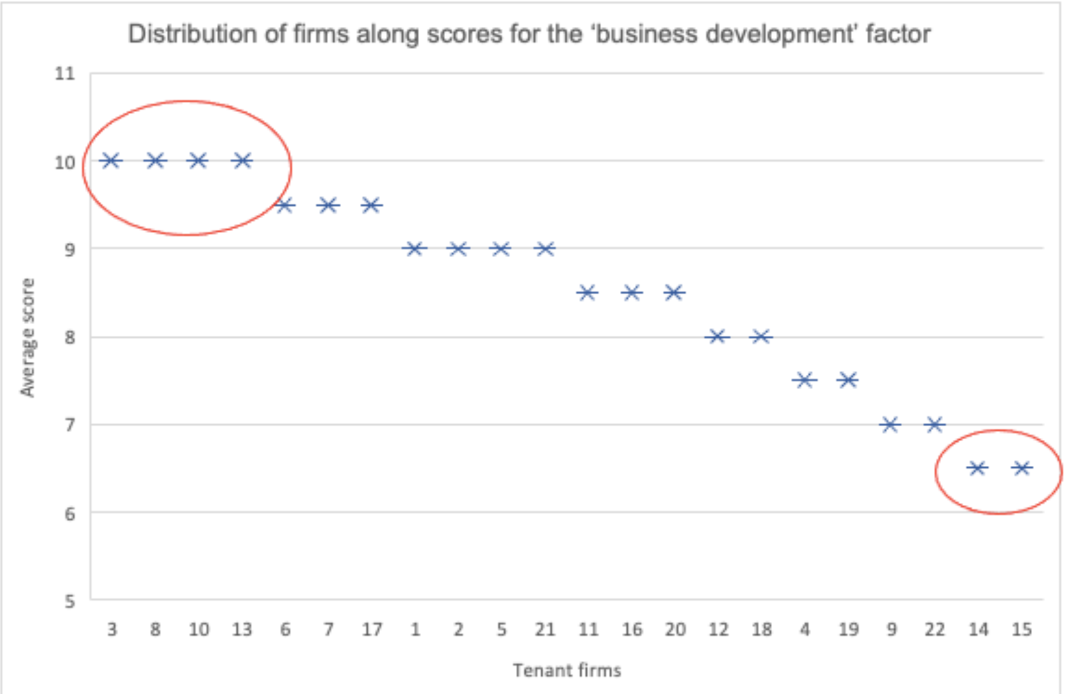

Figure 5.8 Distribution of firms along scores for the 'business development' factor.

Figure 5.8 shows the distribution of tenant firms along score for the 'business development' factor (which relates to government incentives, company reputation, market opportunity, and business performances). There are 4 tenant firms (tenant firms 3, 8, 10, and 13), each with the highest average score of 10. These include three start-ups and one SME - two of these are from software and application; one from food and agriculture; and one from medical devices. These are new entreprises expecting their businesses to grow and rise to the challenges of competition in the market. The lowest average of 6.5 was scored by an SME from software and application. One large enterprise, (tenant firm number 9), scored 7. This is relatively low compared with the average score of smaller firms, which reflects the ability of large firms to survive in highly competitive markets because of the edge they have in business capability and customer loyalty.

5.2.2 Tenants' view for innovative activities

5.2.2.1 R&D expenditure

In this part, we explore the views of tenant firms about the likelihood of their preparedness to engage in innovative activities as a result of their participation in the NSP. Table 5.15 indicates the type of expenditures tenant firms would make to invest in innovative activities. The result shows that in the overall schedule of investment expenditure for innovation, R&D labour costs stand out prominently with a score of 4.68. Other factors of significance are knowledge linkage and software and technology, which scored 4.45 and 4.01 respectively. Table 5.15 below shows the degree of importance that tenant firms would attach to the various components of R&D when deciding on investment expenditure. These R&D components are then set against the age, business scale, capital cost (investment cost), and business type factors to gauge the key factors that would influence the engagement tenant firms in R&D activities through investment expenditures.

Table 5.15 Type of R&D expenditures for innovation investment by Likert's scale.

No.	Components of R&D expenditures	Degree of Importance					Means	S.D.	Interpret
		Strongly unimportant	unimportant	Undecided	important	Strongly important			
1	R&D labour cost	0	0	1	5	16	4.6818	0.5679	Strongly important
		(0.00%)	(0.00%)	(4.55%)	(22.73%)	(72.73%)			
2	Land, building & other structure	2	2	5	7	6	3.5909	1.2596	important
		(9.09%)	(9.09%)	(22.73%)	(31.82%)	(27.27%)			
3	Machinery and equipment	2	0	9	7	4	3.5000	1.1019	important
		(9.09%)	(0.00%)	(40.91%)	(31.82%)	(18.18%)			
4	software / technology	0	0	2	9	11	4.4091	0.6661	Strongly important
		(0.00%)	(0.00%)	(9.09%)	(40.91%)	(50.00%)			
5	Patents or other intellectual property	1	2	9	4	6	3.5455	1.1434	important
		(4.55%)	(9.09%)	(40.91%)	(18.18%)	(27.27%)			
6	Knowledge Linkage	0	2	0	6	14	4.4545	0.9117	Strongly important
		(0.00%)	(9.09%)	(0.00%)	(27.27%)	(63.64%)			
	Total	5	6	26	38	57	4.0303	1.0767	important
		(3.79%)	(4.55%)	(19.70%)	(28.79%)	(43.18%)			

Source: Survey data

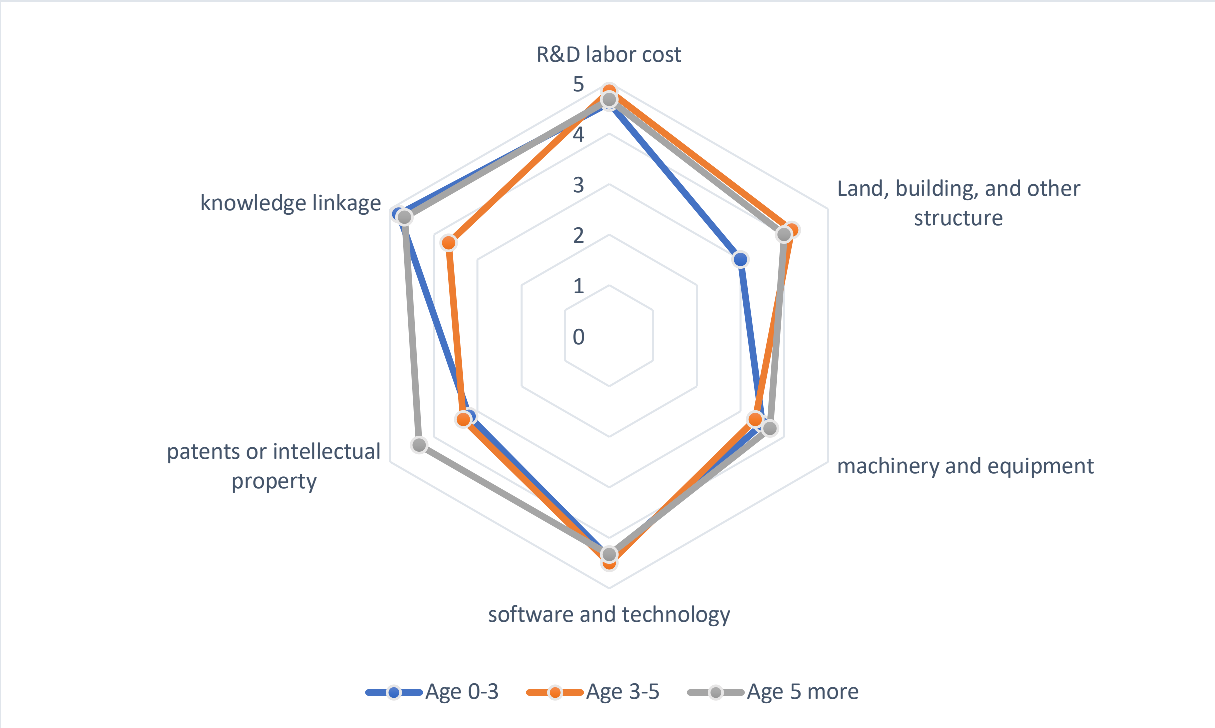

Figure 5.9 Distribution of Investment expenditure across R&D components when firms are set by the age group factor.

Figure 5.9 shows that firms of all age groups would consider investment in R&D manpower, (such as researchers, research consultancy or specialists who are able help firms producing innovative products), crucial for R&D initiatives to be effective. The ‘knowledge network’ factor linking tenant firms with researchers or specialists also scores high, particularly for firms in the youngest and oldest age groups covered in the survey. Recognition of this factor by the firms is important as it is across this network that science park services are delivered to enable firms to generate new ideas that would underpin the development of new products and new processes. With respect to the ‘patent or intellectual property’ and ‘machinery and equipment’ factors, older firms show higher average scores than firms in the other age groups. This is much in keeping with expectation as older firms generally have healthy financial positions and more experience of investment in innovative activities than firms in the younger age groups. Older firm are able to invest in patents or intellectual property and they can use this knowledge to produce new products or generate new ideas of their own. Machinery and equipment are expensive to invest in as are buildings and other infrastructure items. These are generally more accessible older firms than to younger ones. Younger firms show higher average scores only on knowledge linkage which is cheaper than other types of expenditure, as knowledge is often freely dispensed to firms by universities and public research institutes while on-park. Interestingly, the data suggest that younger firms do not want to invest in patents and infrastructure as these are considered to be high budget initiatives. On the other hand, younger firms can rent space at cheap rate as well as having access to various sources of knowledge by locating in science parks. In view of this, their low scores on investment in the 'land, building and structures' component of R&D is hardly surprising.

It is useful to understand how firms in various age groups would consider making their R&D investments effective for improving innovation prospects, as this would at least help science parks to design policies for supporting firms in the various age groups.

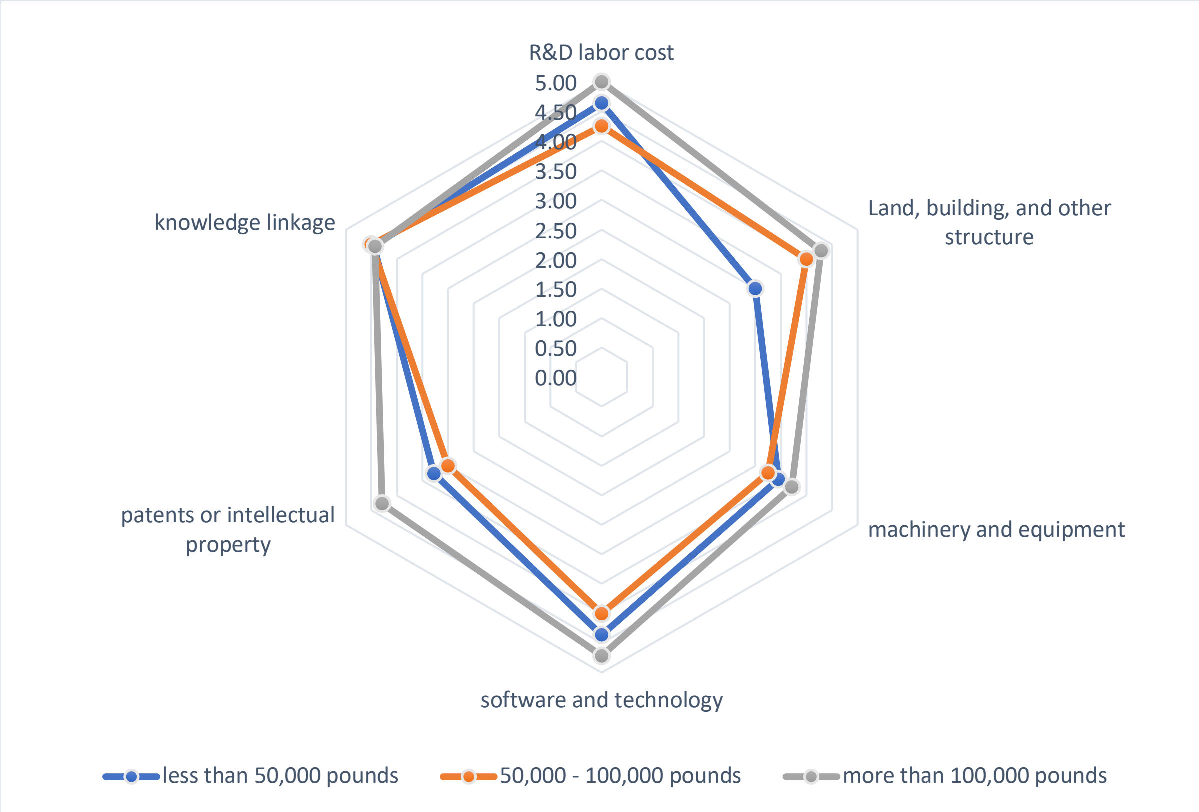

Figure 5.10 Distribution of investment expenditure across R&D components when firms are grouped by the investment cost factor.

From a reading of Figure 5.10 on the 'firm-preferred' distribution of investment expenditure across & R&D components when firms are grouped by investment/capital cost, it is not perhaps surprising that the group of low capitalized firms are shown to have low average scores in every type of R&D expenditure. On the other hand, the group of high capitalized firms are shown to have high scores on all components R&D investment expenditure (R&D manpower, land and buildings, machinery, software, patents and knowledge linkage). Among the firms covered in this study, there is only one firm in the group of highly capitalized firms that is almost 20 years old. This is a large enterprise owned by Japanese investors. Interestingly, the group of firms with medium level of capitalization show high average scores with respect to R&D expenditure in infrastructure, machinery and equipment, software and technology, R&D manpower, and patent or intellectual property. These are firms that are growing and would prefer to invest in innovation initiatives.

Figure 5.11 Distribution of Investment expenditure across R&D components when firms are set by the business scale factor.

According to Figure 5.11, start-ups do not appear to be keen to invest in high budget categories, such as infrastructure, machinery and equipment, patents or intellectual property, and R&D manpower. Instead, they would choose residence in science parks as the best way for them to benefit from the facilities the Park offers, like, for example, access to accommodation space and incubating facilities; knowledge and marketing networks; and funding opportunities. This is why there is a relatively large number of start-ups and small firms participating in the science park. SMEs have more experience than start-ups on both the technology and market fronts, but they still need support from innovative intermediaries, like science parks. They are often observed investing in key areas crucial for the growth of innovative enterprises, such as software and technology, machinery and equipment, patents, facilities and

R&D staff development.

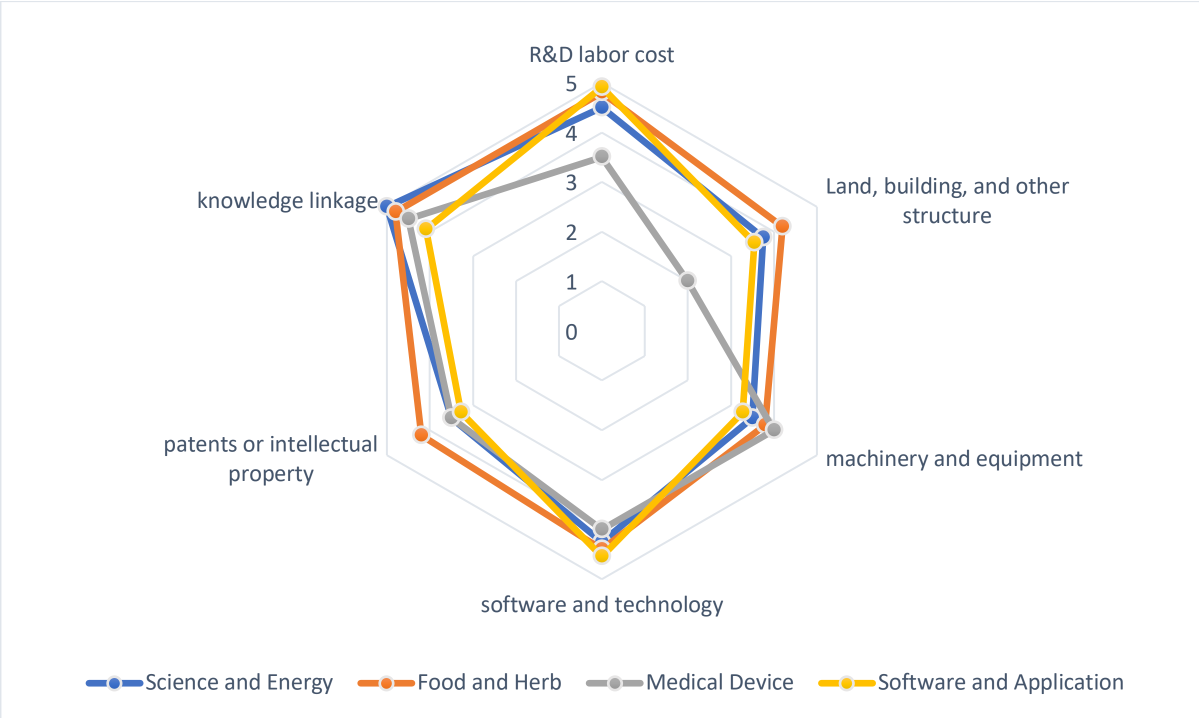

Figure 5.12 Distribution of Investment expenditure across R&D components when firms are set by the business sectors factor.

Figure 5.12 shows the 'software and technology' component of R&D as an important factor for firms in all business sectors considered in the study as a priority area for R&D investment. The 'software and technology' factor helps firms to enhance their productivity performance and competitiveness by reducing unit cost of output. Currently, in the NSP, half of the tenants are software and technology firms. These firms score low on patents, knowledge linkage, machinery, and infrastructure. This could be explained by the fact that firms from this sector would normally require small space, equipment, and knowledge linkage, while preferring to take on specialists in advanced software and technology, thereby increasing investment commitment for R&D staff. In addition, the group of software and technology firms do not appear to put emphasis on patents; nor do they apply for intellectual property rights (IPRs) because they think that the innovation cycle in the area of software and technology is short as technologies change rapidly. On the other hand, firms from the food and herbs category prefer to invest in infrastructure and machinery because this business sector characteristically requires wide accommodation space for processing of raw materials, packaging and warehousing of products.

5.2.2.2 Purpose of R&D investment

Table 5.16 shows average scores of over 4.2 for the various factors specified as purposes for engaging in R&D investment, which suggests that firms are keen to improve existing products or processes; developing new products or processes; and investing in researcher skill development, in the acquisition machinery and equipment, and in promoting innovative activities.

Table 5.16 R&D investment purposes by Likert's scale.

No.	Purposes for investment in R&D	Degree of agreement					Means	S.D.	Interpretation
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
1	Improving existing product or process	0 (0.00%)	0 (0.00%)	4 (18.18%)	6 (27.27%)	12 (54.54%)	4.3636	0.7464	Strongly agree
2	Developing new product or process	0 (0.00%)	0 (0.00%)	2 (13.64%)	5 (18.18%)	15 (68.18%)	4.5714	0.6761	Strongly agree
3	Researchers skill development	0 (0.00%)	0 (0.00%)	2 (9.09%)	7 (31.82%)	13 (59.09%)	4.5000	0.6726	Strongly agree
4	Acquisition of machinery, equipment (including computer hardware), and software.	0 (0.00%)	0 (0.00%)	6 (27.27%)	5 (22.73%)	11 (50.00%)	4.2273	0.8691	Strongly agree
5	Acquisition of other external knowledge (purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other	0 (0.00%)	1 (4.55%)	9 (40.91%)	3 (13.64%)	9 (40.91%)	3.9091	1.0193	Agree

No.	Purposes for investment in R&D	Degree of agreement					Means	S.D.	Interpretation
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
	enterprises or organizations including consultants)								
6	Market introduction of innovations (Market research, changes to marketing methods, and launch advertising)	1	0	1	8	12	4.3636	0.9535	Strongly agree
		(4.55%)	(0.00%)	(4.55%)	(36.36%)	(54.55%)			
	Total	1	1	24	34	72	4.3257	0.8515	Strongly agree
		(0.76%)	(0.76%)	(18.18%)	(25.76%)	(54.54%)			

Source: Survey data

5.2.2.3 Factors inhibiting R&D and innovative activities.

Understanding the factors that inhibit R&D and innovation activities is important for strengthening policy initiatives addressing the role of science parks in promoting R&D and innovation activities, and for science parks to prioritize these factors as problems that would need to be addressed. Table 5.17 shows that firms 'strongly agree' lack of qualified personnel (with average score at 4.40) and lack of information about markets (with average score at 4.27) to be major inhibiting factors. This is broadly in keeping with expectation. The provision of qualified personnel like skilled researchers or experts is crucial for all firms to engage in R&D and innovative activities. The provision of infrastructure and facility, however important and necessary, is not sufficient to ensure innovation to succeed. For this to happen, it has to be complemented with excellent research and consultancy skills. The latter are invariably short in supply among young firms, particularly start-ups and SMEs, as they involve high investment costs. It is particularly for this reason that young firms often find science parks a convenient incubating ground as science parks provide the platform for triple helix-based networking, involving universities/ research centers, government agencies, and private sector organizations from business and industry.

The radar graphs in Figures 5.13–5.16 show factors preventing R&D and innovative activities across firms profiled by age, investment cost, business scale, and business sectors.

Table 5.17 Factors inhibiting R&D and innovative activities.

No.	Details	Degree of agreement					Means	S.D.	Interpret
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
1	Lack of funds within your enterprise or group	1	0	5	4	12	4.1818	1.0970	Agree
		(4.55%)	(0.00%)	(22.73%)	(18.18%)	(54.55%)			
2	Lack of finance from sources outside your enterprise	1	0	8	2	11	4.0000	1.1547	Agree
		(4.55%)	(0.00%)	(36.36%)	(9.09%)	(50.00%)			
3	Innovation cost too high	1	1	6	5	9	3.9091	1.1509	Agree
		(4.55%)	(4.55%)	(27.27%)	(22.73%)	(40.91%)			
4	Lack of qualified personnel	0	1	2	6	13	4.4091	0.8541	Strongly agree
		(0.00%)	(4.55%)	(9.09%)	(27.27%)	(59.09%)			
5	Lack of information on technology	0	2	2	9	9	4.1364	0.9409	Agree
		(0.00%)	(9.09%)	(9.09%)	(40.91%)	(40.91%)			
6	Lack of information on markets	1	1	2	5	13	4.2727	1.1205	Strongly agree
		(4.55%)	(4.55%)	(9.09%)	(22.73%)	(59.09%)			
7	Market dominated by established enterprises	1	2	5	6	8	3.8182	1.1807	Agree
		(4.55%)	(9.09%)	(22.73%)	(27.27%)	(36.36%)			

No.	Details	Degree of agreement					Means	S.D.	Interpret
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
8	Uncertain demand for innovative goods or services	2	3	7	3	7	3.4545	1.3355	Agree
		(9.09%)	(13.64%)	(31.82%)	(13.64%)	(31.82%)			
9	Laws or regulation impediments	1	2	5	4	10	3.9091	1.2309	Agree
		(4.55%)	(9.09%)	(22.73%)	(18.18%)	(45.45%)			
	Total	8	12	42	44	92			
		(4.05%)	(6.06%)	(21.21%)	(22.22%)	(46.46%)			

Source: Survey data

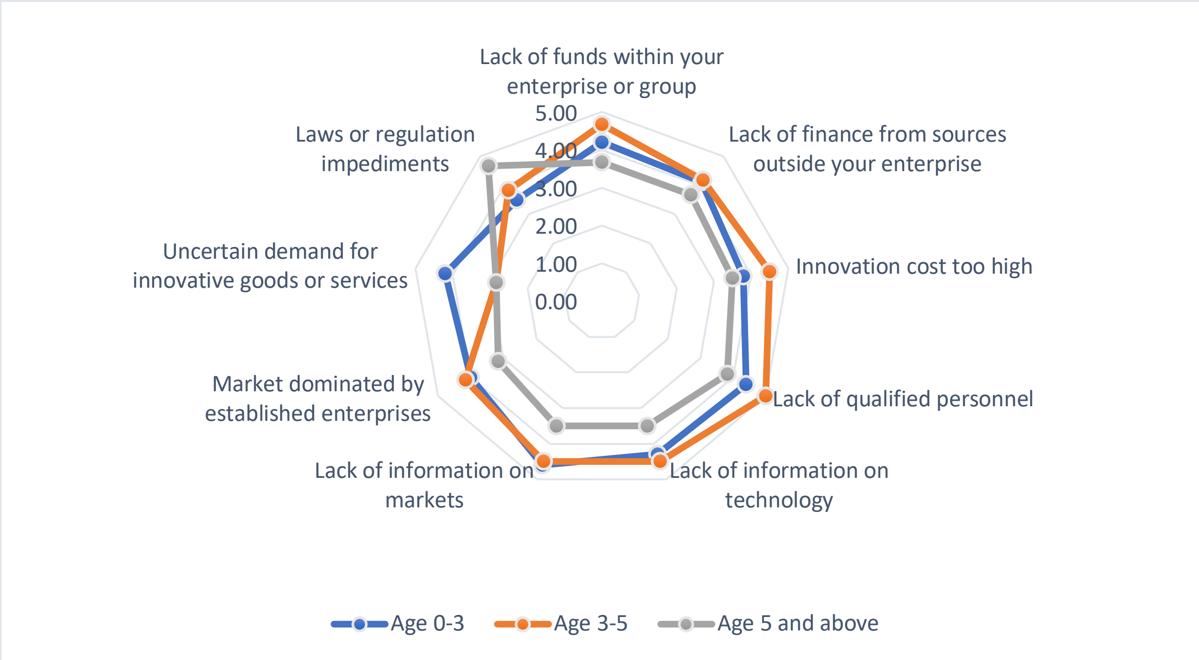

Figure 5.13 Factors inhibiting innovative activities by age group of tenant firms.

Figure 5.13 shows how tenant firms across various age groups of firms relate to the factors that inhibit innovation. Younger firms are shown to be uncertain about the need for engaging in innovation, since they lack information about markets. They would need support in the form of product and market consultancy, so that they would know the products with high market impact which their business strategies should focus on. This would help young firms to grow in confidence and engage in R&D activities that would enable them to deliver innovative products and processes.

Tenant firms in the middle age category show higher average scores on access to funding, cost of innovation, lack of qualified personnel and information on technology, and dominance of markets by large and established enterprises as inhibiting factors. Normally, those in the middle age cohort are SMEs who have been in the market for a while but do not have enough business, market and technology experiences, nor strong financial position to compare with large enterprises. They have business plans but would still need resources for investment in production lines. They usually seek external partners to co-operate with, which they find useful for reducing risk and cost, and for sharing resources.

The oldest firms in the NSP show only one factor – namely, legal and regulatory impediments – with high average score, and they are observed with low average scores on other factors. This is reflective of their long-term experiences and of their robust financial position, which means that they are not, unlike the younger firms, constrained by obstacles such as access to funding, supply of skilled researchers, and availability of market information.

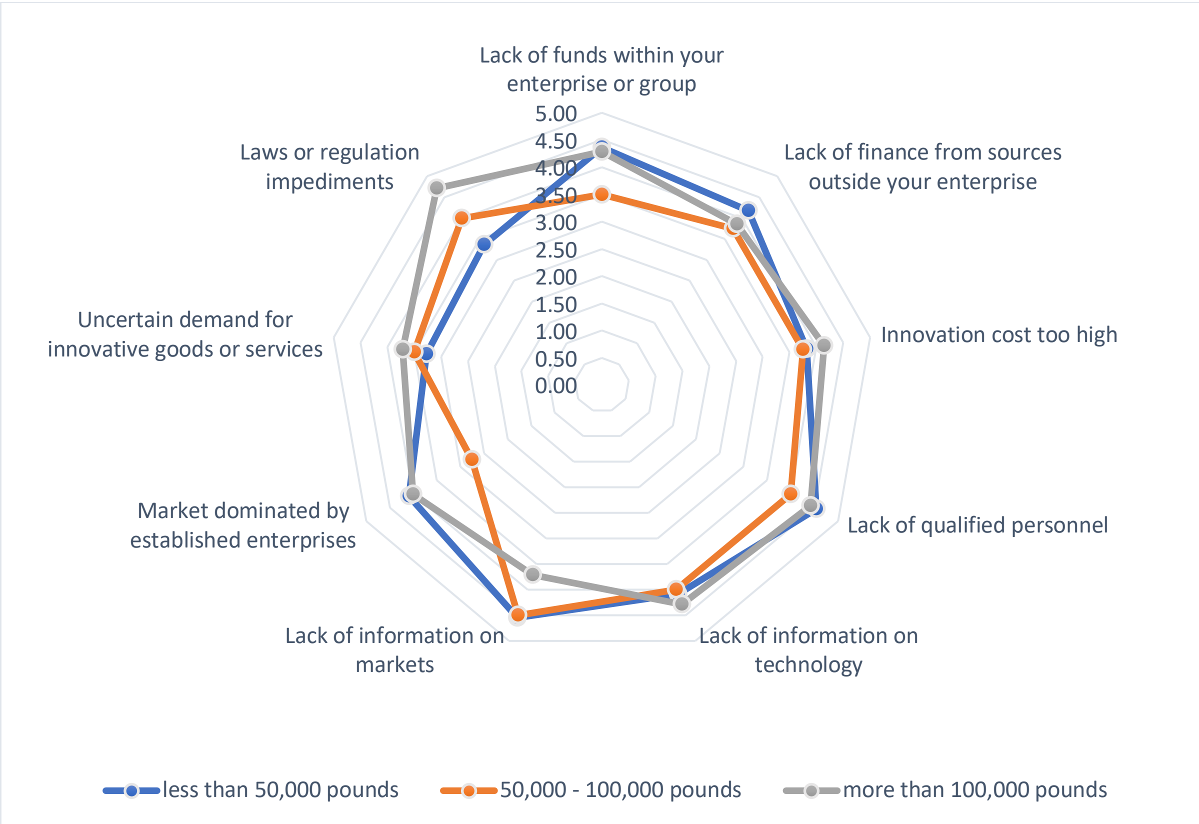

Figure 5.14 Factors inhibiting innovative activities by investment cost.

Figure 5.14 shows tenant firms who have low capital cost do not consider legal and regulatory mechanisms to be a major problem. In contrast, lack of market information, lack of qualified personnel, and lack of outsourced funding are shown to be factors that would constrain R&D and innovative activities. This observation is not surprising, considering that most tenant firms in the NSP who have low capital cost are start-ups and SMEs. Tenant firms in the middle capital cost group show a host of factors that would hold them back from engaging in R&D and innovative activities, including lack of funding, lack of qualified personnel, lack of information technology and market, legal and regulatory impediments, market uncertainties facing innovated products and services, and dominance of markets by large and established firms. One factor is common between tenant firms in the middle and high categories of capital cost – namely, the legal and regulatory factor. This observation suggests that science parks would need to question whether it is not high time that new legal and regulatory measures were put in place to facilitate the development of innovative and entrepreneurial behavior among tenant firms.

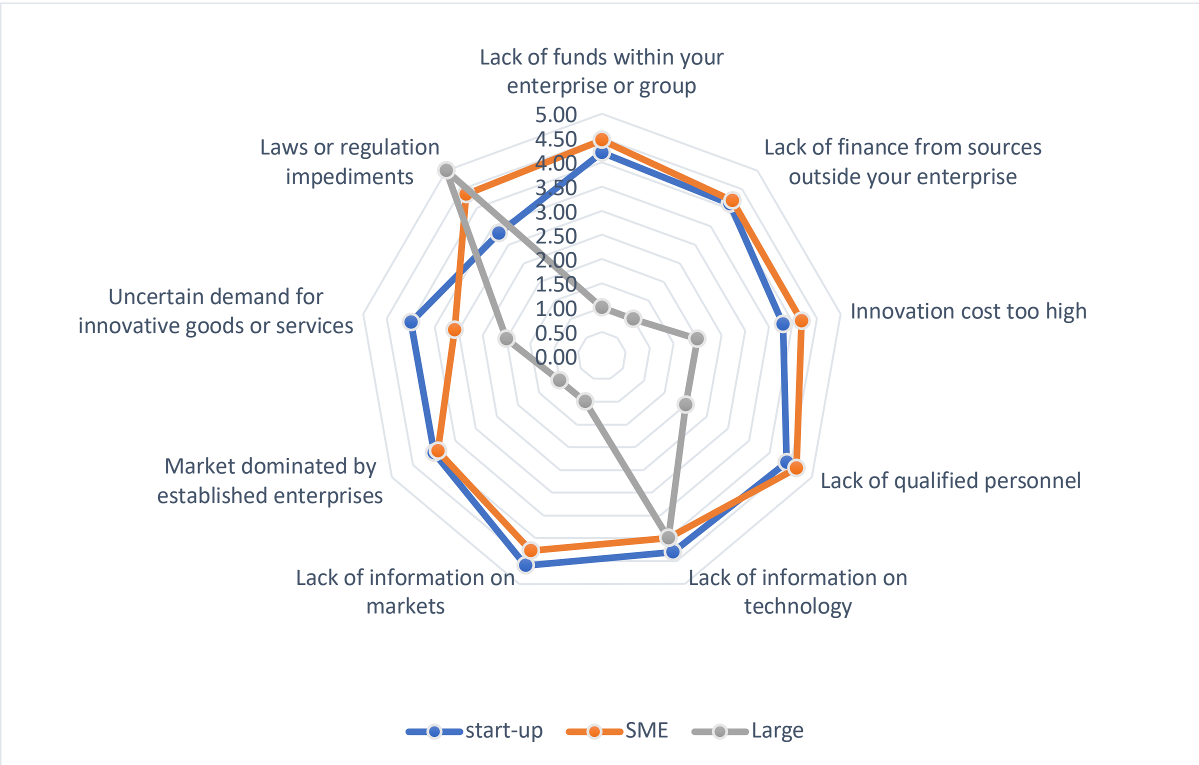

Figure 5.15 Factors in preventing innovative activities by business scale.

Figure 5.15 shows tenant firms on the business scale profile. Accordingly, tenant firms are categorized into three as start-ups, SMEs, and large enterprises. The group of start-ups are shown with high average scores for the factors including uncertainty of demand for innovated products, lack of information on markets, and lack of information on technology. This result bears similarity to the profile of the group of younger age firms most of which are start-ups. These factors are basic factors that inhibit innovation among SMEs and startups. The group of SMEs are shown to have results similar to firms in the medium age range and firms of moderate level of capital investment, high cost of innovation, lack of qualified personnel, market dominated by established company, which are all factors that are inhibitive of R&D and innovative activities. The way forward for these firms is to find ways for increasing investment to upgrade their business scale. So funding is essentially significant for them to invest in the development of research staff, facilities, and technology. It is also shown that only one large enterprise indicated legal and regulatory mechanisms as a factor inhibiting innovation and R&D activities.

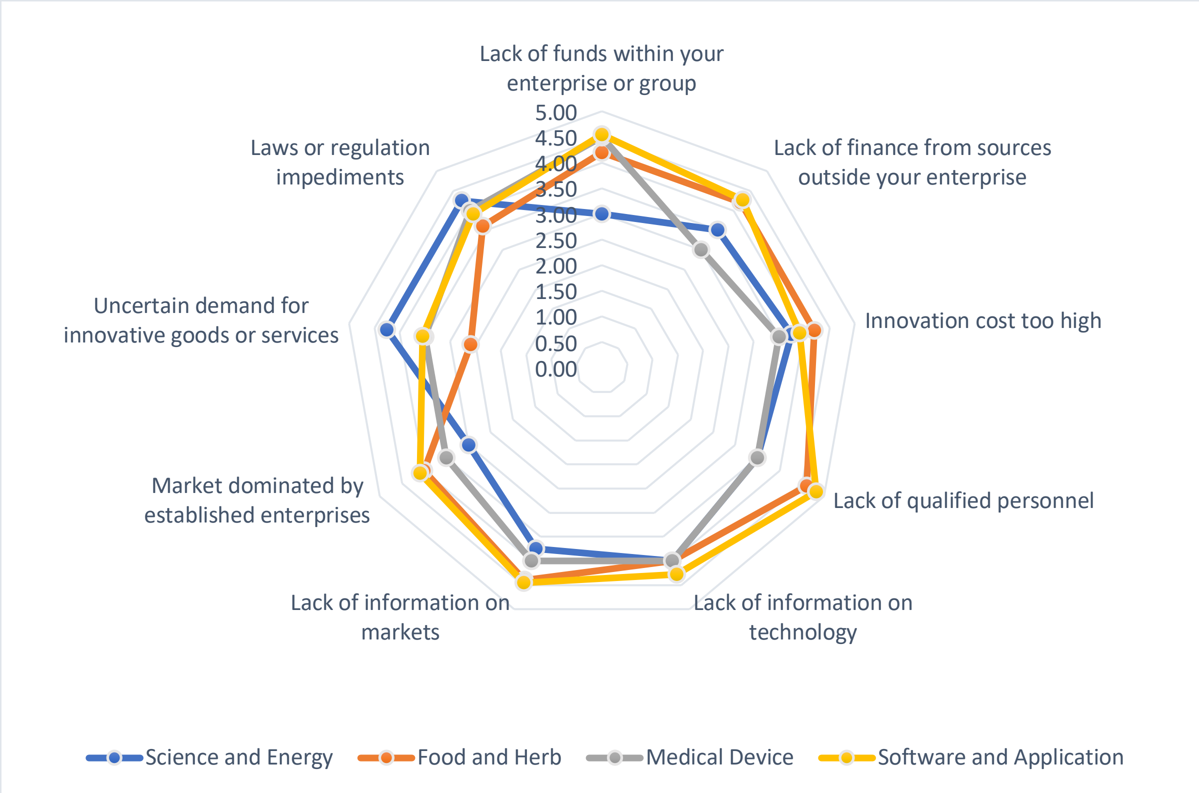

Figure 5.16 Factors in preventing innovative activities by business sectors.

The software and application group is the largest group of firms in the NSP, constituting 50% of the resident population. Funding is particularly important for them because of their requirement of high-performance equipment and technology, and qualified researchers in software and application. Lack of information on technology and markets, which inhibit innovative activities in firms, are reflective of lack of innovation strategy and inadequate commitment of the government to support and encourage firms in this sector to engage in innovative activities. In fact, the sector of software and application should be rapidly updated through waves of investment, to keep up with the very high competition in the global market.

Firms from the sector of science and energy indicated legal and regulatory factors as significant obstacles militating against their innovation effort. For instance, energy firms are subject to environmental law which, while important, could have a limiting effect on the scope of innovation. For firms in the food and medical device sector, the high cost of innovation is highlighted as a barrier. The firms in the food sector, which are dependent on agricultural production, require large areas for manufacturing plant and warehouse. For firms in the medical device business sector, suitable laboratory, including testing and analysis equipment, are costly.

It is apparent from the above observations that tenant firms with diverse needs would pose a serious challenge for science park management in terms of drawing up mechanisms that would be flexible enough to serve all type of tenant firms. It may be argued that science parks would do better if they were set up on specialized basis to cater for firms in specific fields. However, setting up individual science parks in each particular field would be too expensive to consider. Nor is it necessary as science parks are expected to function as multi-disciplinary platforms for firms from various business sectors to interact and benefit from economies of diversity and complementarity.

5.3 Do firms agree the services in the NSP would help them to evolve as innovative and competitive enterprises?

Firms join science parks with the aim of learning and accumulating knowledge that would enable them to cope with challenges particularly on the technology and market fronts. Whether they succeed in meeting their aims in time depends largely on the quality of services provided by the parks. Given the range of services provided by science parks and the effectiveness with which they are administered, tenant firms with seriousness of purpose would be expected to perceptively detect the probability of success with their aim to evolve as innovative and competitive enterprises as a result of their residence in the parks.

In light of the above, how do tenant firms in the NSP assess their experiences over the period of their residence? Do they, for example, agree that the NSP has been promising in its provision of support services, and that they themselves are on the right track to evolve as innovative competitive enterprises? The model of innovative transformation was applied to investigate whether the NSP supports firms in ways that would make them innovative. The model of innovative transformation is divided into three categories: innovative inputs, innovative processes, and innovative outputs. Innovative inputs and innovative processes refer to firms' innovative abilities which occur as a result of residence in the NSP. The five-point Likert scale (very low, low, moderate, high, and very high) was used to gauge if and at what level firms agreed to the proposition that experience in the Park would help them to develop innovative inputs, innovative processes and innovative outputs.

The data in Table 5.18 show very high levels of agreement on the possibility of firms benefiting from the provision of four innovative inputs: space for research and development; support facilities for research and development, consultancy for research and development, knowledge linkage with universities and research institutes, with average scores at 4.5, 4.45, 4.22, and 4.45 respectively. The average scores for the other innovative inputs are approximately between 3.5 – 3.8, which means that firms simply, if perhaps ambivalently, 'agree' to the proposition articulated in Hypothesis 1 (H1).

It is apparent from these scores that tenant firms generally agree about the usefulness of the support they receive from the Park in the form of innovative. The highest average score is for the provision of space for research and development at 4.5. This involves provision of offices and meeting rooms. This is consistent with the finding reported in Figure 5.6 about the infrastructure factor behind the decision of firms to participate in the NSP. Most of the tenant firms (95.45%) are start-ups and SMEs; and 72.7% of these new entrepreneurs are in the age range between 1 – 5 years. Characteristically, such firms have too little in terms of resources to be able to allocate for the provision of infrastructure and would, in the circumstances, find the NSP support helpful as it has the effect of relaxing their resource constraint on their activities by significantly reducing their overhead costs.

Table 5.18 Degree of agreement of tenant firms on the usefulness of innovative inputs (on a 1-5 point Likert scale)

No.	Innovative Inputs provided by the Park	Degree of agreement					Means	S.D.	Interpret
		Very low	Low	Moderate	High	Very high			
1	Increase a number of researchers	0	0	7	13	2	3.7727	0.6119	High
		(0.00%)	(0.00%)	(31.82%)	(59.09%)	(9.09%)			
2	Improve researcher skills	0	0	12	8	2	3.5455	0.6710	High
		(0.00%)	(0.00%)	(54.55%)	(36.36%)	(9.09%)			
3	Improve employee skills	0	3	5	11	3	3.6364	0.9021	High
		(0.00%)	(13.64%)	(22.73%)	(50.00%)	(13.64%)			
4	Specify skill needed	0	0	5	11	6	4.0455	0.7222	High
		(0.00%)	(0.00%)	(22.73%)	(50.00%)	(27.27%)			
5	Recruit high skill employee	0	1	6	12	3	3.7727	0.7516	High
		(0.00%)	(4.55%)	(27.27%)	(54.55%)	(13.64%)			
6	Provide space for research and development	0	0	1	9	12	4.5000	0.5976	Very high
		(0.00%)	(0.00%)	(4.55%)	(40.91%)	(54.55%)			
7	Support facilities for research and development	0	0	3	6	13	4.4545	0.7385	Very high
		(0.00%)	(0.00%)	(13.64%)	(27.27%)	(59.09%)			
8		0	0	3	11	8	4.2273	0.6853	Very high

No.	Innovative Inputs provided by the Park	Degree of agreement					Means	S.D.	Interpret
		Very low	Low	Moderate	High	Very high			
	Assist consultancy for research and development	(0.00%)	(0.00%)	(13.64%)	(50.00%)	(36.36%)			
9	Enhance knowledge linkage with university and research institution	0	0	2	8	12	4.4545	0.6710	Very high
		(0.00%)	(0.00%)	(9.09%)	(36.36%)	(54.55%)			
10	Help with access to funding sources	1	1	1	11	8	4.0909	1.0193	High
		(4.55%)	(4.55%)	(4.55%)	(50.00%)	(36.36%)			
11	Help to improve market skills	0	2	7	6	7	3.8182	1.0065	High
		(0.00%)	(9.09%)	(31.82%)	(27.27%)	(31.82%)			
	Total	1	7	52	106	76	4.0289	0.8269	High
		(0.41%)	(2.89%)	(21.49%)	(43.80%)	(31.40%)			

Source: Survey data

Table 5.19 shows nine innovative processes, including, for example, exploring potential business ideas; drawing up blueprints; developing prototypes; and seeking customer preferences. Innovative process is about the support which science parks offer to tenant firms following provision of innovative inputs or while firms are in the process of product development. The survey data show that firms ‘strongly agree’ on the usefulness of three innovation processes that are available to them in the Park: increased interactions among participants; creation of conducive environment for knowledge exchange; and creation of forum for enterprise networking and for learning from the experiences of others in the Park. The average scores for these are 4.22, 4.27, and 4.41 respectively. The scores for the other innovative processes ranged between 3.5 – 4.1.

The highest average score at 4.41 corresponds to the factor relating to the forum the NSP creates for enterprise networking and for learning from the experience of others. It is very useful and beneficial for participants to know each other, as this allows them not only to learn from each other’s experiences, but also to work jointly on setting up new businesses as co-partners. In addition, there are advantages to be had in terms of market opportunities and business matching where large number of firms with a wide range of products and business types work together in collaborative spirit.

The lowest average score in the category of innovative processes (3.54) is for the factor on ‘seeking customer preferences’. This is, however, a very important factor as tenant firms would need to find customers and markets for their products, once they are up and running. Indeed, it can be argued that the low degree of agreement on this factor is indicative of firms’ concern with questions of immediate priority rather than the erroneous belief that concern with the market and commercialization of products is less important than concern with innovation and the production of innovative outputs.

Table 5.19 Degree of agreement of tenant firms on the usefulness of innovative processes (on a 1-5 point Likert scale).

No.	Innovative processes provided as support to tenant firms	Degree of agreement					Means	S.D.	Interpret
		Very low	Low	Moderate	High	Very high			
1	Explore potential business ideas	0	0	5	11	6	4.0455	0.7222	High
		(0.00%)	(0.00%)	(22.73%)	(50.00%)	(27.27%)			
2	Set of blueprints	1	0	6	12	3	3.7273	0.8827	High
		(4.55%)	(0.00%)	(27.27%)	(54.55%)	(13.64%)			
3	Development of prototype.	0	1	8	9	4	3.7273	0.8270	High
		(0.00%)	(4.55%)	(36.36%)	(40.91%)	(18.18%)			
4	Seek customer preferences.	1	2	6	10	3	3.5455	1.0108	High
		(4.55%)	(9.09%)	(27.27%)	(45.45%)	(13.64%)			
5	Increase the interaction among participants.	0	0	5	7	10	4.2273	0.8125	Very high
		(0.00%)	(0.00%)	(22.73%)	(31.82%)	(45.45%)			
6	Create knowledge exchange environment.	0	3	0	7	12	4.2727	1.0320	Very high
		(0.00%)	(13.64%)	(0.00%)	(31.82%)	(54.55%)			
7		1	0	2	11	8	4.1364	0.9409	High

No.	Innovative processes provided as support to tenant firms	Degree of agreement					Means	S.D.	Interpret
		Very low	Low	Moderate	High	Very high			
	Provide external knowledge exchange.	(4.55%)	(0.00%)	(9.09%)	(50.00%)	(36.36%)			
8	Support product fully functional in real world.	1	0	4	11	6	3.9545	0.9501	High
		(4.55%)	(0.00%)	(18.18%)	(50.00%)	(27.27%)			
9	Creating forum for enterprise network and learn from the experience of others.	0	0	5	3	14	4.4091	0.8541	Very high
		(0.00%)	(0.00%)	(22.73%)	(13.64%)	(63.64%)			
	Total	4	6	41	81	66	4.0051	0.9207	High
		(2.02%)	(3.03%)	(20.71%)	(40.91%)	(33.33%)			

Source: Survey data

Table 5.20 lists twelve innovative outputs including, for example, releasing new products; increasing the range of products; entering new markets; and increasing market shares. Innovative output refers to outputs produced consequent upon the provision of innovative inputs and innovative processes by the science park.

Tenant firms covered in the survey did not participate in the NSP for the same length of time - eight of them that had been participating even before completion of the Park's building project in 2018. As mentioned earlier, the NSP started its life embedded in the Faculty of engineering at Chiangmai University until construction of the park's infrastructure was completed. Therefore, the 8 firms that stayed longest in the Park are more likely to get used to the Park operation than those who joined the Park after 2018 - 4 tenant firms have been in the Park for only one year, while the others have been in the Park for less than one year. This variation in the duration of existence as business entities might cause differences between the views of older tenant firms and that of the younger ones about the usefulness of the services of the Park. However, at the point of the survey, they were all residents in the NSP for just a year following completion of work on the Park infrastructure and building projects.

The objective of firms who join science parks is to produce innovative products that can be commercialized and are capable of being absorbed by the market. This is reflected by the results of the survey presented in Table 5.20, which show that all firms are overall strongly agreed on the usefulness of their residence as a basis for producing innovative outputs specified in terms of the 12 factors in Table 5.20. From the high average scores for each factor, it is apparent that firms are highly agreed on the usefulness of the supports obtained from the NSP for their innovation effort. The average scores for the various factors under the 'innovative output' category range between 3.9 and 4.27. The highest score was obtained when tenant firms were asked if they would agree whether the NSP's assistance would prepare them to meet consumers/ customers demand. The lowest score corresponds to the factor about reducing environmental impact of outputs.

Overall, the survey data discussed above appear to confirm the proposition articulated in H1, that the NSP's mission as cradle of innovation through the provision of a range of services, is generally well received by all tenant firms.

Table 5.20 Degree of agreement of tenant firms on the usefulness of innovative outputs (on a 1-5 point Likert scale).

No.	Innovative outputs	Degree of agreement					Means	S.D.	Interpret
		Very low	Low	Moderate	High	Very high			
1	New products/ processes/ services	0 (0.00%)	1 (4.55%)	5 (22.73%)	10 (45.45%)	6 (27.27%)	3.9545	0.8439	High
2	Increase range of products/ processes/ services	0 (0.00%)	1 (4.55%)	3 (13.64%)	11 (50.00%)	7 (31.82%)	4.0909	0.8112	High
3	Enter new market	1 (4.55%)	0 (0.00%)	3 (13.64%)	11 (50.00%)	7 (31.82%)	4.0455	0.9501	High
4	Increase market share	1 (4.55%)	0 (0.00%)	1 (4.55%)	15 (68.18%)	5 (22.73%)	4.0455	0.8439	High
5	Improve quality of products/ processes/ services	0 (0.00%)	0 (0.00%)	5 (22.73%)	12 (54.55%)	5 (22.73%)	4.0000	0.6901	High
6	Reduce cost per unit output	0 (0.00%)	0 (0.00%)	6 (27.27%)	10 (45.45%)	6 (27.27%)	4.0000	0.7559	High
7	Reduce environment impacts	0 (0.00%)	1 (4.55%)	4 (18.18%)	13 (59.09%)	4 (18.18%)	3.9091	0.7502	High
8		0	0	5	8	9	4.1818	0.7950	High

No.	Innovative outputs	Degree of agreement					Means	S.D.	Interpret
		Very low	Low	Moderate	High	Very high			
	Improve health and safety standards	(0.00%)	(0.00%)	(22.73%)	(36.36%)	(40.91%)			
9	Meet consumers/ customer demand	0	0	3	10	9	4.2727	0.7025	Very high
		(0.00%)	(0.00%)	(13.64%)	(45.45%)	(40.91%)			
10	Increase a number of patents apply	0	1	4	9	8	4.0909	0.8679	High
		(0.00%)	(4.55%)	(18.18%)	(40.91%)	(36.36%)			
11	Increase a number of patents granted	0	1	4	9	8	4.0909	0.8679	High
		(0.00%)	(4.55%)	(18.18%)	(40.91%)	(36.36%)			
12	Increase a number of other intellectual property; pretty patentม trademark, copy right etc.	0	1	4	9	8	4.0909	0.8679	High
		(0.00%)	(4.55%)	(18.18%)	(40.91%)	(36.36%)			
	Total	2	6	47	127	82	4.0644	0.8038	High
		(0.76%)	(2.27%)	(17.80%)	(48.11%)	(31.06%)			

Source: Survey data

5.4 The knowledge exploration (innovation) and knowledge exploitation (commercialization) dimensions of science park services.

There are two principal dimensions to the services provided by the NSP to tenant firms: services relating to the human resource factor including support for the development of knowledge networks; and services relating to the prospecting market opportunities for the products of tenant firms. These represent the human resource and knowledge network dimension, and the market dimension, defining the space for the development of science parks in general as a strategy for innovation and enterprise development (see Figure 2.3 in Chapter 2). They also represent the science parks as a platform for triple helix networks between universities/research institutions, business/industry, and government and public agencies.

5.4.1 The human resource and knowledge network dimension.

This dimension involves participation of universities and public research institutions (knowledge producers) as well as government and non-government agencies (knowledge network facilitators) in the activities of the NSP. The active participation of these actors provides tenant firms an opportunity for triple helix-based collaboration that would not only broaden the scope for learning and accumulation of knowledge but would also enable tenant firms to deepen and broaden their engagement in knowledge networks.

Table 5.21 shows comparison of engagement of tenant firms by activities. Typically, universities and research institutes provide the basis for knowledge networks. They also bring in the benefits of research consultancy, laboratory equipment and facilities, researchers, and sometimes funding and co-research projects. Access to knowledge networks is essential for tenant firms to evolve as innovative and competitive enterprises. Where knowledge is readily accessible, firms would be well positioned to innovate and commercialize.

Table 5.21 shows that tenant firms have been deriving knowledge services more from universities than from other sources. Firms engage with universities in different activities, like for example, conducting joint research, contracting out research, hiring academic consultants, using licensed technologies, hosting student internships, and engaging in co-public research. Students can be offered the opportunity to join companies before they graduate and sometimes, they could be hired by these companies after graduation.

Knowledge linkage with universities and research institutes is not exclusive to firms that are resident in science parks. Off-park firms could also have formal or informal contacts with universities and public research institutes. However, the triple helix network arrangement for on-park firms is often considered to be better organized, although there is no conclusive evidence to show that the links on-park firms forge with universities and research institutes is invariably more effective than links forged by off-park firms (Malairaja, 2006). No attempt is made in this study to explore the knowledge linkage issue with respect to off-park firms as these falls outside the jurisdiction of the thesis. But our investigation of on-park firms at the NSP, appears to suggest that the inclination of firms for interaction with universities and research institutes is somewhat lukewarm. This is reflected by the average score of frequency of contact they would make with universities and research institutes (at 3.54 and 3.45, respectively), as shown in Table 5.21. At best, the evidence borne by the survey data suggest that resident firms at the NSP would rather prefer to informally meet and consult in private wherever the services can be obtained, be it at universities and research institutes or elsewhere. Firms were also observed to be lukewarm in their attitudes about meeting sources of knowledge at conferences (see Table 5.21) and engage in knowledge exchange with academia, and practitioners, including firms from business and industry that usually participate in such events.

These findings suggest evidence of weakness of the NSP in delivering its role of promoting awareness about knowledge networks and broadening and deepening the human resource and knowledge linkage dimension of innovation and enterprise development among resident firms as part and parcel of the triple helix mission of its overall strategy. This raises questions about the priority of the NSP management as between, for example, the real estate management of the Park and the knowledge-based services of the Park. The findings also indicate divergence between what firms perceive to be crucial for advancing their innovative performance (the human resource/knowledge linkage factor, in this case), and what they actually practice, which appears to reflect their unawareness about the significance of the human resource/knowledge linkage factor for their ambition to emerge as innovative and competitive enterprises, possibly with the potential to become global niche players.

5.4.2 The market network dimension.

Complementary to the human resource/knowledge linkage dimension is the market opportunity dimension defining the scope and trajectory for the evolution of tenant firms as innovative and competitive players. Analysis of the survey data shows that tenant firms recognize the importance of the services offered by the NSP with respect to prospecting of market opportunities and role of the market as a key driver of innovation and competitiveness. However, analysis of the survey data relating to the six variants of the market opportunity factor also shows that tenant firms are somewhat lax in their commitment to deepening and broadening the market dimension of their strategy to evolve as innovative and competitive enterprises.

Table 5.22 shows results of analysis of survey data relating to the reasons for co-operation with external parties. Firms strongly agree on the following reasons: to share/ reduce risk and cost; to access technology; to engage in knowledge transfer activities; to expedite access to markets; and to establish long term partnerships. The survey revealed that firms are keen to find ways to survive in the market. In this respect, joint ventures are seen as the way forward to mitigate risk and reduce investment cost as well as forging long-term strategic partnerships.

The NSP would also recognize the significance of strengthening the market network dimension to its tenants, particularly to the younger and smaller firms, as a major role of park management. The NSP would therefore seek to understand the nature of its residents, including what they need in order to have strongholds in their respective markets. Park management also plays key role in matching tenant firms for compatible co-operation and the development of new ideas and innovative products in the Park (Schwartz and Hornych, 2010).

As it is noted later in the next section of this chapter, the tenant firms also demand that the NSP should do well to improve the general support services it provides, particularly the services relating to the creation of increased market opportunities, which they consider should be the Park's priority concern.

Table 5.21 Comparing tenant firms engaging in activities with public research institutes and universities/higher education institutes.

No	Label	Type	N	Mean	Sd.	Effect Size	t	do	Sig.
1	Conduct joint research project	University	22	3.0909	1.9001	0.3221 (Medium)	2.1372*	21	0.0445
		public research institutes	22	2.5000	1.7661				
2	Contract out research project	University	22	2.6818	1.7289	0.3577 (Medium)	2.2696*	21	0.0339
		public research institutes	22	2.0909	1.5708				
3	Hire academic consultants	University	22	2.6818	1.5549	0.4868 (Medium)	3.4641**	21	0.0023
		public research institutes	22	1.9545	1.4302				
4	Use of licensed technology	University	22	2.7727	1.7164	0.5504 (Large)	2.5053*	21	0.0205
		public research institutes	22	1.9545	1.2141				
5	Use of analytical and testing services	University	22	2.8636	1.8334	0.2325 (Medium)	1.1229	21	0.2741
		public research institutes	22	2.4545	1.6826				
6	Use of technical infrastructure	University	22	2.7727	1.7710	0.3789 (Medium)	1.8428	21	0.0795
		public research institutes	22	2.1364	1.5825				

No	Label	Type	N	Mean	Sd.	Effect Size	t	do	Sig.
7	Temporary personnel exchange	University	22	1.7273	1.5791	0.4577 (Medium)	2.0270	21	0.0555
		public research institutes	22	1.1818	0.5885				
8	Host student internships	University	22	3.0909	1.7433	1.2148 (Huge)	5.0353**	21	0.0001
		public research institutes	22	1.3636	1.0022				
9	Training for employees	University	22	2.2273	1.4778	0.1590 (Very Small)	0.9606	21	0.3477
		public research institutes	22	2.0000	1.3801				
10	Co-publications	University	22	1.8636	1.3903	0.2899 (Medium)	2.3470*	21	0.0288
		public research institutes	22	1.5000	1.1019				
11	Meeting or conference	University	22	3.4091	1.5325	-0.0612 (Very Small)	-0.6236	21	0.5396
		public research institutes	22	3.5000	1.4392				
12	Informal personal contact or meeting	University	22	3.5455	1.4050	0.0618 (Very Small)	0.3265	21	0.7473
		public research institutes	22	3.4545	1.5346				
	Total	University	22	2.7273	1.2156	0.5129	4.7625**	21	0.0000

No	Label	Type	N	Mean	Sd.	Effect Size	t	do	Sig.
		public research institutes	22	2.1742	0.9204	(Large)			

Source: Survey Data

Table 5.22 The reasons of cooperating with external parties for the development of innovation and market.

No.	Details	Degree of agreement					Means	S.D.	Interpret
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
1	Share / reduce risk & cost	0	1	5	2	14	4.3182	0.9946	Strongly agree
		(0.00%)	(4.55%)	(22.73%)	(9.09%)	(63.64%)			
2	Enter to new market and technology field	0	0	0	6	16	4.7273	0.4558	Strongly agree
		(0.00%)	(0.00%)	(0.00%)	(27.27%)	(72.73%)			
3	Knowledge transfer	0	0	0	9	13	4.5909	0.5032	Strongly agree
		(0.00%)	(0.00%)	(0.00%)	(40.91%)	(59.09%)			

No.	Details	Degree of agreement					Means	S.D.	Interpret
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
4	Expedite access to market	0	0	3	2	17	4.6364	0.7267	Strongly agree
		(0.00%)	(0.00%)	(13.64%)	(9.09%)	(77.27%)			
5	Pool financial resources	1	0	5	6	10	4.0909	1.0650	Agree
		(4.55%)	(0.00%)	(22.73%)	(27.27%)	(45.45%)			
6	Establish long term strategic partnership	0	0	2	3	17	4.6818	0.6463	Strongly agree
		(0.00%)	(0.00%)	(9.09%)	(13.64%)	(77.27%)			
	Total	1	1	15	28	87	4.5076	0.7863	Strongly agree
		(0.76%)	(0.76%)	(11.36%)	(21.21%)	(65.91%)			

Source: Survey Data

5.5 Benefits tenant firms expect to derive from their residence in the NSP.

This section of the chapter explores what tenants want from the NSP to be able to improve their businesses. Tenants were asked to indicate their preferred recommendations addressing what the NSP should do to improve the quality and effectiveness of its services. Using the five-point Likert scale, Table 5.23 shows three statements of recommendation on which tenants were 'strongly agreed'. These include actions on increasing research consultants (4.27); creating mechanisms for increasing market opportunities (4.27); and creating mechanisms for improving access to funding opportunities for funding (4.54). On the other hand, tenants were not keen to recommend for the NSP to 'expand space'. The other statements of recommendation on which tenants agree at varying levels are: increasing and improving facilities and equipment; and increasing opportunities for interaction between participants.

Tenants were asked to identify three statements of recommendation for possible improvement of the services provided by the NSP and rank them in order or priority from the first to the third. For a recommendation selected first in the order of priority, the total score on that item is determined by multiplying the Likert scale score by a factor of 3. Accordingly, the weighting factor is 2 for the item ranked second, and 1 for the item ranked third. Based on this, Table 5.24 shows the recommendation - 'creating more market opportunities' - has the highest total score (at 34), while the second is 'creating opportunities for funding' (at 31). The recommendation item which ranked third is 'improving the NSP administration and management' with a total score of 14. This particular set of ranking of recommendations has implications for improving the market networking (for knowledge exploitation) and the knowledge networking (for knowledge exploration) services of the Park. The recommendation for the Park to improve funding opportunities is crucial for capacity building both at the level of the Park and also at the level of the individual tenant firms.

As will be discussed below, the recommendations made vary according to the age, capital value, business scale, and business types of firms.

Table 5.23 Recommendation of improvement by firms.

No.	Details	Degree of agreement					Means	S.D.	Interpret
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
1	Expand space	7 (31.82%)	3 (13.64%)	4 (18.18%)	4 (18.18%)	4 (18.18%)	2.7727	1.5409	Moderate
2	Increase and improve facility and equipment	2 (9.09%)	1 (4.55%)	3 (13.64%)	5 (22.73%)	11 (50.00%)	4.0000	1.3093	High
3	Increase opportunity for interaction with participants	2 (9.09%)	1 (4.55%)	6 (27.27%)	7 (31.82%)	6 (27.27%)	3.6364	1.2168	High
4	Exhibition and conferences	1 (4.55%)	2 (9.09%)	2 (9.09%)	5 (22.73%)	12 (54.55%)	4.1364	1.2069	High
5	Increase researcher consultancy	1 (4.55%)	0 (0.00%)	2 (9.09%)	8 (36.36%)	11 (50.00%)	4.2727	0.9847	Very high
6	Improve NSP administration and management	2 (9.09%)	0 (0.00%)	3 (13.64%)	4 (18.18%)	13 (59.09%)	4.1818	1.2587	High
7	Knowledge network development	2 (9.09%)	0 (0.00%)	4 (18.18%)	8 (36.36%)	8 (36.36%)	3.9091	1.1916	High

No.	Details	Degree of agreement					Means	S.D.	Interpret
		Strongly disagree	Disagree	Undecided	Agree	Strongly agree			
8	Access to external knowledge sources	1	0	2	13	6	4.0455	0.8985	High
		(4.55%)	(0.00%)	(9.09%)	(59.09%)	(27.27%)			
9	Purchase license /patents	1	0	7	4	10	4.0000	1.1127	High
		(4.55%)	(0.00%)	(31.82%)	(18.18%)	(45.45%)			
10	Create more market opportunity	1	2	2	2	15	4.2727	1.2414	Very high
		(4.55%)	(9.09%)	(9.09%)	(9.09%)	(68.18%)			
11	Create opportunities for funding	0	2	0	4	16	4.5455	0.9117	Very high
		(0.00%)	(9.09%)	(0.00%)	(18.18%)	(72.73%)			
12	Processing applications for intellectual property	0	2	5	5	10	4.0455	1.0455	High
		(0.00%)	(9.09%)	(22.73%)	(22.73%)	(45.45%)			
	Total	20	13	40	69	122	3.9848	1.2239	High

Source: Survey Data

Table 5.24 Total score of calculation of ranking recommendations.

No.	Recommendation	First order			Second order			Third order			Total score
		Frequency	Percentage	Score	Frequency	Percentage	Score	Frequency	Percentage	Score	
1.	Expand space	0	0	0	0	0	0	1	4.55	1	1
2.	Increase and improve facility and equipment	1	4.55	3	1	4.55	2	1	4.55	1	6
3.	Increase opportunity for interaction with participants	0	0	0	3	13.64	6	0	0	0	6
4.	Exhibition and conferences	1	4.55	3	1	4.55	2	3	13.64	3	8
5.	Increase researcher consultancy	1	4.55	3	1	4.55	2	0	0	0	5
6.	Improve NSP administration and management	4	18.18	12	0	0	0	2	9.09	2	14*

No.	Recommendation	First order			Second order			Third order			Total score
		Frequency	Percentage	Score	Frequency	Percentage	Score	Frequency	Percentage	Score	
7.	Knowledge network development	2	9.09	6	1	4.55	2	1	4.55	1	9
8.	Access to external knowledge sources	0	0	0	0	0	0	3	13.64	3	3
9.	Purchase license /patents	0	0	0	1	4.55	2	0	0	0	2
10.	Create more market opportunity	5	22.73	15	9	40.91	18	1	4.55	1	34***
11.	Create opportunities for funding	6	27.27	18	3	13.64	6	7	31.82	7	31**
12.	Processing applications for intellectual property	2	9.09	6	2	9.09	4	13	13.64	3	13

The radar graph method is used below to show the relative importance of the various recommendations according to profiles relating to the age, capital value, scale, and business types of firms.

Figure 5.17 Recommendations profiled by age group of firms.

The radar graph above (Figure 5.17) shows the strength of agreement on the various statements of recommendation profiled by age group of firms. For instance, firms in the 0 – 3 year age cohort appear to be more concerned with recommendations relating to improvements of mechanisms for accessing funding opportunities; for submitting applications to secure intellectual property rights; and for conference participation. These observations are broadly in accord with expectation. Younger firms that are generally low in capital value would need funding support for most of their activities. Indeed, this is one of the main factors for such firms choosing to locate on-park, as the likelihood of getting funding support while operating off-park would be rather slim. Location in science parks gives firms access to a wide network of information which enhances their credibility to access sources of funding and participate in business and industrial exhibitions and conferences. With respect to the statement of recommendation about intellectual property rights, younger firms would be keen to patent their products on grounds that a patented product could create customer confidence in the reliability of products.

Oder firms, on the other hand, show concern for improvements in the research and consultancy services of the Park; the creation of more market opportunities; and mechanisms for technology transfer through the licensing of patents. This reflects their awareness of the need for the triple helix network underlying the activities of the Park to evolve as a system, so that the Park can be effective in the provision of its services that are aimed at promoting capacity building in tenant firms for knowledge exploration and knowledge exploitation.

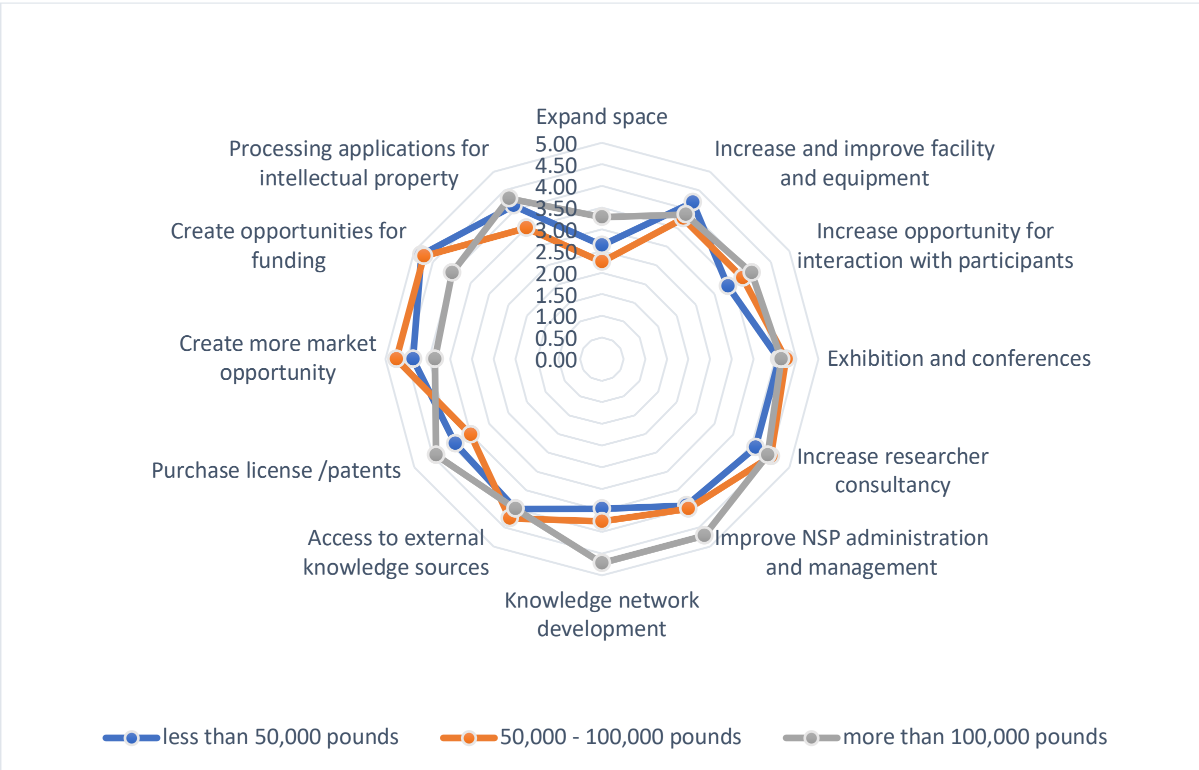

Figure 5.18 Recommendation by capital value of tenant firms.

Figure 5.18 above shows the profiling of the statements of recommendation according to the capital value of tenant firms. The group of low capital value firms expect improvements in the facility and equipment stock of the Park and increases in funding opportunities for tenant firms. The group of high capital value firms are shows to make more recommendations to the Park management than the group of low capital value firms. This is as would be expected since the former has a wider spectrum of demands on the Park than the latter. Thus, for instance, the group of high capital value firms would like to see improvements in the mechanisms for expediting the process for the acquisition of intellectual property rights; for increasing interactions among firms; for broadening and deepening the research consultancy services of the Park; for improving the administration and management of knowledge network development; and for improving technology transfer for on-park firms through the licensing of patents.

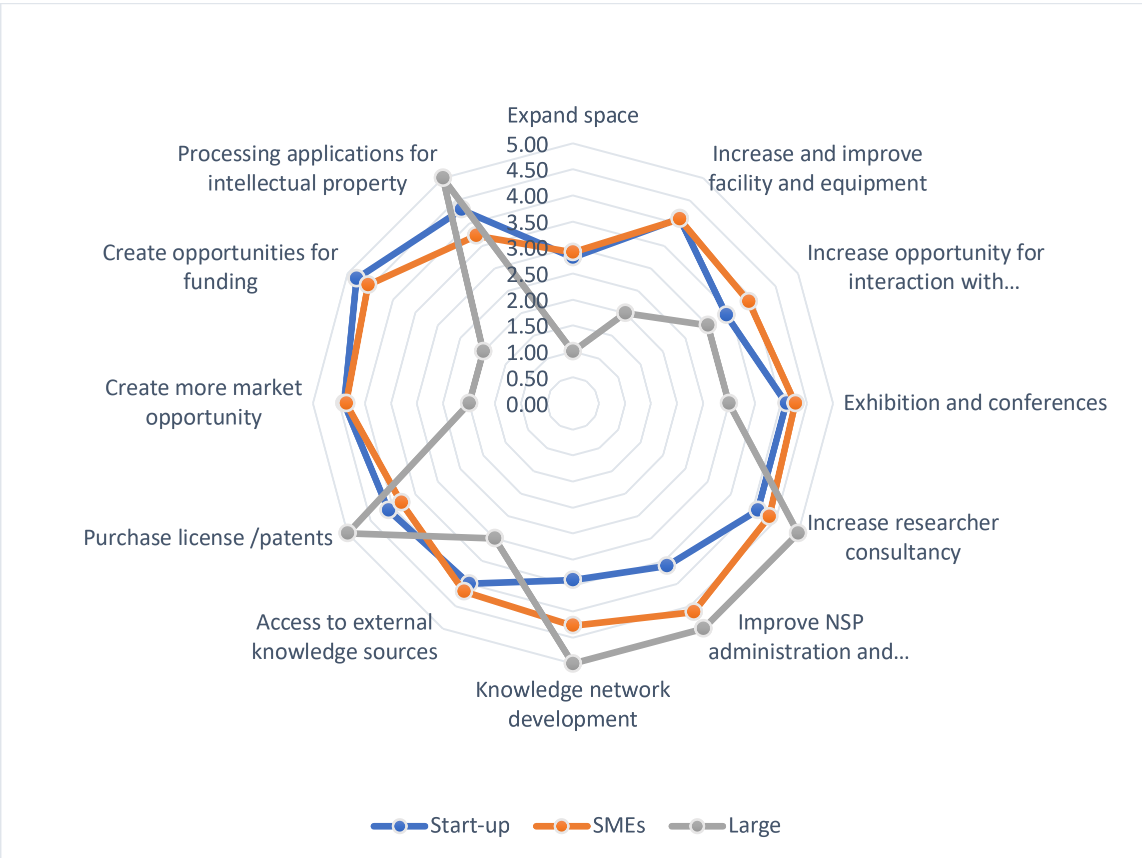

Figure 5.19 Recommendation by business scale of tenant firms.

Figure 5.19 above shows the profiling of the statements of recommendation according to the business scale of tenant firms. The results show concurrence between start-ups and SMEs in their recommendations for improvements in the services of the Park. The recommendations on which they concur relate to: space expansion; participation in exhibitions and conferences; increasing research consultancy services; access to external knowledge; purchase of licenses/patents; creation of more market opportunities, and creation of funding opportunities. The data for large firms would, however, need to be interpreted with caution, because there is only one large enterprise in the Park. Notwithstanding, the recommendations of the large firm include: increasing research and consultancy services; improving administration and management, knowledge network development, cross-licensing of patents, and acquisition of intellectual property rights or patents for innovated products.

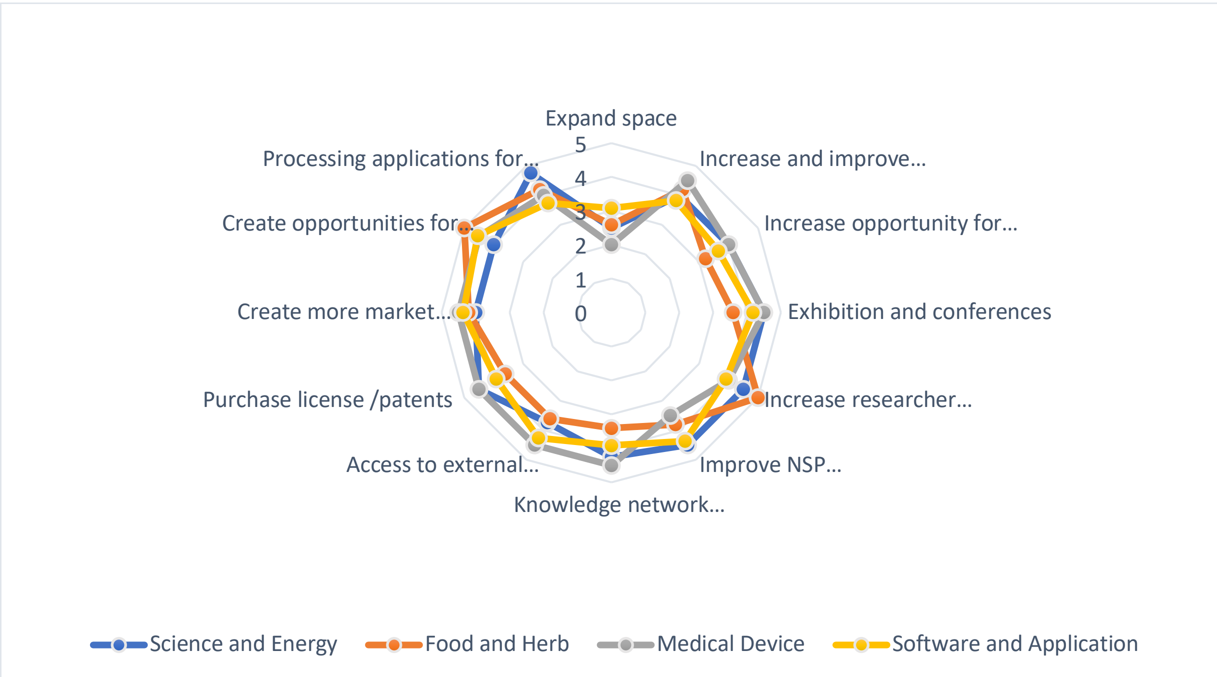

Figure 5.20 Recommendation by business type of tenant firms.

Figure 5.20 shows statements of recommendation profiled according to type of tenant firms as defined by sectoral origin. The most prominent feature of recommendations by firms of all types is that they all appear to be least interested in the recommendation for expanding space. And all appear close on recommendations that would directly or indirectly help improve the knowledge exploration and knowledge exploitation capability of tenant firms. Significantly, firms from software and application business sector, which constitute the largest number of firms in the Park, do not show dominantly high scores in any of the recommendations.

5.6 Conclusion

This chapter has explored the survey data elicited through the administration of questionnaires to tenant firms in the NSP, one of the regional science parks in Thailand. The survey was conducted during the three-month period between January and March 2019. The survey results are presented in five parts. The first part explored basic data about the tenant firms that populate the NSP. Most of the firms in the Park are young and small, with only one large, Japanese-owned enterprise, amidst them. The capital value of most of the start-ups and SMEs is no more than £100,000, while that of the largest firm is well over £350,000. The business types of the firms that populate the Park are varied, including firms from business sectors like software and application, food and herb, material sciences, and medical devices. Most of the firms are from software and application.

The second part investigated and interpreted, using a five-point Likert scale, the reasons why firms decided to locate in the NSP. These results suggest that accommodation space and facility, market opportunity, and business growth are the major factors that influenced firms to join the NSP. Firms were also asked to specify three reasons that most influenced their decisions to join the NSP as tenants and ranking them in order of importance. It was found out that the ‘space and facility’ factor had the highest score, with the ‘innovative improvement’ and ‘reputation’ factors coming second and third respectively. This finding is in keeping with expectation as the ‘space and facility’ factor represent a major and immediate concern of most of the firms in the Park that are categorized as start-ups and SMEs.

The views of firms on the mechanisms for and constraints on engaging in innovative activities were also explored in this part. For instance, R&D manpower or staffing cost was found to be the most important investment expenditure acting as a barrier on innovation, while investment in the development of knowledge linkage, and access to software and technology came second and third, respectively. Older firms, more than younger ones, were found to be capable of investing in high-cost machinery, equipment, infrastructure to promote their innovation effort. On the other hand, younger firms would choose to invest in the development of knowledge linkage, which is cheaper than the other items of expenditure for innovation. The express desire of firms to engage in R&D investment suggests that firms are keen to improve existing products or processes; develop new products or processes; and invest in researcher skill development. It was found that lack of qualified research personnel and lack of information on markets are two essential factors inhibiting innovative activities. While lack of qualified research staff constrains the ability of firms to engage in effective knowledge exploration, lack of information on markets constrains their ability to engage in knowledge exploitation by commercializing their products.

The third part addresses questions about how firms view prospects for their transformation through their access to innovative inputs and innovative processes provided by the NSP, as these would be expected to result in innovative outputs. The survey data show firms strongly agreeing on four innovative inputs as key factors for innovative transformation through R&D: space for research and development; support facilities for research and development; consultancy for research and development; and knowledge linkages with universities and research institutes. Firms also believe that increased interactions among park residents through the creation of enterprise networks would provide them with conducive environment for knowledge exchange, and for learning from the experiences of each other. While firms have received support from the Park in terms of a range of innovative inputs, the occurrence of innovative outputs has, however, been few and far between.

The survey results show only one occasion in which the NSP assisted firms to meet consumers'/ customers' demands. For all that, there is a general consensus among the resident firms that the NSP would be trusted to serve them as a 'cradle of innovation'.

In the fourth part, the engagement of tenant firms with universities and public research centres was explored. The survey results show that tenant firms obtain knowledge services more from universities than from other sources, such as conducting joint research, contracting out research to independent private sector agencies, hiring academic consultants, and using licensed technologies. While there is evidence of a triple helix network underlying the operation of the Park, there is, however, little to suggest that the network is systemic enough to warrant the occurrence of innovation on a sustainable basis.

The fifth part discussed what firms expect the NSP should do to improve the support services it provides to tenants. The survey results show firms making recommendations for increasing research consultancy services; increasing market opportunities; and creating opportunities for funding. Of least concern to tenant firms is the issue about space expansion at the Park. Table 5.2 below shows a summary of empirical results discussed in this chapter.

Table 5.25 Summary of results.

Topic of investigation	Results
Profiles of surveyed tenant firms.	Most tenant firms are new firms with the average age at 5.5 years; and half of tenant firms are less than 3 years old, while the oldest tenant firm is 29 years old. 72.73% are young tenant firms; and they are start-up and small and medium enterprises (SMEs) with quite low capital value. Half of the tenant firms are engaged in software production and applications
Reasons for participating in the park.	Tenant firms participate in the NSP in the belief that it would help them improve their technological, business, and commercial capabilities. The ‘space, utility, and facility’ factors influence the preference of firms to participate the Park. Factors such as government incentives and space utility and facilities, and company reputation have higher influence in the case of younger firms. Firms in the lowest capital value group would prefer to locate in the Park mainly to enhance their reputation; but the participation of firms with high capital value is also influenced by a variety of factors, such as opportunities for developing their R&D and innovative capabilities, and enhancing their access to research centers. Large firms are attracted to the Park mainly for making R&D links with researchers and for engaging in knowledge exchange activities. In contrast, the group of new and small companies like start-ups and SMEs show preference for on-park location to be able to reduce cost of investment in space, utilities, and facilities. The software & application business sector is represented by 50% of tenant firms. However,

Topic of investigation	Results
	software and application firms do not appear to feature prominently on most of the factors that influenced the decision they made to participate in the Park. On the other hand, factors including government incentives, company reputation, knowledge linkage and knowledge exchange appear to have equally appealed to them as they did to firms from the other sectors.
Tenants' views on factors that are crucial for innovative activities.	R&D manpower stands out prominently as area of investment expenditure for innovation. Other aspects of significance are development of knowledge linkages and software technology. Younger firms show uncertainty about prospects for evolving as innovative and competitive enterprises; and this relates for the most part to the lack of information about markets. They would need support in the form of product and market consultancy. For the older firms, it is legal and regulatory impediments that count as inhibiting factors. For the group of start-ups inhibiting factors include uncertain demand for innovated products, lack of information on markets, and lack of information on technologies. For the group of software and application firms, the major inhibiting factor is access to funding. Funding is particularly important for them because of their requirement of high-performance equipment and technology, and qualified researchers in software and applications.
Do the services delivered by the Park help tenant firms?	All tenant firms agree about the usefulness of the support they receive from the Park can help them in improving their innovative performances. This is reflected by the survey data as all firms strongly agreed on the usefulness of their participation in the Park.

Topic of investigation	Results
	This appears to give credence to the general view that on-park firms are likely to be innovative and creative (see Hypothesis 1).
Engagement of firms with university and government institutions.	Tenant firms derive knowledge services more from universities than from other sources. Firms engage with universities in different activities, like, for example, conducting joint research, contracting out research, hiring academic consultants, using licensed technologies, hosting student internships, and engaging in co-public research. Engagement with government institutions is based on demand for the provision of financial and market supports.
Recommendations for improvement in the innovative and competitive performance of tenant firms	In the views of tenant firms, the major recommendations for improvement of firms' innovative and competitive performances would largely depend on 'creating market opportunities'; 'creating opportunities for funding'; and 'improving the NSP administration and management'.

Further analysis of the survey data – quantitative and qualitative - will be conducted in the following chapter.

CHAPTER 6
EMPIRICAL ANALYSIS OF FACTORS INFLUENCING THE EXPECTED INNOVATION PERFORMANCE OF SCIENCE PARK FIRMS

This chapter presents an analysis of a range of observations reflected by the survey data discussed in the previous chapter. It looks into the factors that bear on the behavior of on-park firms to be competitive and innovative by examining the empirical relationship between innovative inputs and innovative processes, on the one hand, and innovative outputs, on the other. Results of the analysis would be expected to inform policy as to how best science parks should be organized and managed to provide a conducive environment for resident firms to make effective use of park facilities and engage in knowledge network systems to be able to evolve as innovative and competitive enterprises.

The remainder of this chapter is in three parts. The first part examines the different categories of innovative inputs that science park provides to resident firms. The second part explores evidence of association between firm characteristics and the provision of innovative inputs; and between the different categories of innovative inputs and the assessment of firms about their prospects for evolving as innovative and competitive enterprises. The third part summarizes the results of the analysis and concludes by identifying the range of issues of policy import that arise from the results of the analysis.

6.1 Categories of the innovative inputs provided by science parks.

Innovative inputs, innovative processes, and innovative outputs are aspects of the innovative transformation model discussed in 4. Innovative inputs and innovative processes are behind the development of innovative capability that accounts for the innovative outputs of firms. This particularly applies to firms being incubated under the umbrella of science parks, like the NSP. Science park residents are generally expected to favorably impact their innovative outputs through the application of creativity to production and marketing problems. In this analysis, innovative inputs and innovative processes are merged into five categories: human resources (HURE), infrastructure and facility (INFA), knowledge linkage (KNLK), funding (FUND), and market opportunity (MAOP). Each category of innovative inputs/processes is examined below to show if there is evidence of differences between the components in each category.

Nonparametric tests were conducted as this is considered appropriate for application to small sample sizes (N=22). The Friedman test (comparing the means of more than two independent groups with purposive sampling) was used to examine if there are any statistically significant differences among components of innovative inputs in each category of innovative inputs. Where significance at the 5% level is obtained, then the Wilcoxon test (comparing differences between two independent groups) was conducted to indicate which component of innovative inputs are significantly different from the other one. For instance, given A, B, C and D as the four components of innovative inputs under the category of human resources, if the Friedman test shows statistically significant difference between these, it means there is a sign of statistical difference among A, B, C, and D. Therefore, it necessary to proceed to the application of the Wilcoxon test to determine where the difference has arisen. The result of this exercise can help science park management to realize which innovative inputs should be improved to have a lasting impact on the innovative performance of tenant firms.

6.1.1 Human resources

Tenant firms were asked to rate the scale of their agreement on the quality of human resources (increase the number of researchers; improve researcher skills; improve employee skills; specify skills needed; and recruit employee with high level skills) available to them as residents in the NSP. The rating scale ranges from 1 – 5 (lowest degree of agreement – highest degree of agreement). The survey results (see Table 6.1) show the highest average score on 'specific skills needed' at 4.05 and the lowest average score on 'improvement of researchers' skills' at 3.54. The absence of any significant difference between the five human resources-based innovative inputs on the Likert scale, (average score ranges between 3.4 – 4.2), suggests that the NSP has supported tenant firms quite well in terms of the provision human resources. However, this has yet to be put to the test to confirm if the apparent absence of any significant difference between the human resources-based innovative inputs can be statically validated. The Friedman test shows evidence of significant difference among the five human resources-based innovative inputs that would reject the null hypothesis of 'no difference', thus giving credence to the alternative hypothesis that 'there is difference' even at less than the 5% level of significance. This means that there is at least one pair among the five innovative inputs that accounts for the statistically significant difference. So, the Wilcoxon test is further applied to the data to show how each innovative input differs from the others. The results of the test are shown in Table 6.2

Table 6.1 Degree of agreement in supporting of human resources.

Items	Increase number of researchers	Improve researchers' skill	Improve employees' skill	Specific skill needed	Recruit high skill employee
Means	3.77	3.54	3.64	4.05	3.77
S.D.	0.61	0.67	0.90	0.72	0.75
N	22	22	22	22	22
Friedman test	N = 22 Chi-Square = 11.107 df = 4 Asymp. Sig. = 0.025*				

Significant at the 0.05 level was used.

The Wilcoxon test shows evidence of significant difference only in one of the ten pairs of the five human resources-based innovative inputs at the 5% level. This relates to 'improvement of researchers' skills' and to 'specific skills needed'. It can be inferred from the results in Table 6.2 that the NSP should place emphasis on the 'improvement of researchers' skills' to be effective in the provision of its service to tenant firms.

Table 6.2 The Wilcoxon test for human resources.

Human resources category	Z	Asymp. Sig. (2-tailed)
1) Increase number of researchers Vs Improve researcher skills	-2.236^{b}	0.250
2) Increase number of researchers Vs Improve employee skills	-0.832^{b}	0.405
3) Increase number of researchers Vs Specific skill needed	-1.897^{c}	0.058
4) Increase number of researchers Vs Recruit high skill employee	0.00^{d}	1.000
5) Improve researcher skills Vs Improve employee skills	-0.535^{c}	0.593
6) Improve researcher skills Vs Specific skill needed	-2.840^{c}	0.005*
7) Improve researcher skills Vs Recruit high skill employee	-1.292^{c}	0.197
8) Improve employee skills Vs Specific skill needed	-1.748^{c}	0.080
9) Improve employee skills Vs Recruit high skill employee	-0.632^{c}	0.527
10) Specific skill needed Vs Recruit high skill employee	-1.511^{b}	0.131

Significant at the 0.05 level was used.

6.1.2 Infrastructure and facilities.

Infrastructure and facilities are of critical importance as component of support services offered by the NSP to tenant firms and are therefore expected to have significant influence on the expected innovative performance of the firms. The survey explored four innovative inputs relating to infrastructure and facilities: providing space for research and development; providing support facilities for research and development; increasing the scope for interaction among participants; and creating knowledge exchange environment. Tenant firms in the NSP were asked to rate the significance of these factors for their impact on their expected innovative performance on Likert's scale ranging from 1 to 5 (1 for lowest degree of agreement and 5 for highest degree of agreement). The Friedman test in Table 6.3 shows means and standard deviations of degrees of agreement in four of the infrastructure and facilities-based innovative inputs.

Table 6.3 Degree of agreement in supporting of infrastructure and facilities

Items	Provide space for research and development	Support facilities for research and development	Increase scope for interactions among participants	Create knowledge exchange environment
Means	4.50	4.45	4.23	4.27
S.D.	0.60	0.74	0.81	1.03
N	22	22	22	22
Friedman test	N = 22 Chi-Square = 1.084 df = 3 Asymp. Sig. = .781			

Significant at the 0.05 level was used.

The results show the highest score (at 4.5) for the factor relating to the Park's provision of 'space for research and development'; and the lowest score (at

4.23) to the Park's service factor relating to 'increasing the scope for interactions among participants'. The four innovative inputs are, however, found to be similar in terms of their influences on the expected innovative performance of tenant firms, considering the narrow range between the highest and lowest average scores (4.2 – 4.5). This is confirmed by the Friedman test at the 5% level of significance, which shows acceptance of the hypothesis that there is no evidence of significant difference among the four innovative inputs. This finding gives credence to the claim that the NSP's support services offered to tenant firms in the form of various aspects of infrastructure and facilities has been found satisfactory. As there is no statistically significant difference of the average mean scores across the four innovative inputs, the Wilcoxon test was considered unnecessary to conduct.

6.1.3 Knowledge linkage

The third innovative input category provided by the NSP is 'knowledge linkage'. This involves assistance to firms in the form of consultancy for research and development; enhancing the knowledge linkage of firms with universities and research institutions; providing firms access to external knowledge exchange; and creating forums and networks for learning. Tenant firms in the NSP were asked to rate the influence these factors have on their expected innovative performance and how much they have been supported in terms of knowledge linkage in these four components of innovative inputs on the Likert scale 1 to 5 (1 for the lowest degree of agreement, and 5 for the highest degree of agreement). The Friedman test is used to explore means and standard deviations of degree of agreement to show if there is any evidence of significant difference among the four innovative inputs with respect to their influences on the expected innovative performance of firms. The results of Friedman test are shown in Table 6.4.

Table 6.4 Degree of agreement in supporting of knowledge linkage

Items	Assist consultancy for research and development	Enhance knowledge linkage with university and research institution	Provide external knowledge exchange	Creating forum and network for learning
Means	4.23	4.45	4.14	4.41
S.D.	0.69	0.67	0.94	0.85
N	22	22	22	22
Friedman test	N = 22 Chi-Square = 4.031 df = 3 Asymp. Sig. = .285			

Significant at the 0.05 level was used.

The results show the highest score (at 4.41) for the factor on ‘enhancing knowledge linkage with university and research institutions’, and the lowest score (at 4.14) for the factor on ‘providing external knowledge exchange’. This shows that there is no evidence of significant difference among the four innovative inputs with respect to their impact on the expected innovative performance of tenant firms, thus confirming the null hypothesis at the 5% level of significance. On the basis of the evidence borne by the survey data, it can be argued that tenant firms are well served by the NSP in terms of the support offered to them for the development of knowledge linkages.

6.1.4 Funding

The importance of ‘access to funding sources’ for enhancing the innovative performance of tenant firms is explored in the survey by soliciting the views of respondents and recording these using the five-point Linkert scale. Analysis of the survey data shows (see Table 6.5) average score for agreement on the importance of access to funding at 3.82, with the scores ranging between 3.4

and 4.2. This is not perhaps surprising considering that access to funding sources is crucial for the innovative performance of firms, particularly the small and newly established ones, as these require investment resources for the provision of infrastructure and facilities, and for the development of research skills and supply chain networks. Thus, the survey data confirms the claim about the importance of access to funding sources, whether these sources arise in the public or the private sector. If the NSP functions as a dynamic intermediary, creating linkages between sources of funding and tenant firms, there is good reason to believe that it could contribute significantly to business mobility across the various parts of the country.

Table 6.5 Degree of agreement in supporting of funding.

Item	help to access to funding sources
Means	3.82
S.D.	1.0
N	22

6.1.5 Market opportunity

Provision of market opportunities or opportunities for access to markets is another factor that would be expected to have significant influence on the innovative performance of firms. The survey data was examined for evidence that would support this view in the context of tenant firms in the NSP. Firms were asked to rate their views about the importance of the 'market opportunity' factor on a five-point Likert scale. There are six variant factors relating to the market opportunity category: help to improve market skills; explore potential business ideas; development of blueprints; development of prototypes; monitor customer preferences; support addressed to perfecting products to ensure functionality. The aim is to test whether the six variables relating to the market opportunity factor are significantly different. If the results of the

Friedman test show any significant difference among them, it is important to explore where the difference is.

Table 6.6 Degree of agreement in supporting of market opportunity.

Items	Help to improve market skills	Explore potential business ideas	Set of blueprints	Development of prototype	Seek customer preferences	Support product fully functional in real world
Means	3.82	4.05	3.72	3.72	3.55	3.95
S.D.	1.0	0.72	0.88	0.82	1.0	0.95
N	22	22	22	22	22	22
Friedman test	N = 22 Chi-Square = 10.827 df = 5 Asymp. Sig. = .055					

Significant at the 0.05 level was used.

According to the results shown in Table 6.6, all respondents agree on the importance of the 'market opportunities' factor for the expected innovative performance of tenant firms, although the average score for the degree of agreement across factors ranges between 3.55 and 4.05. According to the Friedman test, the null hypothesis that there is no significant difference among the six factors relating to market opportunity in terms of their importance for their expected innovative performance is duly confirmed at the 5% level of significance. This means that further test in Wilcoxon test is not necessary. The result suggests that the NSP would do better to enhance its service to tenant firms to help them improve their marketing performance.

6.2 Test of Hypothesis 2 (H2); and Hypothesis 3 (H3).

The ordinal logistic regression model is used to establish evidence of association between independent and dependent variables with respect to Hypothesis 2 (H2) (association between tenant firm characteristics and the development of park services or innovative inputs); and Hypothesis 3 (H3) (association between the provision of park services (innovative inputs) and the expected innovative performance or innovative performance of tenant firms).

Hypothesis 2 (H2) postulates that the characteristics of tenant firms are likely to influence the development of innovative inputs that constitute the support services science parks provide to tenant firms. Hypothesis 3 (H3) postulates that the services parks provide in the form of five categories of innovative inputs would influence to the expected innovative performance of tenant firms. These hypotheses are examined with the aim to bring to light the effectiveness of NSP in providing innovative services to their tenants; and the usefulness of these innovative inputs to help the firms evolve as creative, innovative and competitive enterprises.

The data for the independent and dependent variables in both hypotheses are of nominal and ordinal type generated on the basis of five-point Likert scale. The ordinal logistic regression model is suitable for the analysis of such data, as dependent variables (like development of innovative outputs) are in the form of ordered category, while the independent variables can be dichotomous (yes/no), and of nominal and ordinal type based on a five-point Likert scale.

6.2.1 Testing Hypothesis 2 (H2).

Hypothesis 2 (H2) is set to test the association between the characteristics of firms and the development of innovative inputs that parks would provide to their tenants as support services. The aim of the exercise is to show the flexibility or versatility of science parks in meeting the changing needs of tenant firms. This attribute of science parks has significant implications for the effectiveness of their services as inputs to the development of their tenants as innovative and competitive enterprises.

Ordinal logistic regression is widely applied to predict an ordinal dependent variable given one or more independent variables. More specifically, ordinal logistic regression enables us to know: (a) which of the independent variables have a statistically significant effect on dependent variable; and (b) how well ordinal logistic regression model predicts the dependent variable.

For categorical independent variables (e.g., ‘Conservatives’ and ‘Labour’ party supporters), the ordinal logistic regression model for investigating opinions on the level of tax rates, (whether they are high or low), can be used to interpret the odds that one group (for instance, Conservative supporters) has a higher or lower value on the dependent variable - a higher value could be stating that they ‘Agree’ that ‘Tax is too high’ compared to the second group (Labour supporters). For continuous variables (‘age’, measured in years), the model would predict how a single unit increase or decrease in that variable (one year increase or decrease in age), is associated with the odds of the dependent variable being high or low (Laerd Statistics, 2015).

More generally, the ordinal logistic regression model is used to test evidence of linear relationship between the independent and dependent variables. However, before conducting the ordinal logistic regression model, conditions for robustness of data are checked by testing for any evidence of multi-collinearity across the independent factors. Determining whether there is multi-collinearity is an essential step in ordinal logistic regression. Multi-collinearity appears when there are two or more independent variables that are cross correlated. The existence of multi-collinearity reduces the robustness of the predictive power of the regression model. It is therefore important to diagnose the collinearity of independent variables. Either “Tolerance value” or its reciprocal, i.e. “VIF (variance inflation factor)” are used to test the existence of the problem of multi-collinearity among independent variables before running the ordinal logistic regression. If the tolerance value is less than 0.1, or a VIF value of more than 10, this means there is evidence of multi-collinearity. In Table 6.6, all the tolerance values are higher than 0.1 and (the lowest is 0.203), and the value of VIF is less than 10. So, it can be confidently concluded that there is no evidence of the multi-collinearity problem in these particular set of data, as shown in Table 6.6.

However, to enter this categorical variable directly into the regression equation would be incorrect because the regression equation would assume that the categorical variable is continuous. So, the categorical variables are recoded first by splitting them into the dummy variables. The number of dummy variables thus created for any categorical variable is one less than the number of its categories. In this study, there are three categories of business scale; three categories of capital cost; and four categories of business sectors. So, there will be two dummy variables of business scale and capital cost, and three dummy variables of business sectors, respectively. Then, multi-collinearity test can then be conducted by entering all dependent and independent variables into SPSS.

Table 6.7 Multi-collinearity test of independent variable (characterization of firms).

Independent variables	Collinearity Statistic	
	Tolerance	VIF
PART	0.117	8.577
RENU	0.232	4.308
AGE	0.239	4.178
CONR	0.444	2.255
RDEX	0.546	1.830
L	0.313	3.192
SME	0.168	5.969
MID	0.629	1.591

LOW	0.328	3.052
AGRI	0.411	2.432
SCIENCE	0.362	2.765

a. Dependent variable: Development of innovative inputs by NSP.

b. The explanation of independent variables is described in Chapter 4 (Table 4.6)

The next step is to calculate the odds ratio. In logistic regression, the odd ratio represents the constant effect of a predictor or independent variable, on the likelihood that one outcome will occur. When the logistic regression is estimated, the regression coefficient (β_i) shows the likely increment in the logged odds ratio, which relates to the underlying probabilities of an outcome occurring per unit increase in the value of the independent variable (Osinowo, 2018). The odds ratio is represented as an exponential function of the regression coefficient ($e^{\beta i}$) and is associated with one unit increase in the independent variables (Park, 2013). The logistic or logit function is applied to transform 'S' – shaped curve into straight line.

$$logit\ (y) = \ln(odds) = \ \ln\frac{p}{1-p} = \ \alpha + \ \beta X, \text{ where:}$$

p is the probability of interested outcome,

α is the intercept parameter,

β is the regression coefficient,

X is the predictor or independent variable, and

Y is the predicted logit outcome or dependent variable

The linearised logistic regression model, logit (y) = $\alpha + \beta X$ is similar in construct to a simple linear regression model. Consequently, the association between the independent variable (attributes of firms) and the predicted logit for the level of innovative inputs development supported by NSP, as postulated in H2, is represented by the following logit regression model:

$Y = \alpha_i + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon$, where

Y is development of innovative inputs,

α is the intercept parameter,

β is the regression coefficient,

X_1 is the number of years participating in NSP (PART),

X_2 is the number of researchers (RENU),

X_3 is the age of firms (AGE),

X_4 is to conduct R&D (CONR),

X_5 is the R&D expenditures (RDEX),

X_6 is the business scale (SCAL),

X_7 is the capital cost (CAPC),

X_8 is the business sectors (BUSS), and

ε is an error term

In testing Hypothesis 2 (H2), the study investigates if there is any evidence of association between the various attributes of firms and the level of development of innovative inputs provided by the NSP to its tenants. In other words, the question is whether there is any significant evidence to show firm influence on the development of innovative inputs of firms. Since logistic regression computes the probability of success over the probability of failure, the results of the analysis are presented in the form of the odds ratio. The Wald test is applied to examine the statistical significance of each coefficient in the model. The model fit is shown using pseudo-R2. Nagelkerke-R2, a pseudo-R2, is applied to investigate the goodness-of-fit in logistic models.

Tables 6.7 – 6.11 present the results of ordinal logistic regression for H2, including case processing summary, model fitting information, Goodness-of-Fit Statistics, Pseudo R-Square, and Parameter estimates of ordinal logistic regression.

Table 6.8 Case processing summary for Hypothesis 2.

		N	Marginal percentage
Development of innovative inputs	3 = Moderate	5	22.7%
	4 = High	14	63.6%
	5 = Very high	3	3.6%
Business sectors (BUSS)	(1) Software and application	11	50.0%
	(2) Food and herb	4	18.2%
	(3) Science and energy	3	13.6%
	(4) Medical devices	4	18.2%
Business scales (SCAL)	(1) Start-up	10	45.5%
	(2) SME	11	50.0%
	(3) Large	1	4.5%
Group of capital cost (CAPC)	(1) Less than 50,000 pounds	11	50.0%
	(2) 50,000 – 100,000 pounds	4	18.2%
	(3) More than 100,000 pounds	7	31.8%
Conducting research (CONR)	(1) Yes	16	72.7%
	(2) No	6	27.3%
R&D expenditure (RDEX)	(1) Yes	17	77.3%
	(2) No	5	22.7%
Valid		22	100%
Missing		0	

Total	22

Table 6.9 Model fitting information for Hypothesis 2.

Model Fitting Information					
Predicted	Model	-2 Log Likelihood	Chi-square	Df	Sig.
INNOinput	Intercept Only	39.426			
	Final	27.042	12.384	12	0.415

Link function: Logit

Table 6.8 shows the model fitting information giving the -2 Log likelihood for the ‘intercept only’ and for the ‘final’ model. The -2 Log likelihood is used to examine the differences between two models (Intercept Only and Final). The greater differences between the two models (p<0.05), the better independent variables are at explaining the dependent variable. In other words, at least one independent variable would explain the dependent variable. The aim in this is to show whether or not the model provides sound predictions. The statistical significance of chi-square (0.415) suggests that the Final model gives no significant improvement over the baseline Intercept Only model, which means the model has not shown evidence to gives a reliable prediction. In other words, the final model (with factors that affect the development of innovative inputs) is not significantly better than the model without any consideration of the factors relating to firm attributes. It should, however, be noted that the final model does not give a significant improvement over the baseline Intercept Only model if the sample size is small, as is the case in this study (Osinowo, 2018). The chi-square test is appropriate for testing models with a low number of categorical independent variables. In this case, there are several predictors that are nominal and ordinal scale. But the chi-square test of the model is not conclusive, which means other methods of model testing, such as goodness-of-fit, pseudo R-square, and test of parallel line, should be applied to ordinal logistic regression models.

Table 6.10 Goodness-of-Fit Statistics for Hypothesis 2.

Goodness-of-fit				
Predicted		Chi-square	Df	Sig
INNOinput	Pearson	26.103	28	0.567
	Deviance	27.042	28	0.516

Link function: Logit

Table 6.9 shows Pearson's chi-square statistic for the model to be same as the chi-square statistic based on the deviance. The objective of this statistical test is to examine whether or not the observed data are consistent with the fitted model. The null hypothesis states the fit is good. If, however, $p > 0.05$, there is no evidence to reject the alternative hypothesis in favor of accepting the null hypothesis. The results show the conclusion of accepting the null hypothesis, both Pearson and Deviance (0.567, 0.516).

Table 6.11 Pseudo R-Square for Hypothesis 2.

Pseudo R-Square		
INNOinput	Cox and Snell	0.430
	Nagelkerke	0.517
	McFadden	0.314

Link function: Logit

In the linear regression, R^2 (the coefficient of determination) implies the proportion of variance in the outcome that can be attributed to the explanatory variables. When R^2 is large, it means that more of the variation in the outcome can be explained by the independent variables. According to Spais and Vasileiou (2006), "The R^2 statistic serves the same function as the coefficient of determination in the linear regression, which is to summaries the proportion of variance in the dependent variable associated with predictor (independent) variables". There are three different methods used to estimate the coefficient of determination; the Cox and Snell method; the Nagelkerke method, and the McFadden method. In logistic and ordinal regression analysis, the Nagelkerke Pseudo R^2 is widely used to assess the overall goodness of fit of the model. The result in Table 6.10 shows 0.517 by the Nagelkerke method, indicating that 51.7% of the variance in the predicted outcome (the development of innovative inputs) can be explained by the independent variables.

Table 6.12 Test of Parallel Lines.

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	27.042			
General	6.607[b]	20.435[c]	12	0.59

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.
b. The log-likelihood value cannot be further increased after maximum number of step-halving
c. The Chi-square statistic is computed based on the log-likelihood value of the last iteration of the general model. Validity of the test is uncertain.

One of the assumptions underlying ordinal logistic regression is that the relationship between each pair of response categories is the same. This is referred to the test of parallel lines. If the assumption is met, it would expect the difference in model fit (Chi-square) between these two models to be small and not statistically significant ($p>0.05$). In this case, p-value is 0.59 which is not statistically significant ($p>0.05$). Therefore, it accepts the null hypothesis which states that the location parameter (slope coefficients) is the same across the response categories.

Table 6.13 Parameter estimate of ordinal logistic regression for H2.

		Estimates of logit coefficients (β)	St. Error	Wald	df	Sig. (p)	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[INNOinput =3]	21.381	3.497	37.379	1	0.000	14.527	28.236
	[INNOinput =4]	26.258	4.204	39.010	1	0.000	18.018	34.498
Location	AGE	-0.455	0.218	4.337	1	0.037	-0.883	-0.027
	RENU	-0.513	0.302	2.878	1	0.090	-1.106	0.080
	PART	3.222	1.384	5.419	1	0.020	0.509	5.935
	[CAPC=1]	-3.721	2.226	2.793	1	0.095	-8.084	0.642
	[CAPC=2]	-0.538	1.679	0.103	1	0.749	-3.828	2.753
	[CAPC=3]	0^a	.	.	0	.	.	.
	[BUSS=1]	-2.832	1.917	2.182	1	0.140	-6.589	0.925
	[BUSS=2]	-2.119	2.296	0.852	1	0.356	-6.619	2.381
	[BUSS=3]	1.187	2.882	0.170	1	0.680	-4.461	6.836
	[BUSS=4]	0^a	.	.	0	.	.	.
	[CONR=1]	1.474	1.699	0.753	1	0.386	-1.855	4.803
	[CONR=2]	0^a	.	.	0	.	.	.
	[RDEX=1]	0.781	1.723	0.206	1	0.650	-2.595	4.157
	[RDEX=2]	0^a	.	.	0	.	.	.

	Estimates of logit coefficients (β)	St. Error	Wald	df	Sig. (p)	95% Confidence Interval	
						Lower Bound	Upper Bound
[SCAL=1]	23.081	3.089	55.824	1	0.000	17.026	29.135
[SCAL=2]	17.241	0.000	.	1	.	17.241	17.241
[SCAL=3]	0[a]	.	.	0	.	.	.

Link function: Logit. a This parameter is set to zero because it is redundant.

There are two main objectives that can be achieve with the output from an ordinal logistic regression in Table 6.13: (a) determine which of the independent variables have statistically significant effect on the dependent variable; and (b) determine how well ordinal logistic regression model predicts the dependent variable (Laerd Statistics, 2015). The parameter estimate in Table 6.13 is the main method of exploring the association between explanatory variables and dependent variables. This table shows the association between the coefficients; and the probability of outcomes depends on several aspects of the analysis. The link function is used to examine the order of the response categories, and the reference levels for categorical predictors in the model. Generally, positive coefficients make the first event and the events that are closer to it more likely as the predictor increases. On the other hand, negative coefficients make the last event and the events closer to it more likely as the predictor increases (Laerd Statistics, 2015).

The hypothesis (H2) postulates association between attributes of firms and how likely these attributes are in influencing the development of innovative inputs that constitute the set of services the NSP provides to its tenant firms. Where the p-values are less than 0.05, they indicate that the estimated logit coefficients are statistically significant at the 5% level. Estimates of the threshold coefficients (the constant values of the regression), which are shown in the column of estimates, are statistically different (with $p<0.05$).

The ordinal regression model produces an equation for each one of the J – 1 cumulative logit, where J is the number of categories of the ordinal dependent variable. To the five levels, respondents to the survey questionnaire can attribute to the development of innovative inputs (the Likert scale 1-5 ordinal categories - very low, low, moderate, high, and very high). So, there are four (J -1) cumulative logits and four equations. However, there are in this parameter estimate only two cumulative logits and two equations – i.e. [INNOinput=3; [moderate] and [INNOinput=4; [high] because respondents did not select [INNOinput=1 [very low] and [INNOinput=2 [low], while responding to the survey questionnaire. [INNOinput=5 [very high] is nonetheless used as reference for comparison.

The assumption of 'proportional odd'[5] would have the same slope coefficients for all two equations, with the threshold (the intercept) being the only difference between two equations. The estimates column in Table 6.11 shows the values of the slope coefficients, which means that the cumulative logit equations can be written as follows:

$$\begin{aligned} Y_{INNOinput=3} = {} & 21.381 - 0.455(AGE) - 0.513(RENU) + 3.222(PART) \\ & - 3.721\left(CAPC_{x<50,000}\right) - 0.538\left(CAPC_{50,000<x<100,000}\right) \\ & - 2.832\left(BUSS_{software\&application}\right) - 2.119\left(BUSS_{food\&agriculture}\right) \\ & + 1.187(BUSS_{science}) + 1.474(CONR_{YES}) + 0.781(RDEX_{YES}) \\ & + 23.081\left(SCAL_{start-up}\right) + 17.241(SCAL_{SME}) \end{aligned}$$

[5] It is an assumption of the slope estimation between each pair of outcomes are assumed to be the same in logistic regression model.

$$
\begin{aligned}
Y_{INNOinput=4} = \; & 26.258 - 0.455(AGE) - 0.513(RENU) + 3.222(PART) \\
& - 3.721\left(CAPC_{x<50,000}\right) - 0.538\left(CAPC_{50,000<x<100,000}\right) \\
& - 2.832\left(BUSS_{software\&application}\right) - 2.119\left(BUSS_{food\&agriculture}\right) \\
& + 1.187(BUSS_{science}) + 1.474(CONR_{YES}) + 0.781(RDEX_{YES}) \\
& + 23.081\left(SCAL_{start-up}\right) + 17.241(SCAL_{SME})
\end{aligned}
$$

The equations above can be used to predict the possibility of certain outcomes for the dependent categories by giving the values to the independent variables. The slope coefficients (β) can be interpreted in terms of 'log odds' – i.e. for every single unit increase in the predictor (independent) variable, the predicted value of the dependent variable will change by the proportion of the logit coefficient, (β).

The slope coefficients of the explanatory (independent) variables are shown in the column of estimate (corresponding to the location row) of Table 6.11. It is observed that only three of the estimated coefficients are significant at the 5% level. These relate to the following variables. PART (number of years of participation in NSP); AGE (age of firms); and SCAL (scale of business). The negative signs of the coefficients mean those independent variables have negative effects on the development of innovative inputs, while variables with positive sign coefficients imply direct relationship between dependent and independent variables. The statistically significant association of the dependent variable (development of innovative inputs) with PART, AGE, and SCAL means that the odds of PART, AGE, and SCAL are consistent across the different thresholds of the dependent variables.

In this case, PART is a continuous explanatory variable defining the number of years firms have been participating as tenants in the NSP. From Table 6.11, showing statistical significance at 5% level ($p<0.05$) and log odds = 3.222, the odds ratio is, calculated to be $e^{3.222}$ = 25.08. This means for a change (increase) by one unit (one-year) of participation in the NSP, the odd ratios of the dependent variable (development of innovative inputs) having a higher value would increase by a factor of 25.08. This represents a highly sensitive response of the Park to the needs of tenants with longer years of participation in the Park. Thus, the longer the period firms have been resident in the Park as active participants, the higher the probability the Park would be responsive to their needs through the development and provision of specific innovative inputs or services. This would give ground to the argument that longer duration of residence can create a sense of intimacy and dense interactivity between the Park and its residents, and so would prompt management of the Park to be ever more flexible and innovative in addressing the evolving needs of the firms. The implicit assumption here is that tenant firms have demanding attitudes, so that they can be adequately and appropriately provided with support services, and that the Park management is actively engaged in the development of innovative systems that would enable it to flexibly and innovatively respond to the changing needs of tenant firms.

AGE (age of firm) is also a continuous explanatory variable. In the estimated model, it is found to be statistically significant at the 5% level ($p<0.05$) with log odds at -0.455 and odds ratio, ($e^{-0.455}$), at 0.63. The negative coefficient means that an increase in the age of firms (expressed in years) is associated with a decrease in the odds of considering the development of innovative inputs by a factor of 0.63 – or a 63% probability that the development of innovative inputs is less likely to happen. In effect, this means that Park management is more likely to be responsive to the needs of younger firms than they are to older tenants with respect to the development of innovative inputs.

SCAL (business scale) is a categorical explanatory variable and is found to be statistically significant at the 5% level ($p<0.05$). The business scales of tenant firms covered in the survey are defined in terms of the following categories: start-ups, SMEs, and a large enterprise. SPSS Statistics automatically creates dummy (indicator) variables for categorical variables, such as the SCAL independent variable. By default, the last of the three categories is used as a reference to compare with the other categories. This means that the effect of the first two categories of SCAL are separately compared to the last category - that is, the effect of start-ups is compared to that of the large enterprise, and similarly for SMEs. This is why data corresponding to the large enterprise in the sample [SCAL=3] do not directly feature in the cumulative logit equations, like that of the start-ups and SMEs.

With respect to the effect of the needs of start-ups, Table 6.11 shows an increase in the log odds by a factor of 23.081. It can be read from this that the probability of the dependent variable (i.e. agree on development of innovative inputs) being impacted by start-ups compared to the large enterprise is significantly high. However, as measuring changes in log odds does not have intuitive meaning, so reporting the change in terms of the odds is necessary - that is, the ratio of the odds between the two categories, which is called the odds ratio. For a specific comparison, the odds ratio is the exponential of the log odds of the slope coefficient - that is, the exponential of 23.081, which is $e^{23.081}$ = 10,566,981,250. This means that the odds of significantly impacting the dependent variable (agree on the development of innovative inputs) are very high for start-ups than they are for the large enterprise. In other words, the needs of the start-up firms in the Park are much more likely to impact the development of innovative inputs than the needs of the large enterprise.

With respect to the effect of the needs of SMEs, Table 6.11 shows an increase in the log odds by a factor of 17.241. As in the case of the start-up firms, that the probability of the dependent variable (i.e. agree on development of innovative inputs) being impacted by start-ups compared to the large enterprise is significantly high. The log odd is used to compute odds ratio as an exponential function – i.e. $e^{17.241}$ = 4,274,786,515. This means that, as in the case of the start-up firms, the needs of the SMEs in the Park are much more likely to bring pressure to bear on the management of the Park to invest in the development of innovative inputs than the needs of the large enterprise.

Thus, our empirical analysis of Hypothesis 2 (H2) shows significant evidence of association between the attributes of tenant firms (in terms age, number of years of participation in the NSP, and business scale) and the development of innovative inputs by the Park in response to the learning needs of firms. There is no evidence, however, to show that other factors representing firm attributes are of any statistical significance to explain the likelihood of the Park developing its support services to its tenants. According to the empirical investigation of Hypothesis 2, the needs of younger firms and firms with longer duration of residence in the Park profiled on business scale are more likely to impact the development of innovative inputs provided by the Park as services to its tenants.

6.2.2 Testing Hypothesis 3 (H3).

Hypothesis 3 (H3) is set to investigate the empirical relationship between the Park's support services (expressed in terms of five categories of development of innovative inputs) and the perceived innovative performance (innovative outputs) of resident firms. The ordinal logistic regression model is used to explore these relationships. In this hypothesis, the explanatory or independent factors represent the development of innovative inputs of firms provided by the NSP. These innovative inputs are set in five categories, including the development of human resources (HURE), infrastructure and facility (INFA), knowledge linkage (KNLK), funding (FUND), and market opportunity (MAOP). The data relating to these were obtained by asking firms in the NSP how, on a five-point Likert scale, they would rate the significance of the various categories of innovative inputs developed by the NSP to their expected innovative performance (innovative outputs). The data of the dependent variable (expected innovative performance outputs) is also obtained through a questionnaire survey, asking firms to rate, based on five-point Likert scale, their evaluation of the significance of the park's support services (innovative inputs) for their desire or expectation to evolve as innovative and competitive enterprises.

When conducting the ordinal logistic regression model, it is important to check for the occurrence of the multi-collinearity problem across the independent factors. Therefore, before conducting the ordinal logistic regression model, conditions for robustness of the model are checked by testing any evidence of multi-collinearity across the independent factors. Multi-collinearity occurs when there are two or more independent variables are highly inter-correlated. Its occurrence would reduce the robustness of the explanation of dependent variables using the ordinal logistic regression model.

To diagnose the collinearity problem in the set of independent variables, the "Tolerance" or "VIF (variance inflation factor)" values of Spearman's correlation are used. VIF is a reciprocal of Tolerance value (1/Tolerance). A tolerance value of less than 0.1, or a VIF value greater than 10 is indicative of the multi-collinearity problem. In the case of this study, as shown in Table 6.13, all the tolerance values are more than 0.1 and (the lowest is 0.288), and value of VIF is less than 10. It can, therefore, be reasonably claimed confidently that there is no multi-collinearity problem in this particular set of data as shown in Table 6.13.

Table 6.14 Multi-collinearity test of independent variables (development of innovative inputs).

Independent variables	Collinearity Statistic	
	Tolerance	VIF
HURE	0.682	1.46
INFA	0.288	3.47
KNLK	0.299	3.34
FUND	0.298	3.35
MAOP	0.443	2.25

a. Dependent variable: Development of innovative outputs

Next, the logistic regression model, logit (y) = $\alpha + \beta X$ is set to examine the association between the independent variable (development of innovative inputs) and the predicted logit for the perception of innovative outputs development of firms, as showing the formulas for (H3):

$$Y = \alpha_i + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon, \text{ where}$$

Y is innovative outputs,

α is the intercept parameter,

β is the regression coefficient,

X_1 is the development of human resources (HURE),

X_2 is the provision of infrastructure and facilities (INFA),

X_3 is the knowledge linkage (KNLK),

X_4 is the access to funds (FUND),

X_5 is the access to market opportunity (MAOP), and

ε is an error term

Since logistic regression computes the probability of success over the probability of failure, the results of the analysis are in the form of the odds ratio. When the Wald test is applied to examine the statistical significance of each coefficient in the model, the model fit is shown using pseudo-R2. Pseudo-R2 is usually used to investigate goodness-of-fit in logistic models.

Tables 6.14 – 6.18 present the results of the ordinal logistic regression analysis for H3. These are tables for case processing summary for H3; model fitting information; goodness-of-fit statistics; pseudo R-Square; and parameter estimates of the ordinal logistic regression.

Table 6.15 Case processing summary for Hypothesis 3.

		N	Marginal percentage
Development of innovative outputs	2 = Low	1	4.5%
	3 = Moderate	3	13.6%
	4 = High	13	59.1%
	5 = Very high	5	22.7%
Valid		22	100%
Missing		0	
Total		22	

Table 6.16 Model fitting information for Hypothesis 3.

Model Fitting Information					
Predicted	Model	-2 Log Likelihood	Chi-square	Df	Sig.
INNOoutput	Intercept Only	46.631			
	Final	19.276	27.355	5	0.000

Link function: Logit

Table 6.15 shows the model fitting information giving the -2 Log likelihood for the ‘intercept only’ and ‘final model’ indicating whether the model provides better predictions or not. The chi-square test, which is significant at the 5% level ($p<0.05$), suggests that the final model gives a significant improvement over the baseline intercept-only model, which means the model gives a better prediction. The model fit (-2 Log Likelihood) is 46.631 for the intercept-only model (Intercept Only) compared to the model with the intercept and all independent variables (Final), which has a -2 log likelihood of 19.276. The higher the difference between the two models, the better the independent variables are at explaining the dependent variable. The difference between the two -2 log likelihood values is presented in the 'Chi-Square' column (46.631 – 19.276 = 27.355), which is chi-square distributed with 5 degrees of freedom (df) and is statistically significant at $p < 0.05$. In other words, the final model is robust enough to predict the dependent variable over the Intercept Only model.

Table 6.17 Goodness-of-Fit Statistics for Hypothesis 3

		Goodness-of-fit		
Predicted		Chi-square	Df	Sig
INNOoutput	Pearson	202.471	43	0.000
	Deviance	19.276	43	0.999

Link function: Logit

Table 6.16 shows Pearson's chi-square statistic for the model, which is the same as the chi-square statistic based on the deviance. Both the Pearson and deviance statistics are designed to provide a measurement of how poorly the model fits the data or the variation in the model that cannot be explained. Given the null hypothesis stating that the fit is good, if $p > 0.05$, this means that the null hypothesis cannot be rejected. In this case, the data and the model predictions are similar, showing the indication of having a robust model. In the case of this study, however, the two tests give contradictory results, as can be seen in Table 6.16. The Pearson goodness-of-fit test indicates a lack of fit ($p < .05$), but the deviance goodness-of-fit test indicates a good fit ($p = 0.999$). From this, it can be concluded that there is not enough evidence to claim that the model does not fit the data adequately.

Table 6.18 Pseudo R-Square for Hypothesis 3.

Pseudo R-Square		
INNOoutput	Cox and Snell	0.712
	Nagelkerke	0.809
	McFadden	0.587

Link function: Logit

In the linear regression, R^2 (the coefficient of determination) indicates the proportion of variance in the outcome that can be considered by the explanatory variables. A larger value of R^2, up to a maximum of 1, shows that more of the variation in the outcome can be explained by variations of the independent factors. The Pseudo R^2 is widely used to assess the overall goodness-of-fit of the model. In the case of this study, the Pseudo R^2 is 0.809, indicating that 80.9% of the variance in the outcome is explained by the independent variables (explanatory variables).

Table 6.19 Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	19.276			
General	0.000[b]	19.276[c]	10	0.037

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.
b. The log-likelihood value cannot be further increased after maximum number of step-halving
c. The Chi-square statistic is computed based on the log-likelihood value of the last iteration of the general model. Validity of the test is uncertain.

One of assumptions underlying ordinal logistic regression is that the relationship between each pair of response categories is the same. This is referred to the test of parallel lines. If the assumption is met, it would expect the difference in model fit (Chi-square) between these two models to be small and not statistically significant (p>0.05). In this case, the p-value is shown to be 0.037 or (p<0.05), which means that there is no evidence for accepting the null hypothesis. In other words, the location parameter (slope coefficients) is not the same across the response categories.

Table 6.20 Parameter estimates of ordinal logistic regression for H3.

		Estimate	St. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[INNOoutput = 2]	20.534	8.490	5.850	1	0.016	3.894	37.174
	[INNOoutput = 3]	24.722	9.115	7.357	1	0.007	6.858	42.587
	[INNOoutput = 4]	31.804	10.770	8.720	1	0.003	10.695	52.913
Location	HURE	-2.610	1.472	3.147	1	0.076	-5.494	0.274
	INFA	7.129	3.049	5.468	1	0.019	1.154	13.105
	KNLK	-0.455	1.827	0.062	1	0.803	-4.035	3.125
	FUND	-3.428	1.395	6.041	1	0.014	-6.162	-0.695
	MAOP	6.051	1.977	9.365	1	0.002	2.176	9.927

Link function: Logit. This parameter is set to zero because it is redundant.

Hypothesis 3 (H3) is set to investigate the extent of influence of the provision of innovative inputs (as support services) by the NSP on the expected innovative performance (innovative outputs) of its tenant firms. A p-value that is less than 0.05 indicates that the estimates are all statistically different (p<0.05), indicating that the ordinally dependent variables are significantly different from each other. The type of ordinal regression model adopted here produces an equation for each one of the J – 1 cumulative logit, where J is the number of categories of the ordinal dependent variable. As there are five categories of the dependent variables (development of innovative outputs), so there are four cumulative logits and four equations. However, one of the cumulative logits [INNOoutput=1] is dropped because respondents did not select [INNOoutput=1; very low] while responding to the questionnaire. So, there are only three cumulative logits and three equations. These are [INNOoutput=2; low], [INNOoutput=3; moderate], and [INNOoutput=4; high] for which parameters are estimated. [INNOoutput=5; very high] is used as the reference to be compared with for the other dependent categories: [INNOoutput=2; low], [INNOoutput=3; moderate], and [INNOoutput=4; high].

In the ordinal logistic regression model, the parameter estimates in Table 6.19 empirically define the relationship between the explanatory variables and the dependent variables. As shown in this table, the estimates for INFA (provision of infrastructure and facilities); FUND (access to funds); and MAOP (access to market opportunities) are statistically significant at the 5% level ($p<0.05$). Surprisingly enough, the parameter estimates for variables HURE (development of human resources), and KNLK (knowledge linkage) are not found to have statistically significant influence on firms' expected innovative performance.

The assumption of proportional odd would have the same slope coefficient for all three equations, and it is just in the threshold or intercept values that the three cumulative logit equations differ, as shown below:

$$Y_{INNOoutput=2} = 20.534 - 2.610(X_1) + 7.129(X_2) - 0.455(X_3) - 3.428(X_4) + 6.051(X_5)$$

$$Y_{INNOoutput=3} = 24.722 - 2.610(X_1) + 7.129(X_2) - 0.455(X_3) - 3.428(X_4) + 6.051(X_5)$$

$$Y_{INNOoutput=4} = 31.804 - 2.610(X_1) + 7.129(X_2) - 0.455(X_3) - 3.428(X_4) + 6.051(X_5)$$

where;

Y is categories of innovative outputs; [INNOoutput=2; low], [INNOoutput=3; moderate], and [INNOoutput=4; high].

α is the intercept parameter,

β is the regression coefficient,

X_1 is the development of human resources (HURE),

X_2 is the provision of infrastructure and facilities (INFA),

X_3 is the knowledge linkage (KNLK),

X_4 is the access to funds (FUND), and

X_5 is the access to market opportunity (MAOP)

The equations above can be used to predict the possibility of dependent categories for different values of the independent variables ($X_{1,2,3,4,5}$). It also possibly interprets the slope coefficients (β) in terms of log odds. The statistical test conducted on the β coefficients shows that only the variables representing development of infrastructure and facilities at the Park; the Park's ability to leverage access to funds for its tenants; and the Park's ability to enhance the scope of marketing opportunities facing its residents, are all significant at 5% level. This finding is startling in that the survey data does not provide significant evidence to show that the knowledge and skill services the Park provides to the firms (in terms of development of human resources and knowledge networks) have any bearing on the expected innovative performance of firms. This can happen if resident firms do not have confidence in the robustness of the Park's support services with respect to the provision of knowledge and skill services. Alternatively, the result could be a reflection of the inadequacy of the survey data.

Let us now consider the three factors that are found to have influence on the expectation of science park firms to evolve as innovative and competitive enterprises. The first one is the provision of infrastructure and facilities (INFA) with log odds of 7.129 and an odds ratio of $e^{7.129}$ = 1247.6. This means for a change of one unit of INFA (i.e. a unit increase in the provision of infrastructure and facilities), the odds for the development of innovative outputs would increase by a factor of 1247.6. This is strong evidence supporting the hypothesis that the provision of infrastructure and facilities (INFA) by the Park has significant influence on the expected innovative performance/ innovative output of tenant firms. While infrastructure and facility support are crucial for firms that aspire to evolve as innovative and competitive enterprises, it can be argued that firms could possibly be exuberant about their expectations of innovative performance consequent upon the use of the infrastructure and facilities provided by the Park. In view of this, it can also be argued that while the evidence of firms' expected innovative performance due to the Park's provision of infrastructure and facilities may not be conclusive, the evidence about firms' satisfaction regarding the Park's provision of infrastructure and facilities can hardly be contested.

The second innovative input or support service provided by the park is represented by the independent variable FUND (access to funds) with log odds of -3.428 and with an odds ratio of $e^{-3.428}$ = 0.05. This means that for a change in one unit of the FUND variable (i.e. a unit increase in funding support services), the odds for development of the innovative outputs or innovative performance of firms would decrease by a factor of 0.05. This result is surprising since it is at odds with the Park's conventional role as a liaison facilitating access to funding sources for its tenants with the view to improving prospects of their expected innovative performance. This state of affairs could perhaps be attributed to the low success rate of applications submitted for research grant in Thailand due to high competition, given the small pot of money (0.6% of GDP) allocated by the Government for research budget. In such situations, and particularly where firms do not appear to have confidence in the role of the Park as a funding liaison, firms could possibly be tempted to buy into the perverse view that the marginal cost of submitting applications for research grant is greater than the marginal benefit accruing from it.

The third innovative input of statistical significance is the factor which relates to initiatives within the Park to cultivate market opportunities (MAOP) for tenant firms. The relationship between the services of the Park and the expected innovative output/performance of firms is found to be statistically significant at the 5% level ($p<0.05$) with an estimated log odd of 6.051 which yields an odds ratio of $e^{6.051}$ = 424.5. This means for a unit change in MAOP (a unit increase in the Park's support to cultivate market opportunities for its tenants), the odds for expected innovative outputs would increase by 424.5 times. This finding shows the firms' expected innovative output and the likelihood of them evolving as innovative and competitive enterprises are highly sensitive to the Park's effort to develop the market networks for its tenants. This is an important innovative input as the development of market network, like the development of knowledge network, is a major category of the activities of science parks, in general. Firms that have developed the capability to innovate would need to commercialise their innovative outputs and would even seek to establish themselves as 'niche players' in the global market.

Residence in science parks is usually expected to equip firms with the capabilities to innovate and commercialise. Pursued with vigour, this would make them 'global born' firms – innovative and competitive. The evidence emerging from the survey data is not, however, complete enough to warrant such a conclusion. For firms to develop the ability to innovate and commercialise, they would be expected to be active players both in the knowledge network and market network activities of the Park. There is, however, no evidence to suggest that the Park has been proactive with knowledge network and human resource development activities involving resident firms. This implies that the triple helix system underlying the operation of the Park has not yet taken root, which is perhaps not surprising considering the youthful age of the Park itself. On the other hand, science parks like the NSP that are budget constrained would naturally be inclined to play a real estate role, administering park infrastructure and facilities, while firms within them would be driven by the objective of exploiting short-term market benefits from the vantage point of park residence (Malairaja and Zawdie, 2008). In the circumstances, resident firms may expect their innovative performance to be predominantly market-driven.

6.3 Conclusion

It is worth noting in conclusion that the picture emerging from the empirical analyses of Hypothesis 2 (H2) and Hypothesis 3 (H3) in this chapter bear some evidence of interdependence between the Park as provider of services and firms as tenants that seek to evolve as innovative and competitive enterprises. Investigation of H2 established a statistically significant association between the attributes of firms (in terms of age, number of years of participation in the NSP, and business scale) as independent variables, and the development of innovative inputs by the Park in response to the learning needs of firms, as dependent variable. Based on survey data elicited from the NSP, it was found that the Park would respond to the learning needs of younger firms, firms that have been long in residence in the Park, and firms who are start-ups and SMEs rather than to the needs of the large enterprise.

Analysis of Hypothesis 3 produced a statistically significant association between innovative inputs of firms provided by the Park in the form of infrastructure and facilities (INFA); access to funds (FUND); and development of market opportunities (MAOP), as independent variables, and the development of innovative outputs or the expected innovative performance of firms, as the dependent variable. The findings suggest that the provision of infrastructure and facility (INFA) by the Park, and the Park's effort to develop market networks for its tenants have significant positive influence on the expected innovative performance/ innovative output of tenant firms. It is also found that for a unit change of the FUND variable (i.e. a unit increase in funding support services), the odds for development of the innovative outputs or innovative performance of firms would decrease by a factor of 0.05. This finding is surprising, but its explanations may have its roots in the budget-constrained activities of the Park.

The findings, however, leave some questions unsettled, as in the case of factors like human resources development and knowledge network development activities of the Park that do not appear to have any significant influence on firms' expected innovative performance. Such questions will be explored in the discussion of the data and information elicited through the interviews with NSP firms conducted as part of the study.

Table 6.21 Summary of results.

Issues for investigation	Results of investigation
Association between the characteristics of firms and the development of innovative inputs.	It was found that three factors influence the development of innovative inputs of firms: longer participating in the park, age of firms (younger firms), and business scale (small firms). It was also found that firms of longer period of residence in the Park and younger firms of small business scale are more likely to develop innovative inputs than firms with other characteristics.
The relationship between the Park's support services (innovative inputs) and the perceived innovative performance (innovative outputs) of resident firms.	Provision of infrastructure and facilities, and market opportunities were two factors showing significant positive effect on the perceived innovative performance innovative outputs) of firms, while access to funding show significant negative effect.

CHAPTER 7
QUALITATIVE ANALYSIS OF THE ROLE OF SCIENCE PARKS IN PROMOTING THE INNOVATIVE AND COMPETITIVE PERFORMANCE OF TENANT FIRMS

In the foregoing chapter, questions about the different categories of innovative inputs that science parks provide to resident firms, and the influence of these on the expected innovative performance of tenant firms have been empirically investigated. Also, the chapter has sought to explore evidence of association between firm characteristics and the provision of innovative inputs, to show the responsiveness of science parks to the learning needs of different types of tenant firms. The results of the empirical analysis, however useful and interesting, are not comprehensive, possibly reflecting on the limitations of the survey data. This calls for a further investigation involving qualitative analysis to examine the dynamics in the relationship between science parks and their resident firms as per Hypothesis 4 of this study (see Chapter 4). The aim of this chapter to shed light, through an interview-based survey, on the triple helix-based mechanism underlying the functions of science parks in supporting and promoting tenant firms to be innovative and competitive; and to extract lessons to be learned from the NSP's experiences by identifying, using SWOT analysis, the scope for turning weaknesses into points of strength, and threats into opportunities. The remainder of the chapter will be address questions relating to these objectives.

Also included in this chapter is a section on the results of a follow-up survey conducted a year after the first survey in 2019. The follow-up survey, which covers 50% of the firms covered in the original sample, is primarily intended to check if firms have changed their views regarding their on-park experiences, given the possibility that they could change their views about the usefulness of the services delivered by NSP); and given also the short span of time the firms have been resident in NSP when they were first interviewed, and the questions that arise from this regarding the adequacy and significance of their on-park experiences. In short, the follow-up survey would provide a quick test of the reliability of the findings of the analysis based on the 2019 survey data.

7.1 How does the NSP function as a science park to support and promote its tenant firms to be innovative and competitive?

Interviews were conducted with firms located in the NSP, in a semi-structured form, to look into the mechanism underlying the activities of the Park to support and promote its tenants to be innovative and competitive. The interviews were conducted with the aim to deepen and broaden understanding of the information embedded in the data obtained from each firm.

As noted in the methodology chapter, the 22 firms resident in the NSP were asked to sign consent forms to confirm that they were willing to be interviewed, but with the provision that the data obtained from the interviews would remain confidential.

After the 22 interviews were conducted and transcription of the interviews completed, the data were collated for analysis with the aim to answer aspects of the research questions in ways that would complement or shed more light on the results of the quantitative analysis. The analysis started by comparing and contrasting individual cases to recognize discrepancies and consistencies across the 22 firms. Views expressed by firms were organized into meaningful categories in ways that would allow the underlying thread of meaning recurring across the categories to be identified. NVivo 12 was used to manage and analyze the data.

Questions were asked to explore the mechanism underlying the activities of the Park, and the experiences gained by the firms from the services of the NSP. This relates to the question addressed in Chapter 4 through the investigation of Hypothesis 4 (H4). The responses of firms to the questions are presented and discussed below.

(i) Question about the nature of support services derived from the NSP and how this relates to company's needs.

The interviews brought out that firms were able to receive a variety of support services from the NSP. The analysis used the NVivo tool to capture keywords relating to services provided by the Park mentioned in the interview transcripts. From the transcripts, the key services mentioned repeatedly by the firms in the interviews were grouped into six categories of support services (like space and facilities, knowledge linkage, research consultancy, etc.), to show the number of times these key words were repeated by the firms as shown in Table 7.1 (category of knowledge linkage). The six categories of support services are shown in Table 7.1. The support service most frequently mentioned by firms is space and facilities at 30.65%, while funding support ranked second at 24.19%. Firms appear to consider these services crucial for their development as innovative and competitive enterprises, although the results of the quantitative analysis in Chapter 6 do not reflect the enthusiasm of firms regarding the funding factor.

Based on Table 7.1, this would evidently provide the cognition of favourable services which are in the relief of innovative development. It is not surprised that the basic infrastructure in term of space and facilities are inevitable advantage to most firms. This would help them in the objective of cost reduction and increase the credibility by the location they resident. In contradict, funding becomes the second notion that firms refer which differ to the pervious chapter in quantitative analysis showing funding was neutral in term of increasing the perceived innovative performances. The less mentioned is research consultancy which the Park should improve the platform of services to play an important role in supporting firms with a concrete advise.

Table 7.1 The outputs of repeated words of firms from the interview transcripts using the NVivo tool.

Repeated words	Frequency	Percentage
Space and facilities	19	30.65
Knowledge linkage	8	12.9
Research consultancy	5	8.06
Research development	7	11.29
Market and reliability	8	12.9
Funding	15	24.19
Total	62	100

Analysis of the data in Table 7.1 also gives further insight by cross-tabbing service categories into firm characteristics, such as age group, business scales, and business sectors showed in Table 7.2. The results show that space and facilities are the type of support most frequently voted for by firms in the 1 – 3 years age cohort. Similarly, firms in the categories of SMEs and start-ups prefer support in the form of space and facility, as do firms from the software and applications sector. It should be noted that firms in the 0 – 3 year age cohort; SMEs; and firms engaged in software and applications, constitute the majority of the firms located in the NSP.

Table 7.2 Group of supports mentioned by firms categorizing by characterization of firms.

Characteristics		Space and facilities	Knowledge linkage	Research consultancy	Research development	Market and reliability	Funding	Total
Age group (years)	0 – 3	10	2	2	3	3	8	28
	3 - 5	5	4	1	2	3	3	18
	More than 5	4	2	2	2	2	4	16
	Total	19	8	5	7	8	15	62
	Percentage	30.65**	12.9	8.06	11.29	12.9	24.19*	100%
Business scale	Start-up	9	2	2	3	3	8	27
	SME	10	5	2	4	5	7	33
	Large	0	1	1	0	0	0	2
	Total	19	8	5	7	8	15	62
	Percentage	30.65**	12.9	8.06	11.29	12.9	24.19*	100%
Business sectors	Software and application	9	6	3	3	7	7	35
	Food and herb	5	1	1	2	0	5	14
	Material sciences	3	1	1	2	1	2	10
	Medical devices	2	0	0	0	0	1	3
	Total	19	8	5	7	8	15	62
	Percentage	30.65**	12.9	8.06	11.29	12.9	24.19*	100%

Most firms who reported on the nature of supports they received from the NSP also agreed these supports were beneficial to their businesses. One firm responded to the question about the support services they received and how these supports benefited their company:

> *To be a start-up company, we had to establish credible standards in order to enhance our image. The NSP is able to support and implement the research and development process we need to launch a product. For example, it taught us how to design a business model, apply for research funds, and how to launch products. If we had problems or doubts about anything, the NSP was able to help us with advice. They can provide links to universities, researchers, instructors, and consultants who can help solve any problems. (NSP03)*

The feedback from the interviews shows most firms thought the supports provided by the NSP helped them to develop their products through the knowledge links they forged with particular researchers.

> *The NSP offers us working space, service areas, facilities and some funds for our operations, such as trade shows. If we have any problems, then we can talk to the NSP. They can help us find an agency or researchers to deal with our problems. Sometimes they will talk to researchers first to see whether they can help us or not. Researchers can help us find specialists to solve our problems. It is like creating an information network of researchers by using the NSP as a bridge which is reliable and systematic, and this means the process is faster than if we did things for ourselves. (NSP17)*

Similarly, one of the firms engaged in software and applications and seeking to be on a knowledge network with a particular university, said they were supported in accessing universities since becoming resident in the NSP.

We have got to know the researchers at the university, and we have access to research agencies that are a part of the network. Also, we have a working area where we can have an office for appointments with customers, meetings, and coordinating and cooperating with academic staff at the universities who are doing research work. (NSP20)

Funding is a typical form of support from the NSP particularly to start-ups and small firms. Many firms in the NSP asked for funds or sources of funding. The NSP provides initial funds to firms joining in the incubation programme.

The NSP supported our initial funding for the first year we participated in their development program. We had to submit our business plan and then the NSP advised us on how to implement it. For example, we now have a 3-year development plan, but the NSP monitors our expenditure closely. It is very useful to have someone to take care of and manage our costs and expenditure efficiently. Also, the NSP reviewed my proposal before we applied for funds and advised me on how to present my plan. This is very helpful, and we also have space, facilities, a meeting room, a hall, and convenience stores so we do not need to go anywhere else. In other words, the NSP offers everything we need for running our business and this is particularly convenient for small or new businesses. (NSP10)

It is surprising that some of the points that transpired in the interviews are not reflected by the results of the quantitative analysis of the survey data in Chapter 6. For instance, the knowledge network development factor is found to have no significant influence on the expected innovative performance of tenant firms in the quantitative analysis. On the other hand, the information elicited by the interviews shows that firms would consider knowledge linkage as an important factor that has attracted them to locate in the Park. Also, access to funding is shown in the quantitative analysis to have a negative influence on firms' expected innovative performance, suggesting that firms' access to funding through the NSP would involve more cost than benefit to the firms, and would, if anything, adversely affect their expected innovative performance. But what is shown by the information elicited by the interviews is that firms would rather consider access to funding an essential component of park services to its tenants.

There are at least two ways to understand this apparent confusion. First, it may well be that the survey data are incomplete, which raises the case for improving the data base of research. Secondly, there is good reason to believe that the aim of tenant firms in their early stage of residence in the Park is focused more on commercial than research-related innovative objectives. This view is supported by the observation in both the quantitative and qualitative analyses of the survey data, which show firms highlighting the importance of the provision of infrastructure and facilities as a category of support services to tenant firms.

(ii) Question about the amount of support received from the NSP and how this has benefited firms in terms of R&D and innovation activities

The interviews show that most firms have received the NSP supports in the form of different types of services. 'Knowledge linkage' was frequently mentioned as having benefitted firms in generating new ideas for solving problems. Most firms spoke about the usefulness of the support they received from research consultants, and academic experts through the NSP, and about the benefits they derived from knowledge exchange activities within the Park. Following are the views of some of the interviewees on the benefits they gained from the services of the Park

> *I have been supported so much. Access to information links has been easier, including research consultants and experts. The activities provided by the NSP have given us greater opportunities in terms of co-partners, creating new ideas and products, and exchanging knowledge and experiences. (NSP5)*

They help me a lot in many ways. We have had consultancies with researchers and academic staff from the university. We have also been able to share our experiences and knowledge with other the NSP companies here. (NSP21)

A lot of supports in the NSP, we always meet and discuss things with the private sector. There are links that we can access to government agencies and universities in terms of research consultancies. These agencies can provide funds and researchers as partners. A consultant can train our employees and increase their skills. (NSP1)

In addition, even the only large company resident in the Park with advanced research and development unit of its own, would acknowledge benefits of Park residence to their business which they realized through the Park's university linkage programme.

We are a large company, so our research and development must continue all the time; and even though we have our own research unit, we also need to do research with other research institutes, like university or public research centres. The NSP helps us by providing links with university experts and research consultants. (NSP9)

In some cases, however, firms indicated preference for linkages that would enhance market opportunities rather than improve their research and development capabilities. This appears to reflect firms' preference for benefits to be reaped during the short term period through engagement in market networks, and their reluctance to be involved in knowledge-based activities through research and development that would take long to pay-off.

We are ready in terms of research and development, but we want an opportunity to market our product/s and to develop links with other the NSP companies. Also, it benefits us when we say we are from the NSP which has a good reputation, and it helps us to apply for funds. (NSP7)

In contrast, some firms responded differently, because they already have the capabilities to do the business, they are engaged in.

Not much support, really. We have already had connections with university staff and an information network. We'd like to re-brand our business as a private company because we are a branch of Chiangmai University. After re-branding, it would be easier for procurement and run the business like other private companies. (NSP18)

(iii) Question about how firms would have fared in terms of knowledge exchange, innovation networks and business performance if firms had not joined the NSP

The search for counterfactual evidence as to how firms would perform if they had not joined the NSP as tenants would shed light on their perception of the benefits they have derived from park residence, possibly by intuitively comparing their current position with that of their counterparts off-park. The results of the quantitative analysis in Chapter 6 did not strongly reflect on-park services relating to knowledge exchange and innovation networks as much as they did on market networks and the infrastructure and facilities provided by the Park. What is implicit in the results of the quantitative analysis is that park residence would not make any significant difference to improvements in the business performance of firms as a result of improvements in their knowledge exchange and innovation network effort. This is not, however, what transpires from the interviews. Indeed, some firms argue, as shown below, that their experiences in knowledge exchange, innovation networks, and business performance would have been different had they not joined the NSP. The following quotes from the interviewed firms illustrate their perception regarding knowledge exchange, innovation networks, and business performance:

Yes, I do, because being in the NSP helps me to expand my research network in so many ways, such as researchers, advisors, information, and specific skills. There are also spaces available to us with useful *facilities to do R&D or hold meetings. Young firms will be encouraged, and they can start their own business by joining the NSP. (NSP1)*

Yes, I do. I believe that without the NSP I would only be able to develop slowly, and I would not be sure of the right direction. They have taught me to lean canvas, market validate, market test. They monitor our progress carefully and recommend what we should focus on and how we should implement new ideas. (NSP10)

Yes, I do, because working here at the NSP has helped us grow faster. There are more opportunities to meet new customers, government agencies, universities, and other entrepreneurs. The NSP is creating an eco-system that encourages other entrepreneurs to help each other by sharing their knowledge and experience which can result in new ideas. If we were not here it would be more difficult to maintain our credibility in doing business with our customers. The NSP offers us opportunities to meet customers and it helps us to be more reliable, so that customers will trust us more, and then we can negotiate business more easily. (NSP16)

In contrast to these views, one tenant firm, who happens to be a large Japanese-owned enterprise, believed that becoming a resident in the NSP did not make any difference to their knowledge exchange and innovation network effort. This is because they have their own in-house research and development which they could run to advance the innovative effort of their business. However, they joined the NSP because this would enable them to have access to universities and other research centres.

No, I don’t think so. Our situation would be very different because we are a large company, and we have our own unit for research and development. However, we need a link to the university to help us broaden and deepen our research and development effort. (NSP09)

It is apparent from the responses of the interviewees above that firms recognize knowledge/R&D network as an important component of the services the NSP provides to its tenants. In fact, the decision of the firms to join the Park appears to have been prompted by their desire to develop their research and development capabilities. However, as R&D and innovation capability development is a long-term process, it would not be surprising if in the case of most of the firms in the Park, the expected innovative performance of firms is more sensitive to market networks than it is to knowledge networks, as the results of the quantitative analysis in Chapter 6 show. Although most firms claim that their decision to join the NSP is driven by the knowledge, market and funding networks facilitated by the NSP, this does not mean they would always have an edge over off-park firms in terms of innovative performance (Malairaja, 2008). This argument could possibly be extended to lend support to the validity of the results of the quantitative analysis of the survey data in Chapter 6.

(iv) Question about the range of benefits firms get from the NSP, which they would not be able to get if they were not in the NSP

Tenant firms receive a wide range of support from the NSP, like space and facility, accessing to knowledge and funding networks and access to market networks through platforms like product exhibitions. All interviewed firms indicated that they would not have been able to gain these benefits if they had not joined the NSP.

> *We have obtained a space/area for research and development including other facilities, for example, a meeting room with modern technology where I can negotiate business with groups of customers and partners. This is very useful for improving my reputation with clients and helps me to obtain capital for new ventures. (NSP7)*

> *We use the services provided by the NSP to create innovations and to develop our products. The NSP is an innovative centre where there are*

many firms creating new ideas which can be applied to new products. If we were not here, I would not have known where to find any support and it would have certainly taken us a much longer time to develop. (NSP5)

The NSP provides us with many useful activities relevant to our basic requirement for business growth. NSP always invites experts or people with successful experience to talk to us which I would not have if I was not here. For instance, meeting with other firms located at the NSP, exchanging ideas, easy access to funding resources, and advice from NSP staff. (NSP4)

I think access to the NSP here has helped our business develop and improve our reputation. The NSP can provide an office, a meeting room, consultants and help with negotiations. Most importantly, I can refer to the NSP whenever I need help, so that makes my business easier when talking with customers. The NSP also makes it easier to access resources for funding and information from university. (NSP3)

If we were not located at the NSP, it would be difficult for us to contact and meet university staff and government researchers which is a very important part in the development of our work. If we were not here, no one would know anything about us, and they would not be able to recommend us. If we were not here, then we would have to find researchers and research units for ourselves. This would be a difficult process and subject to trial and error, and it would take us a long time. (NSP20)

The buildings and facilities are new and modern, and the environment is pleasant and attractive. We have tax reductions, facilities, meeting and training rooms here. Also, we can set up an exhibition at the NSP because there is a large hall with room for about 500 people. My *company's image for reliability has improved since we have been at the NSP. (NSP18)*

We can meet other firms and find out what they are doing which can help us develop our own business and set up co-operative projects. If we were not here, it would be more difficult to take advantage of various opportunities such as funding, access to customers in both government agencies and private companies. The NSP has made us realize that it would be a lot more difficult for us we were not here. If we had stayed where we were before, we would have had to operate entirely on our own. (NSP16)

The NSP has supported us with initial funding for small firms or start-ups. For example, we receive our travel costs when negotiating business, and the costs of exhibiting our products. If I hadn't located to the NSP, I would have had many problems and it would have increased my expenditure. (NSP12)

(v) Question about how often firms in NSP meet other tenants to exchange ideas, and if this practice has been of any material benefit to them

It is assumed that most firms enjoy the ecosystem of the Park and the interactions it allows between participating firms to exchange ideas. Most firms use the NSP platform to present their profiles to attract firms that would collaborate with them in developing innovative ideas, innovative designs and innovative products. The NSP would also use social media to inform their residents about ongoing and forthcoming events that could stimulate interactions between firms for knowledge exchange and collaboration on innovative projects. Some firms, however, find having regular meetings with other firms in the Park difficult to manage or even unnecessary, as it transpired from the interviews. The interviews also revealed some cases of success of collaboration between firms, as shown by the following interview transcripts:

We have frequently exchanged ideas and experiences with other the NSP companies. This has been very useful for developing our ideas and products. (NSP6)

There are quite often activities here which enable us to gain new knowledge from mentors, experts, invited guests and also, we have opportunities to attend meetings and to exchange ideas with other firms which might lead to becoming partners in the future. (NSP5)

I always participate in the activities the NSP provides if I have time, or sometimes I ask my staff to participate in my place. There are many activities here which are very useful for my business. The NSP always invites well-known experts to give talks on their experiences and who can give valuable advice. (NSP4)

I quite often meet and exchange ideas with other companies because there have been many activities and events for the NSP clients to participate in. I think it has improved my skills when I participate in the exchange of information and experiences. (NSP3)

Sometimes we meet and exchange ideas but because we have own R & D unit, we don’t need a lot of help. We are already a large company with capital costs, and we have long term experience. In fact, our experience might be of benefit to other smaller companies. (NSP9)

Not often. I’ve missed some events, but I try to attend if I have time. However, at each event I have attended I have had many opportunities to exchange ideas and introduce my company so that it becomes better known to the public and we will be able to have more contacts in the future. Moreover, these meetings help me develop market opportunities and allow us to advertise ourselves. (NSP19)

We have had a few meetings here with other companies during working hours. But it’s difficult for us to attend these meetings as there are more *important things for us to do. Since there are many industries located here, finding common ground and bringing everyone together is quite difficult. Thus, such activities should be organized so that all companies can benefit, and they should be arranged at a convenient time. We have been able to meet and to exchange experiences and knowledge with other companies here. (NSP14)*

What all the interviewees have expressed in the above quotes are their views and tendencies at the level of generalities. They were reluctant to give concrete cases of collaborative projects and how these have evolved through the dynamics of knowledge sharing and knowledge exchange into innovative products. This is not surprising considering that most of the firms have not been in the Park long enough for the collaborative projects they engage in to yield innovative products that are worthy of commercialization.

7.2 Lessons to be learned from NSP's experiences.

This section seeks to address lessons to be learned from the NSP's experiences through feedback from firms reflecting on the strengths and weaknesses of the Park. Five questions are asked to bring out the views of firms on this. These questions also serve the purpose of triangulating the evidence borne out by the investigation of Hypothesis 4 (H4) in Chapter 4.

(i) Question about satisfaction of tenant firms with the support they receive from the NSP

In the interview process, firms were asked if they were satisfied with the support they received from the NSP to grow their businesses; in what ways they were satisfied; and if firms were not satisfied, they were asked to specify reasons for their dissatisfaction.

In all cases, firms said they were satisfied with the various supports they received from the Park. Some showed satisfaction with infrastructure and the

NSP business ecosystem which they found to be conducive for generating innovative ideas. Others showed satisfaction with the support they received in the forms of funding, consultancy, customers' trust, and knowledge linkage. Satisfaction of firms with the different services of the NSP is observed to vary across firm characteristics such as age of firms, capital value, business sectors, and business scale, thus confirming the evidence established in Chapter 5. Firm satisfaction with the NSP services also varies depending on the stage of growth of firms - whether they are at the initial stage or the growth stage or the stable/maturity stage of the firm life cycle. The following quotes allude to the degree of satisfaction of firms with the support services they received from the NSP.

> *Yes, we are satisfied with their support and with all their efforts to follow up the cases when we have asked for their help. Their staff are experienced and always willing to help us. (NSP9).*

> *Yes, we are satisfied. Our research and products are more reliable as a result of the NSP contribution which means they will be easier to sell on the market. As a result, we have also been able to increase the variety of our products. (NSP6).*

> *I am satisfied with the NSP. The NSP is suitable for developing businesses like mine because they provide a variety of services that can help us in the initial stages with space, facilities and funding. (NSP5)*

> *Of course, I am pleased that the NSP can help us establish links with government agencies, universities and the private sector. These channels of communication help us to develop our business more easily. It's easier than doing it ourselves, because we don't know who to talk to. The NSP helps us to recruit or recommends people to help us, for example, they can find us a law firm when we have legal problems. (NSP15)*

(ii) Question about whether tenant firms intend to extend their residence in NSP for long.

The information obtained through the interviews show agreement that all firms agreeing to stay long term in the Park as tenants to be able to realise the comprehensive benefits deriving from the services of the Park, particularly the R&D and knowledge exchange benefits and benefits due to engagement in market networks, which normally accrue to firms over time. This view of the firm is consistent with an earlier observation in the quantitative analysis that 100% of the resident firms would continue to reside in the Park long term. This is anyway what would be expected of serious tenant firms, lest the motive of their residence would be nothing more than the pursuit of reputational gains and also short term commercial gains deriving from the real estate function of the Park. Long term residence of firms in the Park would enable them to be fully engaged as active players in the triple helix system.

> *Yes, we do. We would like to be at the NSP long term so that we can continue our research activities, develop our products and establish a successful business model. (NSP7)*

> *Yes, for as long as possible. As I said previously, the NSP supports us with many services from the first stages of establishing a business. They help us with our business, product development and provide us with an appropriate working environment which leads to new ideas. (NSP5)*

> *Yes, I do intend to stay, because it helps us to develop research links through consulting with researchers and academic staff from the university and with government. We can see that being here has helped us progress faster. Once we have a project, we can get the NSP to set up connections for us to meet those researchers who are suitable for our purposes and reliable enough for us to work with them. (NSP20)*

If we don't need to move out due to the company's expansion, we will stay here because the NSP can provide us with a location and the services we need. (NSP14)

(iii) Question about why firms decided to locate in the NSP.

According to the interviews, the ultimate goal of firms locating in the NSP is to succeed in business – to be innovative and competitive, and so even to emerge as 'global born' enterprises. For this to happen, firms would need to be supported in terms of having access to knowledge networks, funding networks, and market networks. Access to these networks is facilitated by the NSP, which plays an intermediary role, to promote cooperation between academia/research centres, government agencies, and business and industry on innovative projects. The collaborative mechanism among the three pillars offered by triple helix networks is crucial for developing innovation and competitiveness. The following quotes from some interviewees show why firms decided to locate in the NSP;

Yes, I wanted to establish a good reputation and develop our clients' confidence in our company. (NSP8)

We want to develop our research to produce new products. This is the main reason for locating at the NSP and we believe this will lead to business growth, greater credibility and reliability, and also increase the value of our shares which will help us acquire capital for new ventures. (NSP6)

I came here because I saw that there were opportunities for the research and development of our products which would lead to business growth. (NSP4)

7.3 Lessons to be learned from the NSP experiences as feedback for the development of science park strategies.

The interviews asked tenant firms to reflect on the strengths and weaknesses of the NSP as a triple helix platform based on their own experiences in the Park. They were also, based on this, asked to give their recommendations to improve the effectiveness of the services provided by the Park. Their recommendations are then tested against the results of a brief SWOT analysis.

(i) Firms' views on lessons to be learned from the NSP experience

There is a general consensus among tenant firms that as a triple helix intermediary, the NSP has played an important role in supporting and promoting the business performance its tenants with the provision of various platform services. However, there is scope for improving the performance of the NSP in the delivery of services through the development of knowledge networks, funding networks and market networks. Moreover, the system of park management has yet to evolve for the NSP to be able to make effective use of the Park's infrastructure/space and installed facilities specifically targeted at the Park's objective of promoting innovation capability and enterprise development within a triple helix framework.

Two main ideas emerge from the interviews with respect to how the establishment of new science parks would learn from the strengths and weaknesses of the experiences of the NSP. Firstly, new science parks would do better if set up with focus on specific products - like, for example, science parks for food and agricultural products, for technology, for medical products, for material science, etc. In other words, science parks would be effective if they were organized as specialised platforms. This would, however, depend on the diversity of the resource endowments of the country and the distribution of these across the various regions of the country. The argument underlying this view is that it would encourage local entrepreneurs to utilize local resources with which they are familiar to create new products through the application of a specific set of knowledge of implicit and codified nature that is appropriate to the exploitation of the resources for good commercial ends. The interviewees have nonetheless a number of concerns about plans for the establishment of new science parks.

> *The government should focus on specific products prior to making decisions on the establishment of a new science park and they should also improve the benefits and incentives available at the NSP. They should persuade as many firms as possible from a variety of business sectors to re-locate to the NSP. (NSP7)*

> *Vision is important. Future technology and product trends should be carefully studied to ensure that products meet future needs. There should also be adequate modern and technical facilities available at the NSP. The environment surrounding the area is also a factor which should be taken into account in deciding what to produce. (NSP6)*

> *New science parks should have different zones suitable for different types of businesses. (NSP3)*

Secondly, some interviewees thought science parks would perform better if launched with missions that relate to the economy at large. This is important as science parks are investment-intensive projects. Their success in achieving their missions is, therefore, much desired. As such, science park could be organised, for example, as research parks engaged in conducting research in collaboration with academia; or commercial parks, targeting on the marketing of products; or intermediaries linking stakeholders to collaborate. Each type of science park would require different management with specific knowledge and ability. Another idea is to set science parks in locations where they would be surrounded by universities, research institute, private companies, like in the Silicon Valley, to create a community for innovation.

It depends on what you want the NSP to be like. If you want them to be part of a university, then the academic staff will be able to manage it. But if you want it to be a part of the government, then you will need a central executive to manage it. If you want the NSP to become commercial, then you must have an organization that can manages in this field, for example, a stock market manager. So, it depends on the policy makers as to the direction science parks should take. However, as I pointed out earlier, science parks should not be concerned with property management. (NSP22)

The surrounding area should become an innovative district like Silicon Valley. It should be surrounded by universities and business companies, so people who are interested can join like in Stanford. In addition, the NSP companies should play an important role in bringing successful firms from outside to participate. (NSP2)

The NSP should be an experimental space that establishes many values. The environment should encourage new ideas and innovation. The value of science parks is that they should not only offer an attractive environment, but they should be focused on research, especially the use of deep technology which can be used to improve marketing opportunities. Science parks should be a focus point for experts and businesses with high potential so that they can create a significant impact on business. (NSP12)

In sum, it was generally felt that the lessons learned from the NSP's experience were considered useful as a basis for the establishment of science parks in the future, subject, however, to the limitations posed by the small number of firms in the NSP. As a benchmark on which to base the patterns of science parks to be set up in the future, the NSP would not be the best of cases to consider not only for its smallness but also for its newness and limited experience. In view of such limitations, the lessons deriving from the experiences of the NSP would not be expected to fully bring out the diversity of possibilities that can be considered as options for the establishment of science parks in the future. On the other hand, the lessons of experience could be of much use to shed light on strategies for improving the NSP's performance in delivering and administering services to its tenants in ways that would improve their innovative performance.

(ii) Firms' recommendations for improvements of the NSP services

The following recommendations transpired to improve the management system of the NSP:

> *I think the NSP should advertise their platform of services more to persuade other firms to locate to the NSP. The NSP should establish a unit / department to provide companies with the information the NSP companies need to solve their problems. (NSP7)*

> *I would like the NSP to provide us with more channels to contacts when we have problems, to improve the speed in coordinating and reducing limitations, and different holidays for private and government sectors. (NSP4)*

> *It would be better if there were staff with experience in specific areas such as software / applications so they can help companies communicate better with each other and our clients. (NSP3)*

> *The process of working with other departments is too slow, so it would be better if we could request funding for collaborative projects with other agencies. There are too many administrative processes when cooperating with other organizations. It would be better if the time could be reduced. (NSP20)*

> *We work late but the NSP opens and closes at official times, so there is a mismatch with our working hours. I recommend that the NSP's*

working hours should match those of the companies working here. (NSP16)

The NSP should be a certified body and aim to develop the trust of customers. It should not concern itself with property management and it should have a capital market to truly promote businesses and to find suitable markets. From a policy perspective, I believe in the founding vision of this place. When I worked in a college it was easy to make connections, but without the help of university staff, I don't really see how it can work in terms of vision and mission. For example, if the NSP was not located at Chiang Mai University, there would not be any links. (NSP22)

I think the NSP should advertise their platform of services more to persuade other firms to locate to the NSP. The NSP should establish a unit / department to provide companies with the information the NSP companies need to solve their problems. (NSP7)

Another set of recommendations that transpired from the interviews relates to the role of government intervention in the activities of the Park. It was felt that the Government should support the Park through the provision of information and advice about global market needs and trends:

Yes, we should have regular customers which should primarily be through the government. The government should help us find markets for our products. (NSP12)

It would be useful to have information from the government about what the market needs, what the problems are and how our products can be sold. There is a market for our products. I would like the NSP to find or recommend customers and solve our problems with regard to the demands of the market, so that we can continue to use our capabilities *and resources and not waste time studying the market by ourselves. (NSP21)*

(iii) SWOT analysis

The SWOT method is used here to analyze the strengths, weaknesses, opportunities, and threats of the science park strategy for the emergence of innovative and competitive enterprises in the light of the experiences of the NSP. SWOT analysis provides a useful framework for drawing up strategies by showing how weaknesses can be translated into strengths, and threats into opportunities. The results of the SWOT analysis are used to validate the information obtained from the interviews on lessons to be learned from the experiences of the NSP and the recommendations made for improving the performance of the NSP.

Once the SWOT list is drawn up as in Table 7.3 below, the next task is how to build on the points of strength; redress weaknesses turning them into potential strengths; exploit opportunities and create more opportunities; and mitigate threatening circumstances, if not turn threats into opportunities.

Table 7.3 SWOT analysis of the NSP' s activities and experiences.

S STRENGTHS	W WEAKNESSES	O OPPORTUNITIES	T THREATS
- Newly established - Full facilities and services supporting firms. - The only intermediary agency in that area. - Excellent location, located near a university and nice environment for creating innovation - Good management team and service-mind staffs - Closed to firms with strong linkages Networked with government agency and university	-One-year operation -Low number of residents -Limited experiences in management -Limited public relations -Need specific staff skills such as patent, tax laws, etc. -Low success case of walk-in firms -Long process involved in the recruitment of tenant firms -Unreliability in supporting firms -Only one large enterprise recruited as a tenant	- Becoming a new landmark to visit in that area - Growth number of start-ups and small firms - Government encourages growth in the number of local enterprises - Graduated students want to be a new entrepreneur	-Budget shortfalls -Dependence on government funding -Networking problem with business and industry, particularly lack of cooperation with high-profile enterprises - Networking problems relating to triple helix development (the 'structural hole' problem)

Strengths

The NSP is located in Chiangmai Province, the second capital of Thailand, where it was formally established in 2018. As a newly established regional science park, the NSP is fully furnished with the state of the art facilities catering for different services. Locationally, it is near Chiangmai University, the regional airport, and the local market, which makes it ideal as a triple helix platform for knowledge and market networking. The Park environment is attractively designed, so the Park is graced with large number of visitors on account of business matters and visual education. The varieties of services provided to residents are geared to incubating firms to be innovative and competitive. In fact, the NSP is emerging as a well-known intermediary agency in that area, facilitating interactions between academia (knowledge producers), business and industry – i.e. tenant firms (users of knowledge), and government (major source of funding and agency of control and regulation of knowledge production and use).

The NSP is expected to serve local firms who desire to improve their business performance in particular products, such as rice and herb. However, they are also capable of accommodating other business types as they have the infrastructure and facilities as well as extensive networking with government agencies and academia. The NSP's role as an intermediary in a triple helix system is enhanced by the fact that it is managed by academic instructors with expertise in management and enterprise development and is staffed with personnel equipped with the requisite skills for manning the administration of services to tenant firms. These are the strengths of the NSP that would make it attractive for off-park firms to join it.

The NSP is a new establishment set up only in 2018. There is, therefore, wide scope for it to build on its strengths. The most important area of engagement for development will be enhancing its role as a triple helix intermediary by bridging 'structural holes' through the broadening and deepening of knowledge, marketing and funding networks. As these triple helix networks evolve into a dynamic system of innovation, more and more off-park firms would be expected to join the NSP, and this would make its contribution to the local economy significant. For this to happen, the NSP would need to build its staff with proficiency in network development to be able to cope with the challenges of management in the recruitment of tenants and the delivery of professional services to them.

Weaknesses

For a new science park like the NSP, the list of weaknesses would be expected to be longer than the list of strengths. In Table 7.1, the two lists appear proportional in length; but this hides the weight of the challenges in the points itemized as weaknesses. As a triple helix platform, the NSP requires the experience, the expertise and the resources to effectively liaise with academia, government agencies and business and industry, including on-park and off-park firms. As a newcomer, the NSP runs short on all these. Consequently, its networks involving the three triple helix players are fragmented; and the multiplicity of 'structural holes' in the networks would delay decisions and distort priorities. This would have adverse implications for the regularity and effectiveness of the services provided to tenant firms, and ultimately for the prospects of tenant firms emerging as innovative and competitive enterprises on the back of their science park experiences.

There are currently 22 firms; and the smallness of the number of residents in the Park could raise questions for off-park firms with respect to the scope for knowledge exchange and learning from one another through networking, and about the capacity of the Park to effectively cater for larger number of tenants, and so for the prospect of success if they chose to locate in the Park. During the interviews, some firms raised concern that the process of recruitment following applications takes unduly long time. Other areas of concern about the Park include its low public relations capability to reach out off-park firms and serve as an active gatekeeper for on-park firms; and its staff skill profiles that are short in such specialized fields as patenting and corporate tax laws, among others. If these problems persist for long, prospective tenants would scarcely be inclined to locate in the Park, and this would make it difficult for the NSP to increase the number of its tenants.

The NSP will overcome its weaknesses over time while evolving as a triple helix platform. However, there are some points of weakness that could be discarded, if not rectified, immediately, like, for instance, improving the public relations aspect of management, expediting the application and recruitment process and staff training to upgrade and diversify the staff skill portfolio. To make itself attractive to off-park firms, who are now reluctant to join the Park, the NSP can set up a model supporting walk-in firms[6]. This would provide prospective tenants a platform of services to address their queries about the knowledge, market and funding networks liaising with academia and government and non-government agencies. It would also build the confidence of business and industry in the NSP, and so raise its reputation and reliability as a triple helix platform.

Opportunities

Prospects for the expansion of science parks like the NSP depend, among other factors, on the range of opportunities that are available to it. Opportunities can be exploited as points of strength. The NSP stands as a landmark in the region; but beyond this, its networks with academia, government and business and industry make it an attractive policy instrument for the government to focus on it and to make funds available to it. This is more so now that Thailand is moving towards a knowledge-based trajectory of economic growth. It is also the policy of government to encourage and support start-ups and small firms as a strategy of industrialization and regional development. This policy of the government represents an opportunity for science parks like the NSP to increase their turnover of resident firms, while

[6] Office of Industrial Liaison (OIL) is the unit aims to deliver the needs of walk-in firms to the suitable services in the NSP.

strengthening its position and enable it to emerge as a hub of research and innovation in the region. The triple helix orientation of policy also calls for collaboration between academia and industry/business, which means that the knowledge production role of academia will encourage a growing number of graduates in business and engineering, in particular, to exploit their entrepreneurial potential by incubating innovative business ideas in science parks. Some universities in Thailand are known to support their graduates with initial funding once they pass pitching of the market plan of their projects. The NSP can also play a role in this networking of emerging entrepreneurs with consultants and funding sources, as well as in coaching and incubating them.

Threats

The survey data discussed in Chapter 6 show shortfalls in knowledge and funding networks as major challenges, which left unaddressed, would deprive tenant firms of the expectation to emerge as innovative and competitive enterprises. According to the empirical findings, the infrastructure and facilities factor including knowledge networks do not have statistically significant influence on the expected innovative and competitive performance of tenant firms. This is a threat to the NSP to the extent that the knowledge network problem of the fragmented nature of the triple helix networks across the wider economy. According to the survey data, lack of cooperation, especially with large enterprises, is an aspect of the NSP's networking problem. Another challenge facing the NSP is the problem of access to funding because of shortfalls in budget allocation to science parks. Budget allocation depends on the health of the economy, the revenue performance of the country's budget policy, and the range of competitive ends which policy has to address through a system of priorities.

It is also a challenge for the NSP to change threats into opportunities. Thus, for example, the NSP would be expected to increase the number of its resident tenants, as this improves not only the reputation of the NSP and the trust the business and industry sector has in it but would also increase the income stream for the NSP. In this respect, the NSP would do well to persuade big-name companies to join it as residents. The inclusion of such firms in the Park has the advantage of supporting the Park's effort in knowledge sharing and knowledge exchange and mentoring and coaching small firms.

7.4 Follow up survey of resident firms

The additional survey, which was conducted a year after completion of Phase II, aims to follow up the changes in the views of tenant firms about the usefulness and relevance of the services delivered by NSP. The follow-up survey covered 10 of the 22 firms, resident in Park (see Table 7.4). The selection of firms was random, but coverage of detail was constrained by time factor. The data was collected using two methods: interviews and review of annual reports.

Table 7.4 Details of firms covered in the follow up survey.

No.	Name	Establishment	Business sector	Capital cost	Business scale
1.	Company A	2016	ICT & Software	1	Startup
2.	Company B	2017	ICT & Software	5	Startup
3.	Company C	2016	ICT & Software	1	SME
4.	Company D	2017	ICT & Software	0.3	Startup
5.	Company E	2017	ICT & Software	1	Startup

No.	Name	Establishment	Business sector	Capital cost	Business scale
6.	Company F	2005	Food & Agriculture	1	SME
7.	Company G	2017	ICT & Software	1	Startup
8.	Company H	2018	Medical Device	1	Startup
9.	Company I	2016	ICT & Software	1	SME
10.	Company J	2017	ICT & Software	1	Startup

Source: Survey data

*Company names are not specified for ethical reasons

7.4.1 **Company A:**

Product Details: The company is in the business of creating mobile applications for financial planning and examining the financial health of companies. It can be applied for identifying if the financial health of companies is vulnerable to risk and for making recommendations for future financial plans.

Changes and development: After the first survey over a year ago, the company developed an application platform for mobile network that is user-friendly, fast and suitable for both Apple (IOS) and Android. The company's income increased three-fold consequent upon its participation in the Park as a tenant. The incremental incomes derived largely from technology licensing and fees for consultancy services regarding use of the application platform developed by the company. On the other hand, the level of employment has not changed.

This is not surprising considering that the business is characteristically ‘skill-intensive’ and that what is critical for the company to scale up is growth in the number of skilled app developers. Capital investment is also crucial for scaling up. However, this has not increased during the period following the first survey. Overall, the firm appear to have found its feet in the Park, actively participating in the activities of the Park, particularly those relating to marketing through exhibition platforms. This is notwithstanding the Covid-19 factor that has adversely affected business growth across the board.

Current Status: They are still resident in the Park and have no intention to move out of the Park, which suggests that the Company is satisfied with the services delivered to it by the Park.

7.4.2 **Company B:**

Product Details: This company, which is involved in innovative IOT (internet of things), is engaged in the development of software and hardware which can remotely control smart electronic devices via mobile application. Its products add to the comfort and expediency of domestic services in households (smart homes) and industrial services in factories (smart factories).

Changes and development: Since locating on-park as a tenant, the Company has been acknowledged for its activities and participation in market events. This has reportedly brought credibility and trust from the existing and new customers. According to the Company’s report, the Company has engaged several roadshows and business negotiations with smart factories, hospitality events, condominiums, and villages. In addition, the Company’s product is already patented. They are planning to scale up the R&D unit aiming to cover other business fields which call for smart devices.

Current Status: The Company plans to spin off from the Park to scale up the company.

7.4.3 **Company C:**

Product Details: Company C has developed an application for linking dormitory operators or monthly rental businesses and tenants to facilitate payments of rental bills, payment, and produce useful information and financial reports. The application helps users to access relevant information fast without any bottlenecks and transaction costs.

Changes and development: The number of customers has currently increased two-fold since 2019. The Company's plan is to cover 10,000 dormitory operators by 2022. Accordingly, not only has capital investment increased three times since 2019, but the Company's cash flow has also increased. The Company believes its on-park location to be the major reason for the growth to date of its business. According to the Company, its activities have benefited from the services delivered by the Park, particularly the provision of infrastructure and facilities, ready access to knowledge resources and market opportunities that created conducive circumstances for the Company to engage in innovative activities.

Current Status: The Company plans to spin off from the Park to scale up the company.

7.4.4 **Company D:**

Product Details: The service this company provides is an on-line platform for helping students and researchers to select appropriate statistical methods to analyse data and report results.

Changes and development: The Company seems to have settled in the Park, but with slow growth of business with limited clients. The Company is satisfied with the incentives it receives from the Park in the form of rental fee, funding, access to knowledge networks and market forecast services. However, the on-line-service platform of statistical analysis is not innovative enough when compared with existing statistical software packages like SPSS, STATA, and

Minitab. Although the company faces many competitors in the market, it has a competitive edge over others since the software it produces is capable of automatically displaying the full report of statistical results including explanations. The company has yet to overcome the challenge of slow growth and small number of clients by being more innovative that would give it a niche market. The company would need to redouble its effort to make the best of its residence in the Park to draw support that would enable it to be more innovative.

Current Status: The Company is still resident in the Park.

7.4.5 **Company E**

Product Details: The service the company produces is a mobile application for renting heavy machines, linking between suppliers and users. The company's income derives from service fees. The interface of application shows the list of rental heavy machines and where these machines are. The rental is determined based on the distance between the owner of the machine and the client.

Changes and development: The company has experienced brisk growth of business turnover, although only one new employee hired since 2019. There are number of local construction companies in the area engaged in the building of resorts, villages, and residential houses. These companies would prefer to have heavy machines on lease contracts with suppliers rather than buy the machines themselves. This situation provides an opportunity for Company E to expand its client base with support from the Park.

Current Status: The Company is still resident in the Park.

7.4.6 **Company F:**

Product Details: The Company produces food supplements, like those extracted from mushrooms; cosmetics, like herbal soaps; and healthy soft drinks from Thai herbs. The products are particularly popular among older people, and so with the aging population now growing in Thailand, the Company faces a 'healthy' local market and has a potential to find a niche in the global market.

Changes and development: The Company has strong collaborative links with knowledge sources, such as universities and local research institutes, from whom they receive ideas for innovating products and developing prototypes. The Company would then hire OEM (Original Equipment Manufacturer) to scale up and launch the innovated products. This process from the drawing board to the market has been supported by the Park through the provision of relevant consultancy, access to knowledge and facilities and platforms for exhibiting products and join market events, like ThaiFex, Beyond Beauty Asia, Innovation and Design Expo, etc., to promote the Company's products and negotiate terms for marketing the products.

Current Status: The Company plans to spin off from the Park to scale up the company.

7.4.7 **Company G:**

Product Details: Company G is engaged in the development of high-technology devices and software, which fall in the category of artificial intelligence (AI). Cognitive software is a primary product used in factories to observe and collect data relating to workers with the aim to analyse their behavior mainly for security reasons. The product can be employed by other businesses, which seek to adopt AI technology to do behavior analysis of employees and customers to be able to determine the factors that bear on the productivity of the company and the marketability of its products

Changes and development: Since the first survey in 2019, the Company has five-fold the capital value funded by the joint venture initiatives. This is mainly because the Company applies AI technology across its activities. The application of AI technology has the effect of enhancing the prospects of companies to be competitive and innovative. The Company has drawn support from the Park that has given it prompt access to services and knowledge networks, and has enabled it to have a clear picture of market foresight about AI and so to provide the Company information about matching venture capital firms who see an opportunity of investing in high-technology devices.

Current Status: The Company plans to spin off from the Park to scale up its business.

7.4.8 **Company H:**

Product Details: The main product of Company H is a herbal medicine extracted from papaya, which is used for application after mosquito bites, and also bites by other insects.

Changes and development: The Company's business turnover has made significant progress since the first survey in 2019. In part, this is because of the many market outlets for the product the Company arranged at several convenience stores. The Company has also increased its capital value two-fold to cope with the expansion of demand for the product. More importantly, growth of the Company's business turnover is based on the nature of the tropical ecosystem in which mosquitoes and poisonous insects are rampant. The Company's engagement in the business roadshows the Park provided – interfacing with, for example, Thailand Baby Best Buy, Trade Show – has helped it to promote the marketability of its product.

Current Status: The Company is still resident in the Park.

7.4.9 **Company I:**

Product Details: The product of the Company is used to service the management system of on-line commerce, normally on Facebook and Instagram platforms. This amounts to catering management system for on-line commerce to businesses through transport companies, such as SCG Express, Flash Express, Bee Express, Nimja Van, who would act as liaison linking Company I with its client companies.

Changes and development: To date, Company I has over 10,000 orders a day via its co-partner transportation companies Since 2019, Company I has increased its cash flow and invested more in application development, human capability, and has managed to increase the number of its employees. The Company expects to deliver over 100,000 orders a day in future.

Current Status: They plan to spin off from the Park to scale up the company.

7.4.10 **Company J:**

Product Details: Company J set up a mobile application of stock management system for convenient stores. The service enables shop owners to manage their commodity stock (in and out), both online and offline.

Changes and development: Company J has not made much progress since 2019. This is largely because the application it produced is not used by many shop owners. The number of active users is 100, whereas what is needed to sustain such an expert-based consultancy business is over 1.1 million convenience stores in Thailand. The capital value of the Company, its employment and cash-flow has not changed since the first survey in 2019.

Current Status: The Company is still resident in the Park.

The above brief report of the follow-up survey shows the prevalence of a general consensus among resident firms about the usefulness of the services provided by the Park. Most of the interviewed firms report progress of business and plans to scale up and spin-off. On the other hand, only few firms have reported they needed the Park's continual support. Firms that spin off would allow the Park to receive new firms who would like to join the Park to incubate. This is a reflection of success in the business performance of the firms. However, this does not mean that firms showing progress in their businesses would be required to leave the Park. The follow-up survey shows that firms that show business progress are still resident in the Park where they feel secure and confident with the support services provided by the Park. Most firms believe that since they located in the Park, they have done well in terms of their preparedness to be the innovative and competitive in spite of the Covid-19 intervention since 2020 that has had the effect of slowing growth of activities across the economy. Overall, the finding of the follow-up survey has nothing more to show than to confirm the findings that resulted from the first survey in 2019.

7.5 Conclusion

Through a qualitative analysis of the survey data and information, this chapter has explored the mechanism underpinning the functions of science parks in supporting and promoting tenant firms to be innovative and competitive, as postulated in Hypothesis 4 of this study. All the 22 firms located in the NSP were interviewed face-to-face and asked questions about the services they receive in the NSP. Most firms expressed positive views on the support they received in terms of infrastructure and facilities and funding. These two services are typical supports which tenants firms have received from the Park. Their views do not, however, corroborate the empirical evidence obtained from the analysis of the quantitative survey data discussed in Chapter 6.

Most firms agreed that the services they received from the NSP were helpful and that these would help them to achieve better results in terms of innovative and competitive performance than what would be the case if they did not join the Park. The apparent contradiction between the results of the quantitative and qualitative analyses can be explained by the possibility that the former is based on the experiences of the firms over the short period since they joined the Park, whereas the latter relates to the longer experience the firms expect to derive from their residence in the Park.

The interviews show most firms were satisfied with the NSP's management and would continue to reside in the NSP for as long as necessary. In the long term, the firms believe that the NSP's supports can help them incubate and evolve as competitive enterprises by enabling them to participate in knowledge networks; opening market opportunities and giving them access to sources of funding. Results of the SWOT analysis showed that in the long term, firms can build on their strengths, transform their current weakness into strengths, exploit the opportunities that are already open to them, and turn the threats that are confronting them into opportunities.

The straw follow-up survey conducted a year after the first survey in 2018 showed that the perception of firms about the usefulness of the support services delivered by the Park has not changed - if anything, it appears to have been strengthened. This is evidenced by the business performance of resident firms as reflected by the interviews conducted in the surveys and the annual reports of the firms. Most of the firms have been able to scale up and to spin off from the Park, thanks to the platform of services the Park

Table 7.5 Summary of the empirical results.

Issues	Results derived from interviews with firms
Nature of support services delivered to resident firms by the NSP.	The range of services includes: space and facilities, knowledge linkage, research consultancy, research development, funding, and market opportunities and business reliability; but the most frequently mentioned service category by the firms is space and facilities.
How support services received from the NSP benefit firms to impact their innovativeness and competitiveness	'Knowledge linkage' (or knowledge network) was the factor frequently mentioned as having benefitted firms in generating new ideas for solving problems. Research consultants and linkages with

Issues	Results derived from interviews with firms
	academia are the mechanisms used for promoting the development of knowledge networks.
Decision to join the Park and plan of residing in the Park.	Firms have been prompted to locate on-park by their desire to develop their research and development capabilities such as knowledge and funding networks and access to market networks. All firms indicated that they would not have been able to gain these benefits if they had not joined the NSP. All firms agreed to stay long-term in the Park as tenants to be able to realise the comprehensive benefits deriving from the services of the Park.
Lessons to be learned from NSP's experiences and the feedback for the development of science park strategies.	Firms were satisfied with the various support services they received from the Park. Most firms enjoy the ecosystem of the Park and the interactions it allows between participating firms to exchange ideas which they found to be conducive for generating innovative ideas. Two main ideas emerge from the interviews with respect to how the establishment of new science parks would learn from the strengths and weaknesses of the experiences of the NSP. Firstly, new science parks would do better if they were set up with focus on specific products - like, for example, science parks for food and agricultural products, for technology, for medical products, for material science, etc. Secondly, science parks would perform better if launched with missions that relate to the economy at large. Another idea is to set science parks in

Issues	Results derived from interviews with firms
	locations where they would be surrounded by universities, research institutes, private companies, like in the Silicon Valley, to create a community and business environment conducive for innovation.
Have resident firms changed their perception of the services delivered by NSP since they were last surveyed in 2018?	The follow-up survey a year after the first survey shows that the perception of firms about the usefulness of the support services delivered by the Park has not changed - if anything, it appears to have been strengthened. This is evidenced by the business performance of resident firms as reflected by the interviews conducted in the surveys and the annual reports of the firms. Most of the firms have been able to scale up and to spin off from the Park, thanks to the platform of services the Park provides. The performance of tenant firms depends on the characteristics of the firms and the underlying growth trend of business sectors. Given this, the interview results show that the Park's support would need to focus on those firms that are weak and have yet to find their feet through the incubation process.

CHAPTER 8
DISCUSSION AND CONCLUSION

This chapter summarizes the findings of the study in the light of the existing body of relevant knowledge, and the research question, aim and objectives of this study. It also looks into the practical and theoretical implications of the results of this study. The chapter also discusses the limitations of the study and the tentativeness of conclusions that are drawn based on the results of the empirical analysis of the study.

The remainder of this chapter is in five parts. The first part highlights and discusses the results of the study deriving from the empirical analyses in chapters 5, 6, and 7. In Chapter 5, Hypothesis 1 is investigated; Hypotheses 2 and 3 are investigated in Chapter 6; and Chapter 7 explores Hypothesis 4 through qualitative analysis. The second part addresses the policy and research implications of the results of the study, particularly from the vantage point of government investment in science parks and management of science parks. In the third part are discussed limitations of the study, which have implications for the significance of the results of the study in terms of their usefulness as basis for policy. In the fourth part, recommendations are made for the development and management of science parks based on the empirical evidence derived from the results of this study, the limitations of the study notwithstanding. The conclusion of the chapter is in the fifth part.

8.1 Discussion of findings of the study

A survey was conducted covering a total of 22 tenant firms in the NSP to investigate the research question on how tenant firms would respond to the services that the NSP provides to support them to be innovative and competitive enterprises. The responses relate to the age, scale, and capital cost of tenant firms, the business sectors the firms come from and the perception of tenant firms about the importance of their participation in the NSP for enhancing their aim to evolve as innovative and competitive enterprises.

8.1.1 Firm characteristics and reasons for participating in the NSP.

Most tenant firms in the NSP are new firms with the average age at 5.5 years. In fact, almost half of tenant firms are less than 3 years old, while the oldest tenant firm is 29 years old. Interestingly, 72.73% are young tenant firms; and they are start-up and small and medium enterprises (SMEs) with quite low capital value. Half of the tenant firms in the NSP are engaged in software production and applications where there has been growth in information and communication technology (ICT) and knowledge-based firms over the last two decades (since 2000).

As per objective 1, the study explored the reasons for participating in the NSP of tenant firms to understand the core factors that determine the decision of firms to locate in the Park. Tenant firms participate in the NSP in the belief that it would help them to improve their technological, business and commercial capabilities. The ‘space, utility, and facility’ factors also influence the preference of firms to participate the park as tenant firms.

The study also explored reasons for the participation of firms in the NSP according to their age groups, business scales, business sectors they come from, and capital value. It is apparent from the survey data that factors like government incentives and space utility and facilities, and company reputation have higher influence in the case of younger firms. These factors are also of relevance for firms that fall under the low capital value category. The firms with such characteristics are generally small and of low investment capability and would, therefore, badly need incentives and access to space and facilities which they would not be able to have if they located off-park. On the other hand, for the group of mature firms (5 years and above), factors like opportunities of new ideas, potential for innovation through research and development activities, and research consultancy services appear to be more appealing in terms of their decision to locate in the Park than provision of incentives and facilities. Such firms have sufficient financial resources, and business and market experiences; so where they need support most is in the area of research and development.

Firms in the lowest capital value group would prefer to locate in the Park mainly to enhance their reputation; but the participation of firms with high capital value is also influenced by a variety of factors, such as opportunities for developing their R&D and innovative capabilities, and enhancing their access to research centers etc. Given their relatively comfortable financial position and the R&D support they receive at the Park, firms in this category are secure with respect to the issue of readiness for starting business.

In this study, business scales are categorized into start-ups, SMEs and large enterprises. For large scale companies, reputation and government incentives do not count as significant influence on their participation in the Park. Unlike small companies, large firms are financially independent. They are attracted to the Park mainly for making R&D links with researchers and for engaging in knowledge exchange activities. In contrast, the group of new and small companies like start-ups and SMEs show the preference for on-park location to be able to reduce cost of investment in space, utilities and facilities. Provision of government incentives; access to research centers for consultancy; and learning from the experiences of others through networking are additional factors new and small firms would factor in while deciding to locate on-park.

The software & application business sector is represented by 50% of the tenant firms in the NSP. However, unlike firms from other business sectors, software and application firms do not appear to feature prominently on most of the factors that influenced the decision they made to participate in the Park. On the other hand, the factors including government incentives, company reputation, knowledge linkage and knowledge exchange appear to have equally appealed to them as they did to firms from the other sectors.

Tenant firms were asked to indicate their first, second, and third important reasons for participating in the NSP. It is found that the provision of space, utility and facilities is what matters most for most tenant firms - particularly firms that are new and low capital value. This factor has the effect of reducing the overhead costs they would be landed with for developing infrastructure and facility if they did not choose to locate in the NSP. The second factor that influences the decision of firms to participate in the Park is the aim to 'innovate and improve'. This is particularly the case with firms engaged in activities that call on the development of in-house research and development capabilities. The third factor influencing firms' decision to participate in the Park relates to the desire of firms to enhance their 'company reputation' as a result of locating on-park (Löfsten and Lindelöf, 2003). This factor is important as it has implications for the ability of firms to increase their customer acceptability and hence their business turnover. In other words, science parks would be preferred by tenant firms since they are usually expected to increase firms' reliability and trust in the eyes of customers and in business negotiations.

8.1.2 Tenants' views regarding innovative activities.

8.1.2.1 R&D expenditures.

Exploring the views of tenant firms on science parks as promoters of innovative activities is important as this would enable science park management to understand aspects of R&D that firms would consider to be crucial for promoting innovative activities. The results of the survey indicate the type of expenditures which tenant firms would invest in to promote innovative activities. It is shown that in the overall schedule of investment expenditure for innovation, R&D manpower stands out prominently. Other aspects of significance are development of knowledge linkages and software technology.

Firms of all age groups show consideration of investment in R&D staff to engage in innovative activities. Older firms show that they can invest in patents or intellectual property, while small firms cannot. For all small firms in the Park, investment in machinery and equipment are expensive as is investment in buildings and other advanced infrastructures. Younger firms prefer to invest in the development of knowledge linkages which is cheaper than other types of R&D expenditures since knowledge is often ‘freely’ provided by universities and public research institutes to on-park firms. Younger firms do not want to invest in patents and infrastructure as these are considered to involve budget commitments that are beyond their reach. So, for such firms, locating in science parks is a better choice to the extent it facilitates the provision of services that meet their specific needs. In view of this, if science park management understood the nature of investments required for specific aspects of R&D to promote innovative activities, they would be able to provide the type of investment that firms cannot afford, such as patent and intellectual property, building, machine and equipment, software and technology. This could attract off-park firms to join the Park. Increase in the number of firms in the Park could broaden the scope for knowledge sharing among firms and create conducive environment for innovation.

Start-ups do not appear to be keen to invest in high budget categories, such as infrastructure, machinery and equipment, patents or intellectual property, and R&D staff development. They choose residence in science parks as this provides the best way for them to receive benefits from the facilities the Park offers. Hence the large number of start-ups and small firms participating science parks, as in the case of the NSP considered in this study.

8.1.2.2 Factors inhibiting R&D and innovative activities.

Identification of the factors that inhibit R&D and innovative activities is important for strengthening policy on the role of science parks in promoting R&D and innovative activities. Science parks could prioritize these factors as problems that would need to be addressed. This study shows younger firms to be uncertain about the need for engaging in innovation. The uncertainty relates for the most part to the lack of information about markets. They would need support in the form of product and market consultancy, so that they would know the products with high market impact that should be focused on as part and parcel of their business strategies. This would help young firms to grow in confidence and engage in R&D activities that would enable them to deliver innovative products and processes. For the older firms, it is legal and regulatory impediments that count as inhibiting factors. Awareness of this would bring pressure to bear on policy regulators to provide regulatory mechanisms that do not unduly interfere with business activities.

The group of start-ups show inhibiting factors including uncertain demand for innovated products, lack of information on markets, and lack of information on technologies. This result bears similarity to the profile of the group of young firms most of which are start-ups. These are basic factors that inhibit innovation among SMEs and startups. Only one large enterprise indicates legal and regulatory issues as a factor inhibiting innovation and R&D activities.

For the group of software and application firms, the inhibiting factor is funding. Funding is particularly important for them because of their requirement of high-performance equipment and technology, and qualified researchers in software and applications. Lack of information on technology and on markets is reflective of lack of innovation strategy and inadequate commitment of government to support and encourage firms in this sector. In fact, the of software and applications sector should be rapidly updated through waves of investment, to keep up with the very high competition in the global market.

8.1.3 The effectiveness of the delivery of park services.

The second objective of the study is about the effectiveness of the delivery of park services to tenant firms. So the views of tenant firms on the effectiveness of the delivery of park services are explored based on the model of innovative transformation; innovative inputs; innovative processes; and innovative outputs. The range of services provided by science parks would be expected to bear on the success of tenant firms to evolve as innovative and competitive enterprises.

The data show firms benefiting from the provision of innovative inputs: space for research and development; support facilities for research and development; consultancy for research and development, knowledge linkage with university and research institutes. Tenant firms generally agree about the usefulness of the support they receive from the Park in the form of innovative inputs. The highest preference of firms was for the provision of space for research and development. This is consistent with the evidence in the literature about the infrastructure factor provided in science parks across countries (Boehm and Hogan, 2013; Aliahmadi *et al.*, 2015).

Most of tenant firms in the sample surveyed (95.5%) are start-ups and SMEs; and 72.7% of these new enterprises are in the age range between 1 – 5 years, who are satisfied with the support services provided by the Park. In view of this, the NSP support to tenant firms is generally understood to be helpful as it can, among other things, significantly reduce their overhead costs.

Innovative process or the process of product development is incorporated into the support which science parks offer to tenant firms, following the provision of innovative inputs. Firms 'strongly agree' on the usefulness of increased interactions among participants; creation of conducive environment for knowledge exchange; and creation of a platform for enterprise networking and for learning from the experiences of others in the Park. As in the literature (Dettwiler, Lindelof and Lofsten, 2006; Yang, Motohashi and Chen, 2009; Díez-Vial and Fernández-Olmos, 2015), the survey data show the usefulness of park participation for firms to know each other well, so that they can learn from each other's experiences, and collaborate in solving problems and in setting up new businesses as co-partners. In addition, the science park platform provides opportunities for market prospecting and for business matching where large number of firms with a wide range of complementary products and business types work together in collaborative spirit. This is reflected by the survey data as all firms strongly agreed on the usefulness of their participation in the NSP for their innovative effort. Firms also reflect their sensitivity to the issue of market prospecting through their positive reaction to the opportunities the Park offers to network with consumers/ customers.

The results discussed above appear to confirm the hypothesis (Hypothesis 1) that on-park firms are likely to be innovative and creative, depending on the type of services, i.e. their appropriateness provided by parks.

8.1.4 The relationship between the various categories of support services provided by the NSP and the perceived innovative performance of firms.

Most surveyed firms are of the view that the effectiveness of the NSP in providing them with innovative services is crucial for their objective to evolve as creative, innovative and competitive enterprises. This view is empirically explored through the investigation of the hypothesis (H2), which postulates that the development of innovative inputs, which constitute the range of support services science parks provide to tenant firms, is influenced by the characteristics of the firms, namely: number of years participating with the NSP (PART); age of firms (AGE); scale of business (SCAL). Following this is investigated the hypothesis (H3), which postulates that firms' perception of their innovative performance largely depends on the services parks provide in the form of five categories of innovative inputs, namely: provision of infrastructure and facilities (INFA); access to funds (FUND); access to market opportunities (MAOP); human resources (HURE); and knowledge linkage (KNLK).

8.1.4.1 On the investigation of Hypothesis 2 (H2).

The study investigated if there is any evidence of significant relationship between the characteristics of firms and the level of development of innovative inputs provided by the NSP to its tenants.

It is observed that only three characteristic variables of firms have significant influence on the development of innovative inputs. These characteristic variables include: PART (number of years participating with the NSP); AGE

(age of firms); and SCAL (scale of business). The empirical results are shown in Table 6.12.

It is apparent from the results of the empirical analysis that, with respect to the characteristic variable represented by PART, a one-year increase of experience in the Park would increase the chance of firms considering possibilities of achieving development of innovative inputs by a factor of 7.02. This relationship suggests that the Park would focus on tenants with longer years of participation in the Park. So, the longer the duration of firms' residence in the Park, the higher the probability that the Park would be responsive to their needs through the provision of innovative input services. This would give credence to the argument that longer duration of residents can create a sense of intimacy and dense interactivity between the Park and its residents. This is in keeping with the findings of other studies (Motohashi, 2013; Albahari, Catalano and Landoni, 2013).

With respect to the characteristic variable represented by AGE (age of firm), the result of the empirical analysis shows a one-year increase in the age of firms would decrease the chance of firms considering possibilities of development of innovative inputs by a factor of 0.63. This means that the influence of the age factor on the development of innovative inputs is minor, at best, and negative, at worst. A word of caution is in order here, however, as the majority of firms in the Park are young, with the age half of them 3 years and below.

With respect to the firm characteristic variable represented by SCAL (business scale of firms) and its relationship with the development of innovative inputs, the survey data was analysed separately for start-ups (SCAL1) and for SMEs (SCAL2). As there is only one large firm in the Park, the case for SCAL3 was not considered. Rather, the large firm was used as basis against which SCALE1 and SCAL2 firms can be compared. Results of the empirical analysis show that for both start-ups and SMEs, the chances for developing innovative inputs are pretty high when compared with large enterprise. In other words, start-ups and SMEs are much more likely to be responsive to the development of innovative inputs than the large enterprise. This is not surprising, not least because large firms are usually capable of having their own research and development unit. Large firms would, in principle, pursue different goals for being in the Park when compared to small firms who would have such concerns as access to research consultancy; access to patents and intellectual property; and extending researcher networking (Soetanto and Jack, 2013; Vásquez-Urriago, 2014; Vasquez-Urriago, Barge-Gil and Rico, 2016). This would explain why the influence of business scale on the development of innovative inputs is lower in the case of large scale companies than it is in the case of start-ups and SMEs. According to the empirical analysis of Hypothesis 2, younger firms and firms with longer residence in the Park, which fall into the small business scale category, are more likely to draw support from the Park to develop the innovative inputs.

8.1.4.2 On the investigation of Hypothesis 3 (H3).

Hypothesis 3 (H3) looks into the empirical relationship between the Park's support services (expressed in terms of five categories of development of innovative inputs) and the expected innovative performance (innovative outputs) of resident firms. Results of the empirical analysis show that provision of infrastructure and facilities (INFA); access to funds (FUND); and access to market opportunities (MAOP) are statistically significant as explanatory variables for changes in the expected innovative performance of tenant firms. Surprisingly, factors including the development of human resources (HURE), and knowledge linkage (KNLK) are not found to have statistical significance to explain changes in the expected innovative performance of firms.

With respect to the provision of infrastructure and facilities (INFA), the results show that increase in the provision of infrastructure and facilities, would increase the chance of development of innovative outputs. This is a strong evidence supporting the hypothesis that the provision of infrastructure and facilities (INFA) by the Park has significant influence on the expected innovative performance/innovative output of tenant firms. This is consistent with what is borne out in the literature that infrastructure and facility supports are crucial for firms that aspire to evolve as innovative and competitive enterprises (Lindelöf and Löfsten, 2004; Phan, Siegel and Wright, 2005).

Regarding access to funds (FUND) as an explanatory variable, results of the analysis show that improvement in the funding support services provided by the Park, would, ironically enough, reduce the chance for the development innovative outputs by a factor of 0.05. At face value, this is at odds with conventional wisdom that access to funding would improve the R&D and innovation performance of firms. It may even suggest that tenant firms would feel that access to funding currently provided by the NSP is not likely to help them in the development of innovative output. However, as this argument is far from convincing and without any sound conceptual underpinning, it would be proper to conclude – assuming adequacy of the survey data can be trusted - that the absolute size of the factor (0.05) is small enough to be considered as good as zero, which means that the effect access to funding through the Park is negligible and can be discounted. This would make sense in principle; in practice, however, it would make more sense to cast doubt on the efficacy of the data on which the empirical analysis is based.

With respect to market opportunities (MAOP) as a factor influencing the expected innovative output/performance of firms, the empirical result shows that improvement in market opportunities would improve the chances for improvement of the expected innovative outputs of tenant firms. This evidence shows the firms' expected innovative output, and the likelihood of their emergence as innovative and competitive enterprises is highly sensitive to the Park's effort to develop the market networks for its tenants. This is an important innovative input as the development of market network, like the development of knowledge network, is a major category of the activities of science parks. The Park should recognize that firms that aspire to develop innovative capability would need to commercialize their innovative outputs (Montoro-

Sanchez, Ortiz-de-Urbina-Criado and Mora-Valentin, 2011; Sa and Lee, 2012; Martinez-Canas, Saez-Martinez and Ruiz-Palomino, 2012).

8.1.5 The triple helix mechanisms underpinning the functions of science parks aimed at supporting and promoting tenant firms to be innovative and competitive.

Science parks have their functions underpinned by the triple helix mechanism to facilitate interactions between the spheres of knowledge (academia), wealth creation (industry), and policy and regulation (government). Interactive links between the government, academia, and industry through the platform provided by science parks make science parks bridging agencies for promoting collaboration among network players through knowledge exchange processes. This section looks into the triple helix mechanism underpinning the NSP performance in an attempt to investigate Hypothesis 4 (H4) of this study, as was carried out in Chapter 7. What does the NSP do to support tenant firms to be innovative and competitive based on knowledge exchange through the triple helix network?

First of all, the NSP plays a role as provider of infrastructure and facilities to tenant firms. This would offer new firms the opportunity to emerge as innovative and competitive enterprises; and to enable existing firms to enhance their innovative and competitive performance. The NSP provides tenant firms services such as space, facilities, and the environment for conducting research and learning new business ideas. The interviews brought out that firms were able to receive a wide range of support services from the NSP - particularly mentioned by firms are the provision of space and facilities. As a result, the growing number of activities in the Park have given tenant firms the opportunity to engage with co-partners in innovative activities, and in exchanging and sharing knowledge and experiences with other firms in the Park. The NSP also uses social media to inform their residents about ongoing and forthcoming events that could stimulate interactions between firms for knowledge exchange and collaboration on innovative projects. The NSP creates an eco-system that encourages tenants to help each other by sharing their knowledge and experiences, which can result in new ideas and the emergence of venture companies.

Most of the firms interviewed during the survey said that when they had problems, the NSP was able to help them offering them useful advice; and linking them to universities, researchers, instructors, and consultants who can help them solve their problems. However, the results of the quantitative analysis in Chapter 6 show that the knowledge network development factor does not have significant influence on the expected innovative performance of tenant firms, unlike factors relating to market networks and the infrastructure and facilities provided by the Park. This state of affairs can be explained by the fact that during the early stage of their residence in the Park, tenant firms would tend to be more inclined towards commercial objectives than towards research-related innovative objectives. This argument is supported by the observation in both the quantitative and qualitative analyses of the survey data, which show firms focusing on the provision of infrastructure and facilities as these would help them save on their investment costs and improve their commercial profitability performance.

Triple helix linkage on the NSP platform encourages firms to present their profiles to attract firms that would collaborate with them in developing innovative ideas, innovative designs and innovative products. It also helps them to improve their reputation, to gain trust as market players, and to negotiate business on favourable terms. Moreover, the science park eco-system, which is based on the triple helix system, encourages participants to share their knowledge and experiences.

8.1.6 Lessons to be learned from the NSP's experiences and tenants' views and recommendations.

There are lessons to be learned from the NSP's experiences as the feedback obtained from tenant firms shows. All firms in the Park said they were satisfied with the various support services they received from the Park. Some of the firms showed satisfaction with infrastructure and facility and innovative ecosystem which they found to be conducive for conducting research and generating innovative ideas. Others showed satisfaction with the services the NSP provides in the forms of funding, consultancy, access to market networks through customers' trust, and access to knowledge networks. In addition, satisfaction of firms has been observed across all categories of firms, such as age of firms, capital value, business sectors, and business scale. It is apparent from the discussion in Chapter 5 that firm satisfaction with the NSP services are varied depending on the stage of growth of firms – whether firms are at their initial stage; growth stage or maturity stage. The results also show all firms agreeing to stay long term in the Park as tenants to be able to receive the comprehensive benefits of the services provided by the Park. Firms who intend to reside long term in the Park are the candidates who are likely to be fully engaged as active players in the triple helix network provided by the park platform.

The interviews also asked tenant firms to reflect on how the Park would be able to improve the effectiveness of its services. Most firms suggested that NSP should advertise the benefits of its services accruing to tenants in order to persuade other firms to locate in the Park. This would prompt mobility of talents through the platform provided by the Park, and so broaden opportunities for complementarity and collaboration among tenant firms. To this end, it is suggested that the NSP establish an accessible channel in the Park to provide information to tenant firms, so that they would know about each other and proceed to coordinate efforts to engage in collaborative initiatives in specific areas, such as software development, creative designs and patenting. It was also felt that the government should support the Park through the provision of information and advice about global market conditions and trends.

The interviews also brought out the view that if the science park strategy were to be pursued to be implemented further afield in Thailand, new science parks would do better if set up with a focus on specific products - like, for example, science parks for food and agricultural products, for technology, for medical products, for material science, etc. This would, however, depend on the diversity of the resource endowments of the country and the distribution of these across the various regions of the country. The argument underlying this view is that it would encourage local entrepreneurs to utilize local resources with which they are familiar to create new products through the services of science parks.

Some interviewees reflected that science parks would perform better if launched with missions that relate to the economy at large. This is important as science parks are investment-intensive projects and cannot be expected to be launched with objectives that fail to address the needs of the economy. Science parks could be organised, for example, as research parks engaged in conducting research in collaboration with academia; or commercial parks, targeting on the marketing of products; or intermediaries linking stakeholders to collaborate on specific projects or to create communities of innovation.

8.2 Policy implications of the study

Overall, the results in this study corroborate existing knowledge about science parks as places of incubation for new firms, which start life as start-ups and SMEs. The burden is on science park management to understand how support services could be effectively administered to ensure that start-ups and SMEs grow to become innovative and competitive enterprises, and even global niche players.

One of the suggestions deriving from the results of the study is that it would help park management to take the various characteristic features of tenant firms as a basis for identifying the needs of tenants for different type of services. For instance, factors like access to government incentives and space, utility and facilities, and company reputation are found to be crucial for making decisions to locate on-park among younger firms surveyed for the study. For the group of firms with low capital value, the factors that matter most are the promotion of company reputation; and firms with high capital value attribute their participation in the Park to a variety of factors that enhance the strength of their financial health. The group of new and small companies show interest in factors like space utilities and facilities, government incentives, and access to research centers and research consultancy that would help them reduce overhead costs. The factors that make on-park location attractive to some large-scale companies are improving their reputation and accessing government incentives. But large companies like software and applications do not appear to feature prominently on most of the factors that influence decision for locating on-park.

The result underscores space, utility and facilities as essential factors for most tenant firms, particularly firms that are new and with low capital value, mainly because these factors have the effect of reducing overhead costs. The factor relating to prospects for improving innovativeness is also an essential objective for firms to participate, as this would enable them to engage in activities that would enhance their research and development capabilities.

This study has presented evidence supporting the view of tenant firms on the R&D and innovative activities of on-park firms, which policy makers could apply to promote design and innovative foresight among tenant firms. The factors inhibiting R&D and innovative activities are also examined in this study. The results indicate younger firms being uncertain about the need to engage in innovation. The group of start-ups show market uncertainty, lack of information on markets, and lack of information on technology to be the inhibiting factors militating against engagement in R&D and innovative activities. In the case of the older firms, the main inhibiting factor is the existing legal and regulatory framework. For the group of software and application firms, the major inhibiting factor is funding because of their requirement for high-performance equipment and technology. Science park management and policy makers can take these issues on board to support tenant firms in their effort to evolve as innovative and competitive enterprises.

The relationship between the characteristics of firms and the level of development of innovative inputs is examined by using ordinal logistic regression to determine empirically the factors affecting the level of development of innovative inputs in the Park. Based on the results the analysis of survey data, young firms; firms with longer period of residence in the Park; and firms of small business scale are shown to have more impact on the Park to perform better in terms of the development of innovative inputs than firms with other characteristics. This could help management of the science park to prioritize firms prior to providing support services to them. It is also important for the science park management to understand the nature of firms to be able to reduce the duration of incubation, increase the turnover of spin-off firms and provide the chance for other off-park firms to seek residence as tenants.

Ordinal logistic regression on the relationship between the Park's support services and the expected innovative performance (innovative outputs) of resident firms was also conducted. The results of analysis show that services deriving from the provision of infrastructure and facilities, and market opportunity have significant impact on the expected innovative performance of tenant firms. This calls for the NSP to boost its capacity to provide infrastructure and facilities and space for research development; to increase interactions among participants; and to create and develop its knowledge exchange environment. It also calls for broadening the scope of market opportunities by improving the marketability of business ideas, which has implications for setting out blueprints; for developing prototypes according to customer preferences; and for the quality and functionality of products.

One lesson to be learned from the NSP's experiences is that the provision of infrastructure and facilities are important for firms, especially when seen from the vantage point of reduction of overhead costs. This is supported by the results of both the quantitative and qualitative analyses of the survey data. The science park ecosystem and its triple helix underpinning provide favorable conditions for triggering interactions among tenant firms and for firms to learn from specialized knowledge and experiences that could be accessed via the science park platform.

In addition, results of the study display 100% of the resident firms continuing to reside in the Park long term. This implies the NSP plays an effective role in promoting and supporting firms with respect to business incubation. They believe the provision of services in the Park would help them evolve as innovative and competitive enterprises.

There are lessons to be learned from the experiences of the NSP for the establishment of new parks. One of these relates to the setting up of new science parks. A preferable option is for these to be dedicated to specific products, like science parks for food and agricultural products, for technology, for medical products, for material science, etc. This would encourage local entrepreneurs utilizing the local resources they know well to produce new products through the services of science parks. The second lesson is about setting a mission regarding to the economy at large in which knowledge plays a key role. This will highlight the importance of science parks and of the triple helix system of research collaboration underlying these. Science parks can be organized as research parks engaged in conducting research in collaboration with academia; or as commercial parks, targeting on the marketing of products; or intermediaries linking stakeholders to collaborate. Science parks can also be set up in locations near constellations of universities, research institutes and private enterprises.

8.3 Limitations of the study

A major limitation of this study is the number of firms covered in the sample. The 22 firms covered in the study constitute the total population of firms in the NSP, the only science park that was willing to cooperate with the study. Although a 100% response rate was attained, the number of firms covered in the survey and the evidence borne by the survey data on the role of science parks in promoting the evolution of innovative and competitive enterprises can only be expected to be suggestive and not conclusive. Moreover, the NSP has been fully operational for only one year after completion of the construction of buildings and infrastructure and installation of facilities in early 2018. Among the 22 firms in the NSP, there is only one large firm. This has the effect of skewing the results of analysis aimed at comparing the characteristics of firms in relation to their perceived innovative and competitive performance.

In addition, some of the tenant firms have not been residents in the Park since the launch of the Park, and this limits their experiences in the Park as residents. This has the effect of spiking the data profile and hence the efficacy of the results of analysis. Besides, many firms did not have financial reports, which means they were unable to provide numeric data on total sales, number of new products, R&D investment, number of patents etc. These numeric variables (ratio and interval scale) are important for statistical analysis as they provide more objective indicators than categorical and ordinal data.

Because the duration of residence of firms in the Park is not long enough, nor the experiences of some firms in the NSP, the study has had to design a method of data collection by focusing on data which can be consolidated into particular categorical and ordinal data. Some of survey data are categorical such as business scale, business sectors, capital value, and dichotomous (Yes/No). The major challenge of using categorical and ordinal data is difficult to interpret, especially if ordinal data are elicited in the form of Likert scale as dependent variables, as in the case of Hypothesis 2 and Hypothesis 3.

In view of such limitations, the lessons deriving from the experiences of the NSP would not be expected to fully bring out the diversity of possibilities that can be considered as options for the establishment of science parks as a strategy for the development of innovative and competitive enterprises. At best, the lessons of experience could possibly help in designing strategies for improving the NSP's performance in delivering and administering services to its tenants. Some of these limitations envisaged in this study can also help provide opportunities for future research.

8.4 Recommendation for future studies

As noted above, because of the limitations of the data, which provided the basis for this study, the conclusions than are drawn on the results of the empirical analysis of this study can only be tentative, at best, and hence suggestive and not conclusive. This has implications for future research in the area. First, the study could have more robust results if repeated later with a larger sample size when the NSP will have gained enough experience catering for a larger number of tenant firms, including start-ups, SMEs, and large enterprises. With time, the triple helix network in the NSP would be expected to evolve and broaden the scope for a large number of innovative outcomes (innovative inputs and innovative outputs) to be observed in the Park.

Second, another venue for further research should consider a longitudinal study of progressive development of firms before and after being resident in the Park in order to show the effectiveness of park performance. This would allow the capabilities of firms to be compared longitudinally before and after locating in the Park. The comparison could be conducted on such profiles as knowledge linkage, access to funding, intellectual property, market opportunity, trust and reliability in the eyes of customers, privilege and prestige, total sale, revenue, business expansion, new products or processes, and financial status etc. After a long spell of residence in the Park, firms would be expected to generate robust data on the factors listed above.

Third, yet another venue for future research is an empirical analysis of comparable on-park and off-park firms for their innovative and competitive capabilities. There is lack of such comparative studies; it is important that such studies are conducted as comparative analysis is a well-established method for evaluating the impact of science parks. The results from a comparative analysis based on robust survey data can guide policy whether on-park location of firms is more effective than off-park location in terms of incubation of firms and their access to knowledge-based services.

Fourth, a more comprehensive study on science parks would be expected to compare firms not only within a park, as done in this study, but also across parks. Such a study would show differences in the effectiveness of the management of different science parks. Thus, future research could be conducted comparing the NSP with at least another two regional science parks, including Northeastern and Southern science parks.

8.5 Conclusion

This study has looked into the role of science parks in promoting the development of innovative and competitive enterprises, drawing on the experiences of tenant firms in the NSP, the first regional science park in Thailand. Is there any evidence to suggest that science parks would help in enhancing prospects for the innovative and competitive performance of firms? What is apparent from the findings of this study is that there is no blanket answer to the question set for empirical investigation. A whole range of factors relating to firm profiles come into play; and the empirical results show that firms vary for their innovative and competitive performance across these profiles. The robustness of results of the analysis pointing to this conclusion is, however, constrained by the limitations of the data used for the study.

For all that, the balance of evidence from experiences elsewhere suggests that it would be safe to claim that science parks have an important role to play as intermediate agency integrating tenant firms into the triple helix system of innovation. As discussed in this study, the triple helix system is at the heart of the activities of science parks and the wider policy agenda for the development innovative and competitive capabilities in enterprises. The provision of various services in parks are crucial for business incubation and the emergence of innovative enterprises that constitute an essential basis for the development of knowledge economies. The findings of this study give credence to the view that science parks, while costly in the short term, particularly for developing countries, would in the long-term help as useful strategy for promoting services-based-innovation through network development. Accordingly, the NSP should seek to build on its triple helix experience to promote their services to tenant firms and ramp up the number of players in the Park, thus enhancing the mobility of talents and knowledge exchange among firms in the Park. Meanwhile, on the research front, more effort should be made to have at hand more and better quality data from as many tenant firms and science parks as possible, so that the lessons to be gained from the experiences of Thai parks can have wider applicability.

Table 8.1 Summary of key finding and contribution.

Hypotheses	Key findings	Contribution to knowledge
H1: Science parks are effective in their mission as cradle of innovation when the services they provide are of the type that would assist tenant firms to be creative in developing their inputs and outputs.	All tenant firms agree the usefulness of the support they have received from the Park that can help them to develop their innovative inputs and outputs. This is confirmed by the results of the follow-up survey conducted a year after the first survey in 2019.	The experience of NSP illustrates the significance of the role the Park is able to assist and contribute to the business development of tenant firms. This has prompted the establishment of science parks as a platform for promoting the performance of firms, particularly small firms.
H2: Firms with varying attributes and characteristics are likely to have varied perception about the benefits to be derived from the support services offered to them by science parks.	It is observed that only three characteristic variables of firms have significant influence on the development of the innovative inputs delivered by the Park. **PART** (number of years of firms' participation in the NSP): the longer the duration of firms' residence in the Park, the higher the probability that the Park would be responsive to their needs through the provision of innovative inputs.	Identification of the factors that are crucial for the development of innovative inputs provided to tenant firms by NSP would help management of the Park to see where it should focus in delivering its services to its tenants. Although the findings show that the Park would be more responsive to the needs of firms of longer duration of residence than those with shorter duration of residence, management of the Park should seek to reverse the trend, focusing rather on the needs of the

Hypotheses	Key findings	Contribution to knowledge
	AGE (age of firms): increase in the age of firms (expressed in years) is associated with a decrease in the odds of considering the development of innovative inputs. It means younger firms show more responsiveness to the development of innovative inputs delivered by the Park than older firms. **SCAL** (scale of business): the odds of significantly influencing the innovative performance of the Park are higher for start-ups than for large enterprises. In other words, the needs of the start-up firms in the Park are much more likely to impact the development of innovative inputs delivered by the Park than the needs of the large enterprise.	newer tenants. This would encourage firms to spin-off and do not have to stay long in the Park. This is corroborated by other findings that show younger firms and firms of small business scale have significant influence on the innovative performance the Park.
H3: The existence of a properly functioning triple helix network in science parks is crucial for the growth of social capital and so for the development of the innovative capabilities and performance of tenant firms through the development of innovative products and the scaling and commercialization of these products.	The findings show that infrastructure and facilities (INFA), funding (FUND), and market opportunity (MAOP) are the service platforms that have significant influence in terms of enhancing the innovative performance/ innovative outputs of firms	The evidence suggests that management of the Park would do well to invest in the development of infrastructure and facilities that would help tenant firms enhance their innovative performance/innovative outputs and enable them to

Hypotheses	Key findings	Contribution to knowledge
		effectively exploit market opportunities.
H4: The decision of firms to locate in science parks is driven by the belief that triple helix-based science park services, when properly administered by parks and properly received by the tenant firms, would trigger the innovative and enterprising potential of firms to be realized in part or in full.	Interactive links between the government, academia, and industry through the platform provided by science parks make science parks bridging agencies for promoting collaboration among network players through knowledge exchange processes. The triple helix linkage provided by the NSP platform encourages firms to present their profiles to attract firms that would collaborate with them in developing innovative ideas, innovative designs, and innovative products. Moreover, the science park eco-system, which is based on the triple helix system, encourages participants to share their knowledge and experiences.	The evidence suggests that park management should invest effort and resources to broadening and deepening the triple helix network incorporating tenant firms to benefit from the innovative eco-system involving mechanisms for collaboration among firms. It is believed that increased engagement among government, academia, and firms through NSP as an intermediate agency would enhance the potential for innovative development among firms.

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APPENDICES

A. Ethics application form

1. Title of the investigation
The role of science parks in promoting and supporting tenant firms to be innovation and competitive with particular reference to the case of Thailand
Please state the title on the PIS and Consent Form, if different:

2. Chief Investigator (must be at least a Grade 7 member of staff or equivalent)
Name: Dr Girma Zawdie ☐ Professor ☑ Reader ☐ Senior Lecturer ☐ Lecturer ☐ Senior Teaching Fellow ☐ Teaching Fellow Department: Civil and Environmental Engineering Telephone: 0141 548 4443 E-mail: g.zawdie@strath.ac.uk

3. Other Strathclyde investigator(s)
Name: Kanit Sawasdee Status (e.g. lecturer, post-/undergraduate): post-graduate Department: Civil and Environmental Engineering Telephone: +44(0)74 532 44223 E-mail: kanit.sawasdee@strath.ac.uk

4. Non-Strathclyde collaborating investigator(s) (where applicable)
Name: Status (e.g. lecturer, post-/undergraduate): Department/Institution: If student(s), name of supervisor: Telephone: E-mail: Please provide details for all investigators involved in the study:

5. Overseas Supervisor(s) (where applicable)
Name(s): Status: Department/Institution: Telephone: Email: I can confirm that the local supervisor has obtained a copy of the Code of Practice: Yes ☐ No ☐ Please provide details for all supervisors involved in the study:

6. Location of the investigation
At what place(s) will the investigation be conducted Thailand. (Changed to Northern Thailand Science Park, Chiangmai, Thailand)
If this is not on University of Strathclyde premises, how have you satisfied yourself that adequate Health and Safety arrangements are in place to prevent injury or harm? No harmful activities will be carried out beyond usual day to day perceived risk possibilities.

7. Duration of the investigation
Duration(years/months) : 3 months Start date (expected): 7 / 01 / 2019 Completion date (expected): 31 / 03 / 2019

8. Sponsor

Please note that this is not the funder; refer to Section C and Annexes 1 and 3 of the Code of Practice for a definition and the key responsibilities of the sponsor.

Will the sponsor be the University of Strathclyde: Yes ☐ No ☒

If not, please specify who is the sponsor: No sponsor required

9. Funding body or proposed funding body (if applicable)

Name of funding body:

Status of proposal – if seeking funding (please click appropriate box):

☐ In preparation

☐ Submitted

☐ Accepted

Date of submission of proposal: / / Date of start of funding: / /

10. Ethical issues

Describe the main ethical issues and how you propose to address them: The interviews to be conducted will ensure anonymity of tenant firms in the science park. This is important as firms are not keen to publicise details about their business performance as this would possibly undermine their competitive positions. In particular, the names of interviewees will be anonymised.

11. Objectives of investigation (including the academic rationale and justification for the investigation) Please use plain English.

This research is aiming to explore the research question in the context of the commercial, market, technical and research, and development experiences of tenant firms in the Northern Thailand Science Park (NSP) in comparison with the experiences of a sample of similar off-park firms to determine if science park firms command a competitive edge over off-park firms in terms of innovative performance; access new ideas and knowledge, market competitiveness and growth in market share; to explore the 'systemness' of the triple helix mechanism underpinning the functions of science parks in relation to the generation and application of new ideas as well as their commercialisation. Moreover, to explore the lessons to be learned from NSP's experiences in the light of global science park experiences and to determine using SWOT analysis areas of strengths, weaknesses, opportunities and threats for the development of regional science parks in developing countries, in general, and Thailand, in particular.

12. Participants

Please detail the nature of the participants:
Technology based firms who are located in Northern Thailand Science Park
Summarise the number and age (range) of each group of participants:
Number: 22 tenants   Age (range) 1 – 30 years old of establishment.
Please detail any inclusion/exclusion criteria and any further screening procedures to be used:
SMEs, employment, capital cost, business sector, R&D firms.

13. Nature of the participants
Please note that investigations governed by the Code of Practice that involve any of the types of participants listed in B1(b) must be submitted to the University Ethics Committee (UEC) rather than DEC/SEC for approval.

Do any of the participants fall into a category listed in Section B1(b) (participant considerations) applicable in this investigation?: Yes ☐ No ☑
If yes, please detail which category (and submit this application to the UEC):

14. Method of recruitment

Describe the method of recruitment (see section B4 of the Code of Practice), providing information on any payments, expenses or other incentives.
No payment is made, but authorisation is sought from the management of the science park to have access to the various tenant firms for interviews and administration of

questionnaires. Also the consent of the firms is sought to proceed with the procedures of data collection.

15. Participant consent

Please state the groups from whom consent/assent will be sought (please refer to the Guidance Document). The PIS and Consent Form(s) to be used should be attached to this application form.

22 Tenants in Northern Thailand Science Park

16. Methodology

Investigations governed by the Code of Practice which involve any of the types of projects listed in B1(a) must be submitted to the University Ethics Committee rather than DEC/SEC for approval.

Are any of the categories mentioned in the Code of Practice Section B1(a) (project considerations) applicable in this investigation? ☑ Yes ☐ No

If 'yes' please detail:

Describe the research methodology and procedure, providing a timeline of activities where possible. Please use plain English.

Based on the objectives, the study will involve quantitative and qualitative analysis examining Northern Thailand Science Park as a case by eliciting longitudinal data over the period 2014 – 2019. The quantitative analysis will be conducted longitudinally focusing on the innovative performance of on-park firms before and after accessing NSP. The qualitative analysis will be performed through in-depth interviews with on-park firms for exploring the mechanisms they adopt for extracting innovative ideas and maximizing the benefits of participation in NSP. The sample of tenants will cover all technology-based firms who have been doing research and development. There were in all 22 technology-based firms registered as tenants of NSP in 2019.

The questionnaires and questions for interview will be translated from English into Thais before being translated back into English. After that, this questionnaire will be administered face to face to 22 tenants in first two weeks in January 2019 at Northern Thailand Science Park. Arrangements will also be made for in-depth interviews with firm managers in February and March 2019.

What specific techniques will be employed and what exactly is asked of the participants? Please identify any non-validated scale or measure and include any scale and measures

charts as an Appendix to this application. Please include questionnaires, interview schedules or any other non-standardised method of data collection as appendices to this application.
Questionnaires and interviews.

Where an independent reviewer is not used, then the UEC, DEC or SEC reserves the right to scrutinise the methodology. Has this methodology been subject to independent scrutiny? Yes ☐ No ☐
If yes, please provide the name and contact details of the independent reviewer:

17. Previous experience of the investigator(s) with the procedures involved.
Experience should demonstrate an ability to carry out the proposed research in accordance with the written methodology.

I have experience about survey research when I studied in master's degree in forensic science at Mahidol University, Thailand. I had to work in a field for collecting burnt human bone to do the experiment about classification of gender and age group of humans burnt bone. In that time, I had to go to many crematoriums in the local temple and collect some pieces of burnt humans bone categorized by gender and age. These experiences made me to be careful, think systematically, honest, plan and management. I strongly believe these experiences can contribute me in this case.

18. Data collection, storage and security

How and where are data handled? Please specify whether it will be fully anonymous (i.e. the identity unknown even to the researchers) or pseudo-anonymised (i.e. the raw data is anonymised and given a code name, with the key for code names being stored in a separate location from the raw data) - if neither please justify.

pseudo-anonymised

Explain how and where it will be stored, who has access to it, how long it will be stored and whether it will be securely destroyed after use:
All collected data will be stored in digital files in my laptop which is very secure since it has been double coded. Only me and my supervisor are able to access. All collected data will be kept until the research has been finished, then all will be permanently deleted.

Will anyone other than the named investigators have access to the data? Yes ☐ No ☒ If 'yes' please explain: For confidential and secure purposes. All collected data from research field work have to be securely kept in order to protect participants 'information.

19. Potential risks or hazards
Briefly describe the potential Occupational Health and Safety (OHS) hazards and risks associated with the investigation: None above and beyond general daily life.
Please attach a completed OHS Risk Assessment (S20) for the research. Further Guidance on Risk Assessment and Form can be obtained on <u>Occupational Health, Safety and Wellbeing's webpages</u> Done

20. What method will you use to communicate the outcomes and any additional relevant details of the study to the participants?
Statistical analysis will be approached to communicate the results.

21. How will the outcomes of the study be disseminated (e.g. will you seek to publish the results and, if relevant, how will you protect the identities of your participants in said dissemination)?
Only submitted as Ph.D. research to the Department of Civil and Environmental Engineering, conferences, and publication.

Checklist	**Enclosed**	**N/A**
Participant Information Sheet(s)	☒	☐

Consent Form(s)	☒	☐
Sample questionnaire(s)	☒	☐
Sample interview format(s)	☐	☐
Sample advertisement(s)	☐	☐
OHS Risk Assessment (S20)	☐	
Any other documents (please specify below)	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

22. Chief Investigator and Head of Department Declaration

Please note that unsigned applications will not be accepted and both signatures are required

I have read the University's Code of Practice on Investigations involving Human Beings and have completed this application accordingly. By signing below, I acknowledge that I am aware of and accept my responsibilities as Chief Investigator under Clauses 3.11 – 3.13 of the Research Governance Framework and that this investigation cannot proceed before all approvals required have been obtained.

Signature of Chief Investigator

Please also type name here: Girma Zawdie

I confirm I have read this application, I am happy that the study is consistent with departmental strategy, that the staff and/or students involved have the appropriate expertise to undertake the study and that adequate arrangements are in place to supervise any students that might be acting as investigators, that the study has access to the resources needed to conduct the proposed research successfully, and that there are no other departmental-specific issues relating to the study of which I am aware.

Signature of Head of Department

Please also type name here

Date: / /

23. Only for University sponsored projects under the remit of the DEC/SEC, with no external funding and no NHS involvement

Head of Department statement on Sponsorship

This application requires the University to sponsor the investigation. This is done by the Head of Department for all DEC applications with exception of those that are externally funded and those which are connected to the NHS (those exceptions should be submitted to R&KES). I am aware of the implications of University sponsorship of the investigation and have assessed this investigation with respect to sponsorship and management risk. As this particular investigation is within the remit of the DEC and has no external funding and no NHS involvement, I agree on behalf of the University that the University is the appropriate sponsor of the investigation and there are no management risks posed by the investigation.

If not applicable, tick here ☐

Signature of Head of Department

Please also type name here

Date: / /

For applications to the University Ethics Committee, the completed form should be sent to ethics@strath.ac.uk with the relevant electronic signatures.

24. Insurance

The questionnaire below must be completed and included in your submission to the UEC/DEC/SEC:

Is the proposed research an investigation or series of investigations conducted on any person for a Medicinal Purpose? Medicinal Purpose means: ▪ treating or preventing disease or diagnosing disease or ▪ ascertaining the existence degree of or extent of a physiological condition or ▪ assisting with or altering in any way the process of conception or ▪ investigating or participating in methods of contraception or ▪ inducing anaesthesia or ▪ otherwise preventing or interfering with the normal operation of a physiological function or ▪ altering the administration of prescribed medication.	Yes / No

If "**Yes**" please go to **Section A (Clinical Trials)** – all questions must be completed

If "**No**" please go to **Section B (Public Liability)** – all questions must be completed

Section A (Clinical Trials)

Does the proposed research involve subjects who are either: i. under the age of 5 years at the time of the trial; ii. known to be pregnant at the time of the trial	Yes / No

*If "**Yes**" the UEC should refer to Finance*

Is the proposed research limited to: iii. Questionnaires, interviews, psychological activity including CBT; iv. Venepuncture (withdrawal of blood); v. Muscle biopsy; vi. Measurements or monitoring of physiological processes including scanning; vii. Collections of body secretions by non-invasive methods; viii. Intake of foods or nutrients or variation of diet (excluding administration of drugs).	Yes / No

*If "**No**" the UEC should refer to Finance*

Will the proposed research take place within the UK?	Yes / No

*If "**No**" the UEC should refer to Finance*

Title of Research	The role of science park in promoting knowledge exchange and innovation with particular reference of the case of Thailand.	
Chief Investigator		
Sponsoring Organisation	None	
Does the proposed research involve:		
a) investigating or participating in methods of contraception?		Yes / <u>No</u>
b) assisting with or altering the process of conception?		Yes / <u>No</u>
c) the use of drugs?		Yes / <u>No</u>
d) the use of surgery (other than biopsy)?		Yes / <u>No</u>
e) genetic engineering?		Yes / <u>No</u>
f) participants under 5 years of age (other than activities i-vi above)?		Yes / <u>No</u>
g) participants known to be pregnant (other than activities i-vi above)?		Yes / <u>No</u>
h) pharmaceutical product/appliance designed or manufactured by the institution?		Yes / <u>No</u>
i) work outside the United Kingdom?		<u>Yes</u> / No

If **"YES"** to **any** of the questions a-i please also complete the **Employee Activity Form** (attached).

If **"YES"** to **any** of the questions a-i, <u>and this is a follow-on phase</u>, please provide details of SUSARs on a separate sheet.

*If "**Yes**" to any of the questions a-i then the UEC/DEC/SEC should refer to Finance (insurance-services@strath.ac.uk).*

Section B (Public Liability)	
Does the proposed research involve :	
a) aircraft or any aerial <u>device</u>	Yes / <u>No</u>

b) hovercraft or any water borne craft	Yes / <u>No</u>
c) ionising radiation	Yes / <u>No</u>
d) asbestos	Yes / <u>No</u>
e) participants under 5 years of age	Yes / <u>No</u>
f) participants known to be pregnant	Yes / <u>No</u>
g) pharmaceutical product/appliance designed or manufactured by the institution?	Yes / <u>No</u>
h) work outside the United Kingdom?	<u>Yes</u> / No

*If **"YES"** to any of the questions the UEC/DEC/SEC should refer to Finance (insurance-services@strath.ac.uk).*

For NHS applications only - Employee Activity Form

Has NHS Indemnity been provided?	Yes / No
Are Medical Practitioners involved in the project?	Yes / No
If YES, will Medical Practitioners be covered by the MDU or other body?	Yes / No

This section aims to identify the staff involved, their employment contract and the extent of their involvement in the research (in some cases it may be more appropriate to refer to a group of persons rather than individuals).

Chief Investigator		
Name	**Employer**	**NHS Honorary Contract?**
		Yes / No
Others		
Name	**Employer**	**NHS Honorary Contract?**
		Yes / No
		Yes / No
		Yes / No
		Yes / No

Please provide any further relevant information here:

B. Participant Information Sheet for [………..]

Name of department: Civil and Environmental Engineering

Title of the study: The role of science parks in promoting and supporting tenant firms to be innovation and competitive with particular reference to the case of Thailand.

Introduction
This research is a part of Ph.D. study currently undertaken by Mr.Kanit Sawasdee (Ph.D. student) who is studying within the Department of Civil and Environmental Engineering, University of Strathclyde, Glasgow G1 1XQ, Scotland. English will be used in the Participant Information Sheet. Any further information can be contacted at Department of Civil and Environmental Engineering, James Weir Building Level 5, 75 Montrose Street Glasgow, G1 1XJ, +44 (0)141 548 3275, kanit.sawasdee@strath.ac.uk

What is the purpose of this investigation?
The purpose of this survey is to collect data and information on business activities of companies located in Northern Thailand Science Park. This investigation is undertaken to test the hypothesis of Northern Thailand Science Park whether they perform effectively to support tenants in term of knowledge exchange and innovation.

Do you have to take part?
You can choose to participate or not in this research. Additionally, there are no right or wrong answers the questionnaire purely looks for your views and opinions. Your consent for the questionnaire is assumed by participation; you are free to fill in or not as you wish. If you do not wish to take part in any aspect of this investigation, you do not have to take part. Participation is completely voluntary. You have the right to withdraw at any point throughout the interview.

What will you do in the project?
The research involves collecting data from participants about innovative and business performance through a questionnaire that consists of 30 questions. The questionnaire asks you to provide some general background information and then some questions about innovative and business performance. The questionnaire will take 15-30 minutes to complete.

Why have you been invited to take part?
You have been asked to participate in this investigation of the research because you are tenants in Northern Thailand Science Park.

What are the potential risks to you in taking part?
There are no potential risks to you participating in this investigation.

What happens to the information in the project?
All information drawn from your input to our investigation will be anonymised and no participants will ever be identified in person in any findings. Information provided will be used to examine the Ph.D. research. All collected information will be stored electronically in secure. At a suitable time after the completion of the research, normally one year, all the data files will be destroyed. Access to data will only be available to researcher. The University of Strathclyde is registered with the Information Commissioner’s Office who implements the Data Protection Act 1998. All personal data on participants will be processed in accordance with the provisions of the Data Protection Act 1998. Thank you for reading this information – please ask any questions if you are unsure about what is written here.

What happens next?

You will be asked to sign a consent form if you wish to fill in the questionnaire after you have agreed in this research. If you do not wish to contribute you need not fill this out. The information you provided will be used to find out if Northern Thailand Science Park promotes knowledge exchange and innovation. Research feedback and publication of the results will be available to you after the completion of the research.

Researcher contact details:
Kanit Sawasdee from Department of Civil and Environmental Engineering, University of Strathclyde. Department of Civil and Environmental Engineering, James Weir Building Level 5, University of Strathclyde, 75 Montrose Street Glasgow, G1 1XJ, +44 (0)74 532 44223, kanit.sawasdee@strath.ac.uk

Chief Investigator details:
Chief Investigators, Department of Civil and Environmental Engineering, James Weir Building Level 5, University of Strathclyde, 75 Montrose Street Glasgow, G1 1XJ, +44 (0)141 548 3275, contact-civeng@strath.ac.uk

This investigation was granted ethical approval by the University of Strathclyde Ethics Committee.

If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Secretary to the University Ethics Committee
Research & Knowledge Exchange Services
University of Strathclyde
Graham Hills Building
50 George Street
Glasgow
G1 1QE

Telephone: 0141 548 3707
Email: ethics@strath.ac.uk

C. Consent Form for [………]

Name of department: Civil and Environmental Engineering

Title of the study: The role of science parks in promoting and supporting tenant firms to be innovation and competitive with particular reference to the case of Thailand.

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences. If I exercise my right to withdraw and I don't want my data to be used, any data which have been collected from me will be destroyed.
- I understand that I can withdraw from the study any personal data (i.e. data which identify me personally) at any time.
- I understand that anonymised data (i.e. .data which do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project
- I consent to being audio and/or video recorded as part of the project

Where human biological samples are taken e.g. blood samples or biopsy samples then the following wording should be included: I consent to the taking of biological samples from me, and understand that they will be the property of the University of Strathclyde.

Where it is proposed to carry out DNA analysis of material in any samples then the following statement should be included in the consent form: I consent to DNA in the samples being analysed.

For investigations where it has been decided that "no fault compensation" cover will be provided the following wording needs to be included: In agreeing to participate in this investigation I am aware that I may be entitled to compensation for accidental bodily injury, including death or disease, arising out of the investigation without the need to prove fault. However, such compensation is subject to acceptance of the Conditions of Compensation, a copy of which is available on request.

(PRINT NAME)	
Signature of Participant:	Date:

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D. Questionnaire

จุดประสงค์ของแบบสอบถาม

การสำรวจข้อมูลโดยใช้แบบสอบถามนี้เพื่อศึกษารวบรวมข้อมูลของบริษัทที่ใช้บริการในอุทยานวิทยาศาสตร์ภูมิภาคจังหวัดเชียงใหม่ เพื่อใช้ศึกษาบทบาทของอุทยานวิทยาศาสตร์ฯ ในการสนับสนุนการแลกเปลี่ยนองค์ความรู้และนวัตกรรม โดยการศึกษานี้เป็นส่วนหนึ่งของการเรียนระดับปริญญาเอกของ นายคณิต สวัสดี มหาวิทยาลัยสแตรธไคลด์ กลาสโกว์ ประเทศสหราชอาณาจักร

Confidentiality

The information you provide will be held in the strictest confidence. All the data and information to be elicited through this questionnaire will be used exclusively for the purpose of statistical analysis which will form part of the PhD thesis, the student will submit to the University of Strathclyde in Glasgow, UK.

Guidelines

1. Where exact figures cannot be provided estimation of numbers and ratios would be acceptable.
2. Details of contact person in case that there is any questions arise regarding the survey
   Mr.Kanit Sawasdee (Email): kanit.sawasdee@strath.ac.uk /momonid@gmail.com
   Phone: 063 9424249
3. Please complete the questionnaire by...........................
   Your co-operation and assistance is appreciated.
   Thank you
   Kanit Sawasdee
   Ph.D. Student, Department of Civil and Environmental Engineering, University of Strathclyde, Glasgow G1 1XQ, Scotland

Any information provided by you or your enterprise in this survey is confidential. We do not disclose, release or publish any identifiable information on individuals or enterprise entities.

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Table of Contents

สารบัญ

This survey composes of 5 sections and 28 questions as follows:

แบบสอบถามในครั้งนี้ ประกอบด้วย 5 ส่วน 28 คำถาม ดังนี้

ส่วนที่ 1	**ข้อมูลทั่วไป ประกอบด้วยคำถาม 9 ข้อ**
Section 1	General Information – 9 questions
หัวข้อที่สำรวจ:	โครงสร้างของกิจการ สถานภาพทางการเงิน จำนวนบุคลากร และกิจกรรมทางธุรกิจ
Data on: Business structure, financial status, employment, and business activities	
ส่วนที่ 2	**การเป็นผู้ใช้บริการในอุทยานวิทยาศาสตร์ภูมิภาคจังหวัดเชียงใหม่ ประกอบด้วยคำถาม 5 ข้อ**
Section 2:	Tenant firms in The Northern Science Park – 5 questions
หัวข้อที่สำรวจ:	เหตุผลการใช้บริการ, ระยะเวลา, ผลที่คาดว่าจะได้รับ
Data on: Tenancy reason, Tenancy period, Expected benefit	
ส่วนที่ 3	**โมเดลนวัตกรรม ประกอบด้วยคำถาม 4 ข้อ**
Section 3:	Innovative transformation model – 4 questions
หัวข้อที่สำรวจ:	Innovative inputs, Innovative processes, Innovative outputs
Data on: Innovative inputs, Innovative processes, Innovative outputs	
ส่วนที่ 4	**ข้อมูลนวัตกรรม ประกอบด้วยคำถาม 9 ข้อ**
Section 4:	Innovative activities – 9 questions
หัวข้อที่สำรวจ:	กิจกรรมนวัตกรรม, ผลิตภัณฑ์และกระบวนการด้านนวัตกรรม, แหล่งข้อมูลด้านนวัตกรรม, การมีส่วนร่วมกับองค์กรอื่นในด้านการวิจัยและพัฒนานวัตกรรม
Data on: Innovation-related activities, product and process innovations, sources of information for innovation activities and collaborations in R&D and innovation projects with other organizations	
ส่วนที่ 5	**ข้อเสนอแนะ ประกอบด้วยคำถาม 1 ข้อ**
Section 5	Recommendation – 1 question
หัวข้อที่สำรวจ:	ข้อเสนอแนะ
Data on: Recommendation and improvement	

Thank you for your participation on this survey.

Your information is valuable for the research of the role of TSP in promoting knowledge exchange and innovation, improvement of policy, and for the country at large.

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ส่วนที่ 1 ข้อมูลทั่วไป

SECTION 1: General Information

คำอธิบาย: กรุณาทำเครื่องหมาย ☐✓ ในช่อง ☐ หรือเติมข้อความในช่องว่างให้สมบูรณ์

Direction: Please check ✓ in the box ☐ or please fill in the blank

1. **ชื่อของบริษัทผู้ตอบแบบสอบถาม** ____

   Name of company/business

   ตำแหน่งของผู้ตอบแบบสอบถาม____

   Position of respondent in the company

   ปีที่บริษัทก่อตั้ง Year of establishment of enterprise ______________________________

   ที่อยู่ Address

   ____

   ____

   โทรศัพท์ Phone _________________________ **โทรสาร** Fax _______________________

   อีเมล์ Email ____

2. **กรุณาระบุโครงสร้างของผู้ถือหุ้นในกิจการของท่าน**

   Please indicate the ownership structure of your enterprise

(a) ถือหุ้นโดยคนไทยทั้งหมด	Wholly-owned by Thais	☐
(b) ถือหุ้นโดยคนไทยร้อยละ 51-99	51- 99% owned by Thais	☐
(c) ถือหุ้นโดยคนไทยร้อยละ 1-50	1-50% owned by Thais	☐
(d) ถือหุ้นโดยต่างชาติทั้งหมด	Wholly-owned by foreigners	☐

   ถ้าตอบข้อ c หรือ d โปรดระบุประเทศของผู้ถือหุ้นใหญ่

   If your answer is (c) or (d), please specify the nationality of largest

   ____

3. **กรุณาระบุสถานภาพทางการเงินของกิจการของท่าน**

   Please indicate the financial status of your enterprise

   3.1 ทุน Capital________________________ Baht

4. **บริษัทของท่านมีหน่วยงานหรือแผนกรับผิดชอบด้านการทำวิจัยและพัฒนาหรือไม่** Does your company have any R&D unit or department in the area?

   ☐ ถ้ามี โปรดระบุระยะเวลาที่มีหน่วยงานนี้ Yes, how long?

   Please specify...

   ☐ ถ้าไม่มี โปรดระบุเหตุผล No, please specify

   why..

   ☐ เคยมี โปรดระบุเหตุผล please specify

   why..

5. **บริษัทของท่านมีการทำวิจัยและพัฒนาหรือไม่** Does your company conduct any R&D activities?

☐ ถ้าทำ โปรดระบุระยะเวลาที่มีหน่วยงานนี้ Yes, how long?
please specify...
☐ ถ้าไม่ได้ทำ โปรดระบุเหตุผล No, please specify
why...
☐ เคยทำ โปรดระบุเหตุผล please specify
why..

6. **กรุณาระบุกิจกรรมของกิจการท่าน**

Please indicate in the box (es) below the type of activity your company is involved.

6.1 อุตสาหกรรม Manufacturing	☐
6.2 การออกแบบและพัฒนาผลิตภัณฑ์ Production design/development	☐
6.3 การวิจัย Research	☐
6.4 การตลาด/การขาย Marketing/Sales	☐
6.5 โกดังสินค้า Warehousing	☐
6.5 การบริการ/ซ่อมแซม Servicing/repair	☐
6.6 การวิเคราะห์/Analysis	☐
6.7 ที่ปรึกษา/Consultancy	☐
6.8 การฝึกอบรม/Training	☐
6.9 Software	☐
6.10 อื่น ๆ Other: โปรดระบุ Please specify	☐

7. **กรุณาระบุว่ากิจการของท่านเป็นบริษัทประเภทใด**

Which type of sector/industry is your company involved?

7.1 Microelectronic	☐
7.2 Biotechnology	☐
7.3 Pharmaceutical	☐
7.4 Software	☐
7.5 Instrumentation	☐
7.6 Hardware and system	☐
7.7 Analysis and Testing	☐
7.8 Medical	☐
7.9 Mechanical	☐
7.10 อื่น ๆ Other: โปรดระบุ Please specify	☐

8. **กรุณาระบุผลิตภัณฑ์หลักของกิจการท่าน**

What are your company’s main products/services?

Main products/services: ....

9. **กิจการของท่านมีรายงานสถานภาพทางการเงินหรือไม่**

Do you have the financial report?

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☐ Yes ☐ No

หากมี ท่านยินดีเพื่อให้ข้อมูลต่อไปหรือไม่ If yes, is it available for further data inquiry?

☐ Yes ☐ No

ส่วนที่ 2 การเป็นผู้ใช้บริการในอุทยานวิทยาศาสตร์ภูมิภาค

SECTION 2: Tenant Firms in The Northern Science Park

คำอธิบาย: กรุณาทำเครื่องหมาย ☐✓ ในช่อง ☐ หรือเติมข้อความในช่องว่างให้สมบูรณ์

Direction: Please check ✓ in the box ☐ or please fill in the blank

10. **กรุณาระบุว่าท่านทราบว่ามีอุทยาศาสตร์วิทยาศาสตร์ฯ จากที่ใด**

How did your company come to known about Science Park?

☐ ข่าวสาร News/ media/ social media

☐ นโยบายจากรัฐบาล Government agencies

☐ คำแนะนำจากผู้ประกอบการอื่น Recommended by other firms

☐ งานแสดงสินค้า Exhibition

☐ คำบอกเล่า Word of mouth

☐ อื่น ๆ โปรดระบุ Other, please specify: ....

11. **กรุณาระบุปีที่เข้ามาใช้บริการในอุทยานวิทยาศาสตร์ฯ**

Since when has your company been participating in Science Park?

Year started เริ่มปี: ....

12. **กรุณาระบุเหตุผลที่เข้ามาใช้บริการอุทยานวิทยาศาสตร์ฯ พร้อมทั้งเรียงลำดับเหตุผลหลัก 1 - 3**

Please indicate the reason(s) why you decided to participate in Science Park. (Please tick more than one where relevant) (1-lowest degree of agreement; 5-highest degree of agreement; or irrelevant).

	REASONS OF PARTICIPATING	Degree of agreement 1	2	3	4	5	Irrelevant
12.1	สิ่งจูงใจจากรัฐบาล GOVERNMENT INCENTIVES	☐	☐	☐	☐	☐	☐
12.2	พื้นที่ให้ใช้บริการและสิ่งอำนวยความสะดวก SPACE UTILITY AND FACILITIES	☐	☐	☐	☐	☐	☐
12.3	ต้องการพัฒนาด้านการวิจัย PREFER TO DEVELOP R&D	☐	☐	☐	☐	☐	☐
12.4	เพิ่มความเป็นที่รู้จัก COMPANY REPUTATION PURPOSE	☐	☐	☐	☐	☐	☐
12.5	เพิ่มการพัฒนาด้านนวัตกรรม INNOVATIVE IMPROVEMENT; NEW PRODUCTS/ NEW PROCESSES	☐	☐	☐	☐	☐	☐

12.6	เพื่อเข้าถึงหน่วยงานวิจัย ACCESSING RESEARCH CENTER	☐	☐	☐	☐	☐	☐
12.7	เครือข่ายองค์ความรู้ KNOWLEDGE LINKAGE	☐	☐	☐	☐	☐	☐
12.8	การพบปะและแลกเปลี่ยนแนวคิดระหว่างผู้ใช้บริการด้วยกัน COMPANY INTERACTION AND EXCHANGE IDEA	☐	☐	☐	☐	☐	☐
12.9	ปรึกษาด้านการวิจัย RESEARCH CONSULTANCY	☐	☐	☐	☐	☐	☐
12.10	โอกาสทางการตลาด MARKET OPPORTUNITY	☐	☐	☐	☐	☐	☐
12.11	การเจริญเติบโตทางธุรกิจ BUSINESS PERFORMANCE; SALE GROWTH, COST REDUCTION	☐	☐	☐	☐	☐	☐
12.12	อื่น ๆ โปรดระบุ OTHER, PLEASE SPECIFY: …………………………………	☐	☐	☐	☐	☐	☐

13. **อุทยานวิทยาศาสตร์ฯ มีส่วนช่วยให้เกิดการเชื่อมโยงระหว่างภาครัฐ ภาคเอกชน และมหาวิทยาลัย ในการสร้างสรรค์นวัตกรรมและเพิ่มเครือข่ายองค์ความรู้หรือไม่** Does Science Park engage in promoting triple helix interactions on regular basis?

☐ ใช่ โปรดระบุ If yes, please specify: ....

☐ ไม่ใช่ โปรดระบุ If No, please specify: ....

14. **ท่านยินดีที่จะใช้บริการของอุทยานวิทยาศาสตร์ฯ ต่อไปหรือไม่**

Would your company continue to reside in Science Park?

☐ ใช่ Yes

ถ้าใช่ โปรดระบุเหตุผล If yes, please specify: ....

☐ ไม่ใช่ No

ถ้าไม่ โปรดระบุเหตุผล If no, please specify: ....

ส่วนที่ 3 โมเดลนวัตกรรม

SECTION 3: Innovative Transformation Model

คำอธิบาย: กรุณาทำเครื่องหมาย ☐✓ ในช่อง ☐ หรือเติมข้อความในช่องว่างให้สมบูรณ์

Direction: Please check ✓ in the box ☐ or please fill in the blank

15. **ในฐานะผู้ใช้บริการอุทยานวิทยาศาสตร์ฯ ท่านคิดว่าอุทยานวิทยาศาสตร์ฯ ช่วยสนับสนุนกิจการของท่านด้าน Innovative input ดังต่อไปนี้ (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)**

As your company is being in Science Park, does your company think Thailand Science Park assists you in this following (1-lowest degree of agreement; 5-highest degree of agreement; or irrelevant).

	INNOVATIVE INPUT	Degree 1	2	3	4	5	Irrelevant
15.1	เพิ่มจำนวนนักวิจัย INCREASE A NUMBER OF RESEARCHERS	☐	☐	☐	☐	☐	☐
15.2	เพิ่มความสามารถนักวิจัยของท่าน IMPROVE RESEARCHER SKILLS	☐	☐	☐	☐	☐	☐
15.3	เพิ่มความสามารถพนักงานของท่าน IMPROVE EMPLOYEE SKILLS	☐	☐	☐	☐	☐	☐
15.4	สรรหาผู้มีความสามารถเฉพาะทาง SPECIFY SKILL NEEDED	☐	☐	☐	☐	☐	☐
15.5	สรรหาพนักงานที่มีความสามารถ RECRUIT HIGH SKILL EMPLOYEE	☐	☐	☐	☐	☐	☐
15.6	มีพื้นที่ให้ใช้ทำงานวิจัยและพัฒนา PROVIDE SPACE FOR RESEARCH AND DEVELOPMENT	☐	☐	☐	☐	☐	☐
15.7	สนับสนุนสิ่งอำนวยความสะดวกต่อการวิจัยและพัฒนา SUPPORT FACILITIES FOR RESEARCH AND DEVELOPMENT	☐	☐	☐	☐	☐	☐
15.8	ให้คำปรึกษาด้ายการวิจัยและพัฒนา ASSIST CONSULTANCY FOR RESEARCH AND DEVELOPMENT	☐	☐	☐	☐	☐	☐
15.9	เพิ่มเครือข่ายองค์ความรู้ทั้งกับมหาวิทยาลัยและหน่วยงานวิจัยของรัฐ ENHANCE KNOWLEDGE LINKAGE WITH UNIVERSITY AND RESEARCH INSTITUTION	☐	☐	☐	☐	☐	☐
15.10	ช่วยให้เข้าถึงแหล่งเงินทุน HELP WITH ACCESS TO FUNDING SOURCES	☐	☐	☐	☐	☐	☐
15.11	ช่วยพัฒนาด้านการตลาด HELP TO IMPROVE MARKET SKILLS	☐	☐	☐	☐	☐	☐
15.12	อื่น ๆ โปรดระบุ OTHER, PLEASE SPECIFY: ……………………………………………………………………………	☐	☐	☐	☐	☐	☐

16. **ในฐานะผู้ใช้บริการอุทยานวิทยาศาสตร์ฯ ท่านคิดว่าอุทยานวิทยาศาสตร์ฯ ช่วยกิจการของท่านด้าน innovative process ดังต่อไปนี้ (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)**

As your company is being in Science Park, does your company think Thailand Science Park assists you in this following (1-lowest degree of agreement; 5-highest degree of agreement; or irrelevant).

INNOVATIVE PROCESS	Degree of Agreement 1	2	3	4	5	Irrelevant

		1	2	3	4	5	Irrelevant
16.1	ช่วยคัดสรรแนวคิดที่มีศักยภาพ EXPLORE POTENTIAL BUSINESS IDEAS	☐	☐	☐	☐	☐	☐
16.2	วางแผนการดำเนินธุรกิจ SET OF BLUEPRINTS	☐	☐	☐	☐	☐	☐
16.3	ช่วยพัฒนาต้นแบบ DEVELOPMENT OF PROTOTYPE	☐	☐	☐	☐	☐	☐
16.4	ค้นหาความต้องการของลูกค้า SEEK CUSTOMER PREFERENCES	☐	☐	☐	☐	☐	☐
16.5	เพิ่มการพบประระหว่างผู้ใช้บริการพื้นที่ด้วยการเพื่อแลกเปลี่ยนแนวคิด INCREASE THE INTERACTION AMONG PARTICIPANTS	☐	☐	☐	☐	☐	☐
16.6	สร้างสภาพแวดล้อมให้เหมาะสมกับการแลกเปลี่ยนองค์ความรู้ CREATE KNOWLEDGE EXCHANGE ENVIRONMENT	☐	☐	☐	☐	☐	☐
16.7	จัดหาการแลกเปลี่ยนองค์ความรู้จากภายนอก PROVIDE EXTERNAL KNOWLEDGE EXCHANGE	☐	☐	☐	☐	☐	☐
16.8	สนับสนุนผลิตภัณฑ์ให้เกิดขึ้นจริง SUPPORT PRODUCT FULLY FUNCTIONAL IN REAL WORLD	☐	☐	☐	☐	☐	☐
16.9	ส่งเสริมให้เกิดการประชุมต่าง ๆ เพื่อให้ผู้ใช้บริการมีเครือข่ายและเกิดการเรียนรู้จากประสบการณ์ของผู้ใช้บริการท่านอื่น CREATING FORUM LIKE WORKSHOPS, SEMINARS, TRADE FAIRS, ETC. FOR ENTERPRISE TO CREATE NETWORK AND LEARN FROM THE EXPERIENCE OF OTHERS.	☐	☐	☐	☐	☐	☐
16.10	อื่น ๆ โปรดระบุ OTHER, PLEASE SPECIFY: …………………………………………………………………………….	☐	☐	☐	☐	☐	☐

17. **ในฐานะผู้ใช้บริการอุทยานวิทยาศาสตร์ฯ ท่านคิดว่าอุทยานวิทยาศาสตร์ฯ ช่วยกิจการของท่านให้เกิด innovative output ดังต่อไปนี้ (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)**
As your company is being in Science Park, does your company think Science Park assists you in this following (1-lowest degree of agreement; 5-highest degree of agreement; or irrelevant).

	INNOVATIVE OUTPUT	Degree of Agreement					Irrelevant
		1	2	3	4	5	
17.1	เพิ่มผลิตภัณฑ์ใหม่, กระบวนการใหม่, และบริการใหม่ NEW PRODUCTS/ PROCESSES/ SERVICES	☐	☐	☐	☐	☐	☐
17.2	เพิ่มความหลากหลายของผลิตภัณฑ์, กระบวนการ, และ การบริการ INCREASE RANGE OF PRODUCTS/ PROCESSES/ SERVICES	☐	☐	☐	☐	☐	☐
17.3	พัฒนาสู่ตลาดสินค้าใหม่ ENTER NEW MARKET	☐	☐	☐	☐	☐	☐
17.4	เพิ่มส่วนแบ่งทางการตลาด INCREASE MARKET SHARE	☐	☐	☐	☐	☐	☐

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17.5	พัฒนาคุณภาพสินค้า,กระบวนการ และการบริการ IMPROVE QUALITY OF PRODUCTS/ PROCESSES/ SERVICES	☐	☐	☐	☐	☐	☐
17.6	ลดต้นทุนการผลิต REDUCE COST PER UNIT OUTPUT	☐	☐	☐	☐	☐	☐
17.7	ลดผลกระทบทางสิ่งแวดล้อม REDUCE ENVIRONMENT IMPACTS	☐	☐	☐	☐	☐	☐
17.8	เพิ่มคุณภาพชีวิตและความปลอดภัย IMPROVE HEALTH AND SAFETY STANDARDS	☐	☐	☐	☐	☐	☐
17.9	ตอบสนองความต้องการของลูกค้า MEET CONSUMERS/ CUSTOMER DEMAND	☐	☐	☐	☐	☐	☐
17.10	เพิ่มจำนวนการยื่นขอจดสิทธิบัตร INCREASE A NUMBER OF PATENTS APPLY	☐	☐	☐	☐	☐	☐
17.11	เพิ่มจำนวนสิทธิบัตร (ได้รับ) INCREASE A NUMBER OF PATENTS GRANTED	☐	☐	☐	☐	☐	☐
17.12	เพิ่มการยื่นขอจดทะเบียนทรัพย์สินทางปัญญาอื่น ๆ INCREASE A NUMBER OF OTHER INTELLECTUAL PROPERTY; PRETTY PATENTม TRADE MARK, COPY RIGHT ETC.	☐	☐	☐	☐	☐	☐
17.13	อื่น ๆ โปรดระบุ OTHER, PLEASE SPECIFY: ………………………………………………………………………………	☐	☐	☐	☐	☐	☐

18. **สิ่งที่อุทยานวิทยาศาสตร์ฯ สนับสนุนและจัดหาให้ท่านนั้น สามารถช่วยให้กิจการของท่านมีนวัตกรรมและผลประกอบการเพิ่มขึ้นหรือไม่ อย่างไร (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)**
Has Science Park provided your company with any help that would improve your innovative and business performance? (1-lowest degree of agreement; 5-highest degree of agreement; or irrelevant).

Degree of agreement					Irrelevant
1	2	3	4	5	
☐	☐	☐	☐	☐	☐

กรุณาระบุสิ่งที่ท่านพึงพอใจมากที่สุด please specify what kind of provision you prefer the most: ……

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ส่วนที่ 4 ข้อมูลด้านนวัตกรรม

SECTION 4: Innovative Information

คำอธิบาย: กรุณาทำเครื่องหมาย ☐✓ ในช่อง ☐ หรือเติมข้อความในช่องว่างให้สมบูรณ์

Direction: Please check ✓ in the box ☐ or please fill in the blank

19. **กรุณาระบุข้อมูลต่อไปนี้** Please provide data for the following categories:

Categories	Year of Database (1, 0, -1 defined as increased, unchanged, decreased for No. 4, 5, 9, and 10)				
	2014	2015	2016	2017	2018
1. ผลิตภัณฑ์ใหม่/กระบวนการใหม่/การบริการใหม่ (ชิ้น) New products/services/processes					
2. จำนวนนักวิจัย Number of researchers (คน)					
3. จำนวนพนักงาน Number of employees (คน)					
4. ค่าใช้จ่ายด้านการวิจัย R&D expenditure (Baht)***					
5. ค่าใช้จ่ายการว่าจ้างหน่วยงานอื่นให้ทำวิจัย*** Outsourcing R&D expenditure (Baht)					
6. ยื่นขอจดทะเบียนสิทธิบัตร Patents applied (ชิ้น)					
7. สิทธิบัตร (ที่ได้รับ) Patents Granted (ชิ้น)					

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8. ทรัพย์สินทางปัญญาอื่น ๆ (ชิ้น) Other intellectual property; copy right, petty patents, trademark etc. Other; please specific...........					
9. รายได้ทั้งหมด Total sale (Baht) ***					
10. ผลกำไร Total net profit (Baht) ***					

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20. **ท่านคิดว่าการลงทุนด้านการทำวิจัยและพัฒนาตามหัวข้อต่อไปนี้ มีความสำคัญระดับใด (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง) พร้อมเรียงลำดับความสำคัญ 1 – 3** Please indicate R&D expenditures according to following types of expenditure (1-lowest degree of importance, 5-highest degree of importance, or irrelevant).

	R&D EXPENDITURE	Degree of importance 1	2	3	4	5	Irrelevant
20.1	บุคลากรวิจัย R&D LABOR COST	☐	☐	☐	☐	☐	☐
20.2	พื้นที่ อาคาร สิ่งปลูกสร้าง LAND, BUILDING & OTHER STRUCTURE	☐	☐	☐	☐	☐	☐
20.3	เครื่องมือหนักและอุปกรณ์ MACHINERY AND EQUIPMENT	☐	☐	☐	☐	☐	☐
20.4	ซอฟแวร์ SOFTWARE / TECHNOLOGY	☐	☐	☐	☐	☐	☐
20.5	สิทธิบัตรและทรัพย์สินทางปัญญาอื่น PATENTS OR OTHER INTELLECTUAL PROPERTY	☐	☐	☐	☐	☐	☐
20.6	เครือข่ายองค์ความรู้ KNOWLEDGE LINKAGE	☐	☐	☐	☐	☐	☐
20.7	อื่น ๆ โปรดระบุ OTHERS (PLEASE SPECIFY)	☐	☐	☐	☐	☐	☐

21. **ท่านคิดว่าจุดประสงค์ที่ท่านลงทุนด้านการวิจัยและพัฒนาในหัวข้อต่อไปนี้ มีความสำคัญระดับใด (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)** Please indicate the importance of the purposes of your company's engagement in R&D investment (1-lowest degree of importance, 5-highest degree of importance, or irrelevant).

	R&D EXPENDITURE PURPOSES	Degree of importance 1	2	3	4	5	Irrelevant
21.1	ปรับปรุงกระบวนการทำงานเดิม IMPROVING EXISTING PROCESS	☐	☐	☐	☐	☐	☐
21.2	พัฒนากระบวนการทำงานใหม่ DEVELOPING NEW PROCESS	☐	☐	☐	☐	☐	☐
21.3	ปรับปรุงผลิตภัณฑ์ (สินค้าหรือบริการ) เดิม IMPROVING EXISTING PRODUCT (GOOD OR SERVICE)	☐	☐	☐	☐	☐	☐
21.4	พัฒนาผลิตภัณฑ์ (สินค้าหรือบริการ) ใหม่ DEVELOPING NEW PRODUCT (GOOD OR SERVICE)	☐	☐	☐	☐	☐	☐
21.5	เพิ่มองค์ความรู้นักวิจัย RESEARCHERS SKILL DEVELOPMENT	☐	☐	☐	☐	☐	☐

21.6	เพิ่มประสิทธิภาพของเครื่องจักร อุปกรณ์ (รวมทั้งอุปกรณ์คอมพิวเตอร์) และซอฟต์แวร์ ที่ทันสมัย ACQUISITION OF MACHINERY, EQUIPMENT (INCLUDING COMPUTER HARDWARE), AND SOFTWARE.	☐	☐	☐	☐	☐	☐
21.7	เข้าถึงความรู้จากภายนอก อาทิ การซื้อสิทธิทรัพย์สินทางปัญญา (เช่น สิทธิบัตร) ซื้อองค์ความรู้ (KNOW-HOW และองค์ความรู้อื่นๆ) จากกิจการอื่นหรือองค์กรอื่น ทั้งนี้รวมถึง การจัดจ้างที่ปรึกษา ACQUISITION OF OTHER EXTERNAL KNOWLEDGE (PURCHASE OR LICENSING OF PATENTS AND NON-PATENTED INVENTIONS, KNOW-HOW, AND OTHER TYPES OF KNOWLEDGE FROM OTHER ENTERPRISES OR ORGANIZATIONS INCLUDING CONSULTANTS)	☐	☐	☐	☐	☐	☐
21.8	เพื่อนำนวัตกรรมออกสู่ตลาด ประกอบด้วย การวิจัยตลาด การพัฒนากลยุทธ์ทางการตลาด และการโฆษณาประชาสัมพันธ์สำหรับนวัตกรรม MARKET INTRODUCTION OF INNOVATIONS (MARKET RESEARCH, CHANGES TO MARKETING METHODS, AND LAUNCH ADVERTISING)	☐	☐	☐	☐	☐	☐
21.9	อื่น ๆ โปรดระบุ OTHERS (PLEASE SPECIFY) ……………………………………………………….	☐	☐	☐	☐	☐	☐

22. **กรุณาระบุเหตุผลในกรณีที่ท่านว่าจ้าง<u>หน่วยงานภายนอก</u>ทำวิจัยและพัฒนา** Please indicate the reason(s) for outsourcing R&D services following this (1-lowest degree of importance, 5-highest degree of importance, or irrelevant).

REASON FOR OUTSOURCING R&D EXPENDITURE		Degree of importance					Irrelevant
		1	2	3	4	5	
22.1	ขาดแคลนบุคลากรวิจัยและพัฒนาในสาขาที่จำเป็น LACK OF R&D PERSONNEL WITH THE REQUISITE KNOWLEDGE	☐	☐	☐	☐	☐	☐
22.2	ขาดแคลนสถานที่ วัสดุ เครื่องมือ หรืออุปกรณ์ที่จำเป็นสำหรับกิจกรรมวิจัยและพัฒนา LACK OF FACILITIES, MATERIALS, EQUIPMENT AND DEVICES TO CONDUCT R&D ACTIVITIES	☐	☐	☐	☐	☐	☐
22.3	กิจกรรมวิจัยและพัฒนาดังกล่าว เป็นโครงการความร่วมมือกับหน่วยงาน/องค์กรในต่างประเทศ R&D PROJECTS/ACTIVITIES WERE A COLLABORATIVE RESEARCH WITH FOREIGN ENTITY	☐	☐	☐	☐	☐	☐
22.4	เป็นนโยบายของบริษัทแม่ PARENT COMPANY'S POLICY	☐	☐	☐	☐	☐	☐

		1	2	3	4	5	Irrelevant
22.5	ขาดแคลนองค์ความรู้และเทคโนโลยี LACK OF KNOWLEDGE LINKAGE AND TECHNOLOGY	☐	☐	☐	☐	☐	☐
22.6	อื่น ๆ โปรดระบุ OTHERS (PLEASE SPECIFY) …………………………………………………….	☐	☐	☐	☐	☐	☐

23. **ท่านให้ความสำคัญกับหน่วยงานภายนอกดังต่อไปนี้ เพื่อดำเนินการด้านการวิจัยและพัฒนาในระดับใด (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)** Please indicate where from your company outsources R&D services (1-lowest degree of importance, 5-highest degree of importance, or irrelevant).

	OUTSOURCING R&D EXPENDITURE	Degree of importance					Irrelevant
		1	2	3	4	5	
23.1	มหาวิทยาลัย/สถาบันการศึกษาในประเทศ DOMESTIC UNIVERSITIES	☐	☐	☐	☐	☐	☐
23.2	หน่วยงานวิจัยของรัฐในประเทศ DOMESTIC PUBLIC RESEARCH INSTITUTES	☐	☐	☐	☐	☐	☐
23.3	หน่วยงานอื่น ๆ ในประเทศ (รวมถึงกิจการอื่น แต่ไม่รวมหน่วยงานของรัฐ) DOMESTIC ORGANIZATIONS INCLUDING DOMESTIC PRIVATE ENTERPRISES	☐	☐	☐	☐	☐	☐
23.4	มหาวิทยาลัย/สถาบันการศึกษาในต่างประเทศ FOREIGN UNIVERSITIES	☐	☐	☐	☐	☐	☐
23.5	หน่วยงานวิจัยของรัฐในต่างประเทศ OTHER FOREIGN PUBLIC RESEARCH INSTITUTES	☐	☐	☐	☐	☐	☐
23.6	หน่วยงานอื่น ๆ ในต่างประเทศ (รวมถึงกิจการอื่น แต่ไม่รวมหน่วยงานของรัฐ) OTHER FOREIGN INSTITUTIONS INCLUDING FOREIGN PRIVATE ENTERPRISE	☐	☐	☐	☐	☐	☐
23.7	บริษัทในเครือหรือบริษัทแม่ในต่างประเทศให้ดำเนินการวิจัยและพัฒนา FOREIGN AFFILIATED COMPANIES/PARENT COMPANY	☐	☐	☐	☐	☐	☐
23.8	อื่น ๆ โปรดระบุ OTHERS (PLEASE SPECIFY) …………………………………………………….	☐	☐	☐	☐	☐	☐

24. **ท่านเห็นด้วยในระดับใด ว่าข้อต่อไปนี้เป็น<u>อุปสรรคหรือข้อจำกัด</u>ในการดำเนินกิจกรรมนวัตกรรมรวมถึงการวิจัยและพัฒนา (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง) พร้อมเรียงลำดับอุปสรรคหรือข้อจำกัด 1 – 3** Please indicate the degree of agreement of the following factors <u>in preventing</u> your enterprise from innovating or in hampering your R&D and innovation activities: (1-lowest degree of agreement; 5-highest degree of agreement; or irrelevant).

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	อุปสรรคต่อการดำเนินการด้านนวัตกรรม LIMITATIONS OR OBSTACLES OF INNOVATION	Degree of Agreement					Irrelevant
		1	2	3	4	5	
24.1	ขาดเงินทุนจากกิจการหรือกลุ่มกิจการของท่าน LACK OF FUNDS WITHIN YOUR ENTERPRISE OR GROUP	☐	☐	☐	☐	☐	☐
24.2	ขาดเงินทุนจากแหล่งภายนอกกิจการของท่าน LACK OF FINANCE FROM SOURCES OUTSIDE YOUR ENTERPRISE	☐	☐	☐	☐	☐	☐
24.3	ต้นทุนการทำนวัตกรรมสูงเกินไป INNOVATION COST TOO HIGH	☐	☐	☐	☐	☐	☐
24.4	ขาดบุคลากรที่มีคุณสมบัติเหมาะสม LACK OF QUALIFIED PERSONNEL	☐	☐	☐	☐	☐	☐
24.5	ขาดข้อมูลเกี่ยวกับเทคโนโลยี LACK OF INFORMATION ON TECHNOLOGY	☐	☐	☐	☐	☐	☐
24.6	ขาดข้อมูลเกี่ยวกับตลาด LACK OF INFORMATION ON MARKETS	☐	☐	☐	☐	☐	☐
24.7	ความยากในการหาพันธมิตรในการทำนวัตกรรม DIFFICULTY IN FINDING COOPERATION PARTNERS FOR INNOVATION	☐	☐	☐	☐	☐	☐
24.8	ตลาดถูกครอบงำโดยกิจการที่ครองตลาดอยู่ก่อนแล้ว MARKET DOMINATED BY ESTABLISHED ENTERPRISES	☐	☐	☐	☐	☐	☐
24.9	ความต้องการนวัตกรรมด้านสินค้าหรือบริการมีความ ไม่แน่นอน UNCERTAIN DEMAND FOR INNOVATIVE GOODS OR SERVICES	☐	☐	☐	☐	☐	☐
24.10	ไม่จำเป็นเนื่องจากมีนวัตกรรมก่อนหน้านั้นแล้ว NO NEED DUE TO PRIOR INNOVATIONS BY YOUR ENTERPRISE	☐	☐	☐	☐	☐	☐
24.11	ตลาดไม่มีความต้องการนวัตกรรมด้านสินค้าหรือบริการใหม่ NO MARKET DEMAND FOR INNOVATIONS	☐	☐	☐	☐	☐	☐
24.12	กฎหมายหรือข้อบังคับ เป็นอุปสรรคต่อการพัฒนานวัตกรรม LAWS OR REGULATION IMPEDIMENTS	☐	☐	☐	☐	☐	☐
24.13	อื่น ๆ โปรดระบุ OTHERS (PLEASE SPECIFY) …………………………………………………….	☐	☐	☐	☐	☐	☐

25. **กรุณาระบุความสำคัญของแหล่งข้อมูลต่อไปนี้ ในการดำเนินกิจกรรมนวัตกรรม (รวมถึงการวิจัยและพัฒนา) (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)** Please rate the degree of importance of the following sources of information for your R&D and innovation activities. (1-lowest degree of importance, 5-highest degree of importance, or irrelevant).

แหล่งข้อมูลด้านนวัตกรรม INNOVATIVE INFORMATION SOURCES	Degree of importance					Irrelevant
	1	2	3	4	5	

25.1	แหล่งข้อมูลภายในกิจการ SOURCES WITHIN THE ENTERPRISE	☐	☐	☐	☐	☐	☐
25.2	บริษัทแม่/กิจการในเครือ PARENT/ASSOCIATED COMPANIES	☐	☐	☐	☐	☐	☐
25.3	ลูกค้า Clients	☐	☐	☐	☐	☐	☐
25.4	ซับพลายเออร์ไทย Locally-owned suppliers	☐	☐	☐	☐	☐	☐
25.5	ซับพลายเออร์ต่างชาติ Foreign-owned suppliers	☐	☐	☐	☐	☐	☐
25.6	มหาวิทยาลัยหรือสถาบันอุดมศึกษาอื่น Universities or other higher education institutes	☐	☐	☐	☐	☐	☐
25.7	สถาบันวิจัยของรัฐ Public research institutes	☐	☐	☐	☐	☐	☐
25.8	ผู้ให้บริการทางธุรกิจ (เช่น ที่ปรึกษาทางการบริหาร ผู้วิจัยตลาด) Business service providers (e.g. management consultants, market researchers)	☐	☐	☐	☐	☐	☐
25.9	คู่แข่ง Competitors	☐	☐	☐	☐	☐	☐
25.10	ข้อมูลจากสิทธิบัตรที่เข้าถึงได้ Patent disclosures	☐	☐	☐	☐	☐	☐
25.11	งานแสดงสินค้าและนิทรรศการ Fairs and exhibitions	☐	☐	☐	☐	☐	☐
25.12	การประชุมและสัมมนา Conferences & meetings	☐	☐	☐	☐	☐	☐
25.13	บทความวิชาการเฉพาะทาง Specialits literature (journals, monographs etc.)	☐	☐	☐	☐	☐	☐
25.14	อินเตอร์เน็ต Internet	☐	☐	☐	☐	☐	☐
25.15	สมาคมวิชาชีพ/สมาคมการค้าอุตสาหกรรม Professional and industry associations	☐	☐	☐	☐	☐	☐
25.16	อื่น ๆ โปรดระบุ Others (Please specify)......................	☐	☐	☐	☐	☐	☐

26. **กรุณาระบุระดับความสำคัญในการร่วมมือระหว่างองค์กรอื่นเพื่อดำเนินกิจกรรมนวัตกรรม (รวมถึงการวิจัยและพัฒนา) (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง)** Please rate the degree of importance of the following reasons for co-operation with external parties for R&D and innovation activities. (1-lowest degree of importance, 5-highest degree of importance, or irrelevant).

	สาเหตุหลักของความร่วมมือระหว่างองค์กร REASONS FOR COOPERATION	Degree of importance					Irrelevant
		1	2	3	4	5	
26.1	ลด/แบ่งความเสี่ยง & ต้นทุน Share / reduce risk & cost	☐	☐	☐	☐	☐	☐
26.2	การเข้าสู่สาขาเทคโนโลยีใหม่ Enter new technology fields	☐	☐	☐	☐	☐	☐

26.3	ถ่ายทอดความรู้ Knowledge transfer	☐	☐	☐	☐	☐	☐
26.4	ใช้เวลาเข้าสู่ตลาดสั้นลง Expedite access to market	☐	☐	☐	☐	☐	☐
26.5	ใช้ทรัพยากรทางการเงินร่วมกัน Pool financial resources	☐	☐	☐	☐	☐	☐
26.6	สร้างพันธมิตรทางกลยุทธ์ในระยะยาว Establish long term strategic partnership	☐	☐	☐	☐	☐	☐
26.7	อื่น ๆ โปรดระบุ Others (Please specify)......................	☐	☐	☐	☐	☐	☐

27. **กิจการของท่านมีความร่วมมือกับสถาบันวิจัยของรัฐ และ/หรือ มหาวิทยาลัย/สถาบันอุดมศึกษาในกิจกรรมต่อไปนี้ในระดับใด (5-สม่ำเสมอ / 4-บ่อยครั้ง / 3-บางครั้ง / 2-นาน ๆ ครั้ง / 1-ไม่เคย)** Please rate the degree of frequency of your company engage in the following activities with public research institutes and/or universities/higher education institutes? (5 - Always / 4 - Very Frequently / 3 - Occasionally / 2- Rarely / 1 - Never)

ประเภทกิจกรรม TYPE OF ACTIVITIES		Degree of frequency with public research institutes (ภาครัฐ)					Degree of frequency with universities (มหาวิทยาลัย)				
		1	2	3	4	5	1	2	3	4	5
27.1	การทำวิจัยร่วมกัน Conduct joint research project	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.2	การว่าจ้างให้ทำวิจัย Contract out research project	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.3	การจ้างเป็นที่ปรึกษา Hire academic consultants	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.4	การใช้เทคโนโลยี Use of licensed technology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.5	การบริการวิเคราะห์/ทดสอบ/สอบเทียบ Use of analytical and testing services	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.6	การใช้เครื่องมือ/อุปกรณ์ Use of technical infrastructure	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.7	การแลกเปลี่ยนบุคลากรชั่วคราว Temporary personnel exchange	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.8	การรับนักศึกษาฝึกงาน Host student internships	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.9	การฝึกอบรมพนักงาน Training for employees	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.10	ร่วมเขียนบทความในวารสารวิชาการ Co-publications	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.11	การเข้าร่วมประชุมและสัมมนาทางวิชาการ Meeting or conference	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

27.12	การติดต่อ/พบปะส่วนตัว Informal personal contact or meeting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
27.13	อื่น ๆ โปรดระบุ Others (Please specify)...	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

SECTION 5: Recommendation

คำอธิบาย: กรุณาทำเครื่องหมาย ☐✓ ในช่อง ☐ หรือเติมข้อความในช่องว่างให้สมบูรณ์

Direction: Please check ✓ in the box ☐ or please fill in the blank

28. **ท่านเห็นด้วยในระดับใด หากอุทยานวิทย์ฯ ดำเนินการดังข้อต่อไปนี้เพื่อให้เกิดการสร้างสรรค์นวัตกรรม (1-น้อยที่สุด, 5-มากที่สุด, หรือไม่เกี่ยวข้อง) พร้อมเรียงลำดับความสำคัญ 1 – 3** Please indicate the degree of agreement of the following recommendations for your company's innovation effort and what your company expect to get from Science Park (1-lowest degree of agreement; 5-highest degree of agreement; or irrelevant).

ข้อเสนอแนะ RECOMMENDATION		Cooperate Degree of importance					Not cooperate
		1	2	3	4	5	
28.1	เพิ่มพื้นที่สำหรับใช้บริการ Expand space	☐	☐	☐	☐	☐	☐
28.2	เพิ่มและพัฒนาสิ่งอำนวยความสะดวกและอุปกรณ์ต่าง ๆ Increase and improve facility and equipment	☐	☐	☐	☐	☐	☐
28.3	เพิ่มโอกาสในการพบปะกันระหว่างผู้ใช้บริการ Increase opportunity for interaction with participants	☐	☐	☐	☐	☐	☐
28.4	เพิ่มโอกาสเข้าร่วมงานแสดงสินค้าและการประชุม Exhibition and conferences	☐	☐	☐	☐	☐	☐
28.5	เพิ่มที่ปรึกษาด้านการวิจัย Increase researcher consultancy	☐	☐	☐	☐	☐	☐
28.6	พัฒนาระบบการบริหารและการจัดการ Improve Thailand Science Park administration and management	☐	☐	☐	☐	☐	☐
28.7	พัฒนาเครือข่ายองค์ความรู้ Knowledge network development	☐	☐	☐	☐	☐	☐
28.8	เพิ่มการเข้าถึงแหล่งข้อมูลภายนอก Access to external knowledge sources	☐	☐	☐	☐	☐	☐
28.9	จัดหาลิขสิทธิ์และสิทธิบัตร Purchase license /patents	☐	☐	☐	☐	☐	☐
28.10	เพิ่มโอกาสทางการตลาด Create more market opportunity	☐	☐	☐	☐	☐	☐
28.11	เพิ่มโอกาสการเข้าถึงแหล่งเงินทุน Create opportunities for funding	☐	☐	☐	☐	☐	☐

28.12	ช่วยดำเนินการด้านทรัพย์สินทางปัญญา Processing applications for intellectual property	□	□	□	□	□	□
28.13	อื่น ๆ โปรดระบุ Others (Please specify)...	□	□	□	□	□	□

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E. Open-Ended Questions for Interview-Based Study

The open-ended questions will be asked to explore in detail the experiences gained from Northern Thailand Science Park (NSP) as tenants in term of the development of knowledge exchange and innovation networks; to determine the effectiveness for promoting innovation and competitiveness among tenants. This will be conducted after participants have completed the questionnaires.

1. What kind of considerable supports have you received from NSP and how have they benefited the business of your company in terms of R&D and innovation activities?
2. Please explain the nature of support derived from NSP and how it relates to your company's needs?
3. Please indicate the benefits you get from existing in NSP which you wouldn't be able to get if your company was not a NSP resident.
4. How often do you meet and exchange ideas with tenants located in NSP? And this is benefit to your company?
5. Are you satisfied with the support given by the management of NSP for your business? If yes, what kind of your satisfaction. If no, why?
6. Do you think that the position of your company would be significantly different in term of knowledge exchange, innovation networks, and business performance, if you had not joined NSP?
7. Do you have any recommendations for the improvement of service in NSP?
8. Any specific reason why your company decided to locate the company in NSP?
9. Do you intend to stay in NSP for long? If yes, for how long? If no, why?
10. If the Government were to establish a new science park, what, in your opinion, would be the lessons to be learned from the strengths and weaknesses of NSP?

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F. Permission letter for fieldwork in Thailand

University of Strathclyde
Engineering

The University of Strathclyde
16 Richmond St, Glasgow
G1 1XQ, UK

November 30, 2018

Subject: Permission Letter for fieldwork in Thailand

To Whom It May Concern:

I am writing to let you know that I am permitting my student, MR.KANIT SAWASDEE who is a postgraduate student at the University of Strathclyde, Glasgow, United Kingdom, to travel to Thailand to collect data for his Ph.D. research.

His research is on 'The Role of Science Parks in Promoting Knowledge Exchange and Innovation Particular with References. He would need primary data to be obtained through fieldwork to be able to complete his Ph.D. thesis.

The fieldwork will span three months from 30th December 2018 – 1st April 2019. While on fieldwork, he will regularly report to me on the progress of his fieldwork.

Thank you very much.

Respectfully yours,

Dr.Girma Zawdie
Supervisor
Senior lecturer
Department of Civil and Environmental Engineering
The University of Strathclyde, Glasgow, UK.

G. Table of interview records

Name of Tenants	Capital cost (million baht)	Type	Business	contact details		Interview Date	Interview recorded time
	5	SML	Materials Science & Chemicals			6/2/2019	0
	5	SML	Herbs & Cosmetics / Materials Science & Chemicals / Food & Agriculture			6/2/2019	1.55 hrs.
	1	Startup	ICT & Software			7/2/2019	1.22 hrs.
	5	Startup	ICT & Software			7/2/2019	1.56 hrs.
	1	Startup	ICT & Software			8/2/2019	1.02 hrs.
	1	SML	Food & Agriculture			8/2/2019	2.54 hrs.
	0.3	Startup	ICT & Software			11/2/2019	1.07 hrs.
	1	Startup	ICT & Software			11/2/2019	0.49 hrs.
	906.5	SML	Materials Science & Chemicals			13/02/1019	1.21 hrs.
	1	Startup	Food & Agriculture			14/2/2019	2.31 hrs.
	1	SML	Food & Agriculture			15/2/2019	1.05 hrs.
	1	Startup	ICT & Software			15/2/2019	0.54 hrs.

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Name of Tenants	Capital cost (million baht)	Type	Business	contact details		Interview Date	Interview recorded time
	1	Startup	Medical Device & Pharmaceutical			20/2/2019	1.06 hrs.
	1	SML	ICT & Software			26/2/2019	1.35 hrs.
	5	SML	ICT & Software			26/2/2019	0
	2	SML	Experience Design Service			27/2/2019	1.0 hrs.
	3	SML	Food & Agriculture			5/3/2019	0.52 hrs.
	2	Startup	Energy			6/3/2019	1.35 hrs.
	1	Startup	Medical Device & Pharmaceutical			6/3/2019	1.16 hrs.
	13	SML	ICT & Software			7/3/2019	1.22 hrs.
	1	Startup	ICT & Software			7/3/2019	1.24 hrs.
	5	SML	ICT & Software			8/3/2019	1.12 hrs.

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H. Cronbach's alpha of a five-Likert scale used in questionnaire

Part 2; Reasons of participating in NSP

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.812	.845	11

Part 3; Innovative inputs

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.794	.800	11

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Part 3; Innovative process

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.887	.905	9

Part 3; Innovative outputs

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.871	.858	12

Part 4; Type of R&D expenditure

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.817	6

Part 4; Purpose of engagement in R&D investment

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.571	6

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Part 4; Reasons for outsourcing R&D services

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.546	5

Part 4; Outsource of R&D company services

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	9	90.0
	Excluded[a]	1	10.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.814	7

Part 4; Factor in preventing R&D activities and innovation

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.870	9

Part 4; Information source of R&D activities and innovation

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.855	15

Part 4; Reasons for co-operation with other firms for R&D activities and innovation

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.805	6

Part 5; Recommendation

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	10	100.0
	Excluded[a]	0	.0
	Total	10	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.773	.783	12

I. Friedman Test

- Human resource

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
IncreaseResearcher	22	3.7727	.61193	3.00	5.00
ImproveResearcherSkill	22	3.5455	.67098	3.00	5.00
ImprovEmploySkill	22	3.6364	.90214	2.00	5.00
SpecificSkillNeed	22	4.0455	.72225	3.00	5.00
RecruitSkillEmploy	22	3.7727	.75162	2.00	5.00

Friedman Test

Ranks

	Mean Rank
IncreaseResearcher	3.05
ImproveResearcherSkill	2.50
ImprovEmploySkill	2.73
SpecificSkillNeed	3.59
RecruitSkillEmploy	3.14

Test Statistics[a]

N	22
Chi-Square	11.107
df	4
Asymp. Sig.	.025

a. Friedman Test

- Infrastructure

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
SpaceForRD	22	4.5000	.59761	3.00	5.00
FacilityRD	22	4.4545	.73855	3.00	5.00
InteractionFirm	22	4.2273	.81251	3.00	5.00
KnowledgeExchangeEnvironment	22	4.2727	1.03196	2.00	5.00

Friedman Test

Ranks

	Mean Rank
SpaceForRD	2.61
FacilityRD	2.59
InteractionFirm	2.36
KnowledgeExchangeEnvironment	2.43

Test Statistics[a]

N	22
Chi-Square	1.084
df	3
Asymp. Sig.	.781

a. Friedman Test

- Knowledge linkage

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
ConsultRD	22	4.2273	.68534	3.00	5.00
EnhanceKnowledge	22	4.4545	.67098	3.00	5.00
ExternalKnowledge	22	4.1364	.94089	1.00	5.00
CreateForum	22	4.4091	.85407	3.00	5.00

Friedman Test

Ranks

	Mean Rank
ConsultRD	2.32
EnhanceKnowledge	2.64
ExternalKnowledge	2.27
CreateForum	2.77

Test Statistics[a]

N	22
Chi-Square	4.031
df	3
Asymp. Sig.	.258

a. Friedman Test

- Funding (It has not been done because there was only one sub topic)
- Market opportunity

-

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
MarketSkill	22	3.8182	1.00647	2.00	5.00
ExploreBusinessIdea	22	4.0455	.72225	3.00	5.00
SetBuleprints	22	3.7273	.88273	1.00	5.00
DevelopPrototype	22	3.7273	.82703	2.00	5.00
CustomerPrefer	22	3.5455	1.01076	1.00	5.00
ProductFuntionall	22	3.9545	.95005	1.00	5.00

Friedman Test

Ranks

	Mean Rank
MarketSkill	3.57
ExploreBusinessIdea	4.00
SetBuleprints	3.32
DevelopPrototype	3.30
CustomerPrefer	2.89
ProductFuntionall	3.93

Test Statistics[a]

N	22
Chi-Square	10.827
df	5
Asymp. Sig.	.055

a. Friedman Test

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J. Multicollinearity tests

- Multicollinearity test for Hypothesis 2 (H2)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	4.267	.570		7.483	.000		
	Age	-.067	.040	-.828	-1.670	.126	.239	4.178
	RENU	-.083	.069	-.607	-1.205	.256	.232	4.308
	MID	-.120	.473	-.078	-.255	.804	.629	1.591
	LOW	-.571	.505	-.479	-1.130	.285	.328	3.052
	L	-1.361	1.240	-.475	-1.098	.298	.313	3.192
	SME1	-.961	.706	-.806	-1.361	.203	.168	5.969
	Agri4	-.383	.584	-.248	-.655	.527	.411	2.432
	Scien4	-.614	.481	-.515	-1.277	.230	.362	2.765
	ConY	.402	.487	.300	.824	.429	.444	2.255
	RDY	.125	.467	.088	.269	.794	.546	1.830
	PART1	.416	.218	1.354	1.907	.086	.117	8.577

a. Dependent Variable: INinmedian

- Multicollinearity test for Hypothesis 3 (H3)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	-.244	.978		-.249	.806		
	HUREmedian	-.437	.197	-.354	-2.217	.041	.682	1.466
	INFAmedian	1.030	.343	.737	3.004	.008	.288	3.471
	KNLKmedian	-.056	.275	-.049	-.203	.841	.299	3.342
	FUNDmedian	-.499	.179	-.673	-2.790	.013	.298	3.358
	MAOPmedian	.964	.181	1.055	5.330	.000	.443	2.259

a. Dependent Variable: INoutmedian

K. Hypothesis 2 (H2)

Case Processing Summary

		N	Marginal Percentage
INinmedian	3.00	5	22.7%
	4.00	14	63.6%
	5.00	3	13.6%
CAPC3	less than 50,000	11	50.0%
	50,000-100,000	4	18.2%
	more than 100,000	7	31.8%
SCAL3	Start-up	10	45.5%
	SME	11	50.0%
	Large	1	4.5%
CONR	No	6	27.3%
	Yes	16	72.7%
RDEX	No	5	22.7%
	Yes	17	77.3%
BUSS4	software&application	11	50.0%
	food&agriculture	4	18.2%
	science	3	13.6%
	Medical devices	4	18.2%
Valid		22	100.0%
Missing		0	
Total		22	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	39.426			
Final	27.042	12.384	12	.415

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	26.103	28	.567
Deviance	27.042	28	.516

Link function: Logit.

Pseudo R-Square

Cox and Snell	.430
Nagelkerke	.517
McFadden	.314

Link function: Logit.

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Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[INinmedian = 3.00]	19.126	3.659	27.320	1	.000	11.954	26.298
	[INinmedian = 4.00]	24.003	4.147	33.500	1	.000	15.875	32.131
Location	RENU	-.513	.302	2.878	1	.090	-1.106	.080
	Age	-.455	.218	4.337	1	.037	-.883	-.027
	PART	3.222	1.384	5.419	1	.020	.509	5.935
	[CAPC3=1]	-3.721	2.226	2.793	1	.095	-8.084	.642
	[CAPC3=2]	-.538	1.679	.103	1	.749	-3.828	2.753
	[CAPC3=3]	0[a]	.	.	0	.	.	.
	[SCAL3=1]	23.081	3.089	55.824	1	.000	17.026	29.135
	[SCAL3=2]	17.241	.000	.	1	.	17.241	17.241
	[SCAL3=3]	0[a]	.	.	0	.	.	.
	[CONR=0]	-1.474	1.699	.753	1	.386	-4.803	1.855
	[CONR=1]	0[a]	.	.	0	.	.	.
	[RDEX=0]	-.781	1.723	.206	1	.650	-4.157	2.595
	[RDEX=1]	0[a]	.	.	0	.	.	.
	[BUSS4=1]	-2.832	1.917	2.182	1	.140	-6.589	.925
	[BUSS4=2]	-2.119	2.296	.852	1	.356	-6.619	2.381
	[BUSS4=3]	1.187	2.882	.170	1	.680	-4.461	6.836
	[BUSS4=4]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Test of Parallel Lines[a]

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	27.042			
General	6.607[b]	20.435[c]	12	.059

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.

b. The log-likelihood value cannot be further increased after maximum number of step-halving.

c. The Chi-Square statistic is computed based on the log-likelihood value of the last iteration of the general model. Validity of the test is uncertain.

L. Hypothesis 3 (H3)

Case Processing Summary

		N	Marginal Percentage
INoutmedian	2.0	1	4.5%
	3.0	3	13.6%
	4.0	13	59.1%
	5.0	5	22.7%
Valid		22	100.0%
Missing		0	
Total		22	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	46.631			
Final	19.276	27.355	5	.000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	202.471	43	.000
Deviance	19.276	43	.999

Link function: Logit.

Pseudo R-Square

Cox and Snell	.712
Nagelkerke	.809
McFadden	.587

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[INoutmedian = 2.0]	20.534	8.490	5.850	1	.016	3.894	37.174
	[INoutmedian = 3.0]	24.722	9.115	7.357	1	.007	6.858	42.587
	[INoutmedian = 4.0]	31.804	10.770	8.720	1	.003	10.695	52.913
Location	HUREmedian	-2.610	1.472	3.147	1	.076	-5.494	.274
	INFAmedian	7.129	3.049	5.468	1	.019	1.154	13.105
	KNLKmedian	-.455	1.827	.062	1	.803	-4.035	3.125
	FUNDmedian	-3.428	1.395	6.041	1	.014	-6.162	-.695
	MAOPmedian	6.051	1.977	9.365	1	.002	2.176	9.927

Link function: Logit.

Test of Parallel Lines[a]

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	19.276			
General	.000[b]	19.276	10	.037

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.

b. The log-likelihood value is practically zero. There may be a complete separation in the data. The maximum likelihood estimates do not exist.